National Irrigation Administration (NIA)
The Republic of the Philippines

PREPARATORY SURVEY ON MALITUBOG-MARIDAGAO IRRIGATION PROJECT (PHASE II) IN THE REPUBLIC OF THE PHILIPPINES

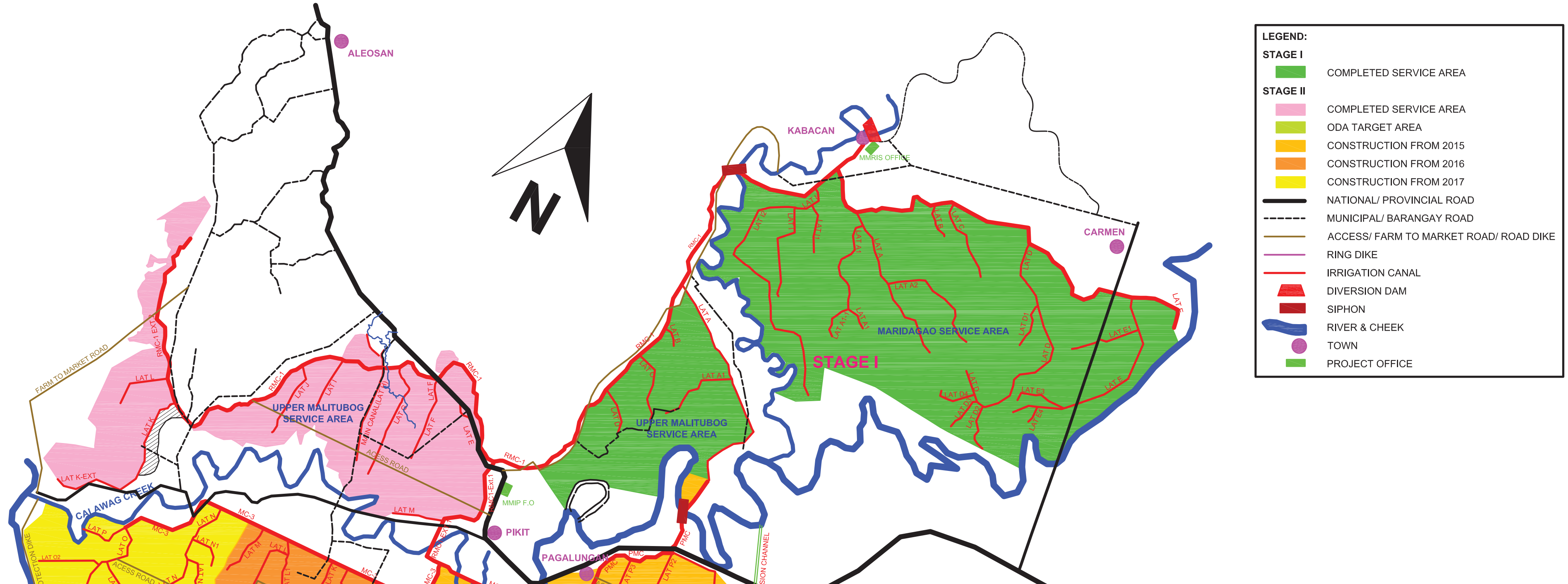
FINAL REPORT

September 2018

Japan International Cooperation Agency (JICA)
Sanyu Consultants Inc. (SCI)

1R
JR（先）
18-066

LOCATION MAP : MALITUBOG MARIDAGAO IRRIGATION PROJECT



Service Area	Phase	Starting Year	Irrigation Area, ha	Beneficiary FHH	Population	Area/ FHH, ha
Maridagao	Phase 1	Completed in 2011	5,562	4,278	21,521	1.30
Upper Malitubog	Phase 1		1,611	1,239	6,233	1.30
Upper Malitubog	Phase 2	Started in 2011	2,958	1,782	8,963	1.66
Pagalungan Ext.	Phase 2	2015	988	788	3,963	1.25
Lower Malitubog	Phase 2	Whole	6,590	5,255	26,434	1.25
		2015	1,303	1,039	5,227	1.25
		2016	1,736	1,384	6,963	1.25
		2017-18	1,418	1,131	5,688	1.25
		2019 (ODA)	2,133	1,701	8,556	1.25
Total	**Phase 1**		**7,173**	**5,518**	**27,754**	**1.30**
	Phase 2		**10,536**	**7,825**	**39,360**	**1.35**
Ground Total			**17,709**	**13,343**	**67,114**	**1.33**

Note: No. of typical family members was assumed to be 5.03 persons per family as per Census 2015.

EXECUTIVE SUMMARY

PREFACE

0.1 Submitted herewith is the Final Report prepared at the end of the field surveys on 'the Preparatory Survey on Malitubog-Maridagao Irrigation Project Phase II (MMIP II)'. A survey team organized by JICA headquarters commenced a series of field surveys for the Preparatory Survey from the beginning of May 2017, and this report presents major findings, flood simulation, project components, project cost, implementation arrangement, project evaluation, environmental and social consideration including indigenous peoples' issues, and conclusion and recommendations. **(It is noted that non-disclose information for 3-year is included hereunder as procurement by the Philippines government is scheduled.)**

1. RATIONALE OF THE SURVEY

1.1 National Economic and Development Authority (NEDA) Board officially approved the Philippine Development Plan 2017-2022 on February 20, 2017. In this Plan, growth is expected to be more inclusive, where overall poverty ratio for the nation is targeted to decline from 21.6 % to 14 percent, and poverty incidence in rural areas to decrease from 30 % in 2015 to 20 % in 2022. Thus, the Plan puts priority on the poverty reduction in rural areas, e.g. central Mindanao area where the MMIP II site is located.

1.2 The Plan 2017-2022 is founded on three main pillars of: 1) regaining of people's trust, 2) inequality-reducing through increasing opportunities for growth, and 3) increasing of potential growth through sustaining and accelerating economic growth. Under the second pillar, opportunities in agriculture sector are expected to expand. Further, under the three pillars lie cross-cutting strategies, i.e.: 1) attaining just and lasting peace, 2) ensuring security, public order and safety, 3) accelerating infrastructure development, and so on. In this regard, MMIP I, the foregoing project to MMIP II, is well known to have contributed to the peace and order in that area.

1.3 The National Irrigation Administration (NIA) has its six-year plan for the period from 2012 to 2017. According to this plan, the rate of irrigation development in central Mindanao area was as low as 41.7% compared to the national average of 55.6% in the year 2015. In order to address such under-development in irrigation and the challenge to poor maintenance for the existing irrigation facilities, among other challenges, the plan aims at accelerating the development and rehabilitation of irrigation facilities as well as a partial transfer of the O&M responsibilities of National Irrigation Systems (NISs) from NIA to Irrigators Associations (IAs).

1.4 The project site for the MMIP II has not been yet socio-economically developed. The agricultural production is low in spite of its potential being high, and thus improvement on irrigation facilities and agricultural productivity is an important development issue in the area. Based on these circumstances, MMIP II is expected to contribute to poverty reduction and long-lasting peace of this area. MMIP II could benefit the population of this area by bringing about an economic development through the irrigation development, hence, the MMIP II should be implemented/ completed as early as possible, and accordingly this Preparatory Survey is commenced.

1.5 In fact, this Survey was initiated by a request for Japanese ODA loan funding to the Lower Malitubog Service Area (LMSA), or to a part of the LMSA as MMIP II has been undergoing since year 2011. However, it is noted that flood simulation undertaken in this Survey revealed that dyke construction surrounding the LMSA for the purpose of protecting the area from flood coming from Pulangi river is not feasible technically and finically. With this outcome in which dyke should not be constructed, NIA has recognized that the current NEDA approved budget could be enough to complete the remaining parts of the MMIP II.

1.6 NIA issued a letter to Department of Finance on May 22, 2018 stating that NIA would intend to withdraw its proposal for the funding of MMIP II through the Japan ODA financing as NIA believes that the remaining balance is too inconsequential for it to be funded by ODA loan. Following this NIA's action, government officials of the Philippines raised during a Japan-Philippines Economic Cooperation Infrastructure Joint Meeting held on June 21, 2018 that the GOP withdraws the ODA loan request for the MMIP II.

1.7 With above withdrawal, this Survey now places priority more on its feasibility and sound development plan formulation of the LMSA. The outputs of the Survey are thus the recommendations of the project components, and investment scale of the MMIP II with feasibility evaluation, including measures against flooding. The Survey is therefore to investigate and analyze the different aspects of the project and consolidate the results in form of a project implementation plan taking into account the impact of Pulangi river flooding.

2. THE PROJECT AREA

2.1 The Project, Malitubog Maridagao Irrigation Project (MMIP) is composed of MMIP I and MMIP II, and the entire Project area covers 17,709 ha consisting of 7,173 ha from MMIP I and 10,536 ha from MMIP II. The Project site is spread over 5 municipalities of Carmen, Kabacan, Pikit, Datu Montawal and Pagalungan. The first 3 municipalities fall in Cotabato province while the latter 2 municipalities in Maguindanao province (ARMM). A total of 13,343 farmer households or 67,114 persons was estimated to be benefitted from the entire MMIP (5,518 households from MMIP I and 7,825 households from MMIP II).

2.2 The Project area of MMIP I starts at the diversion point established on the Maridagao river, through which water is withdrawn into the Maridagao Service Area (MSA), and then after crossing the river with a siphon, it irrigates the Upper Malitubog Service Area (UMSA) upstream site. The irrigation water further reaches to the MMIP II area, namely, UMSA downstream site, the Pagalungan Extension Service Area (PESA) and the Lower Malitubog Service Area (LMSA). Thus, the MMIP area extends over from north to south, approximately 27 km, and form west to east about 30 km. The diversion point has the highest elevation of 35 m, while the most downstream point has the lowest elevation, almost 0 m.

2.3 The implementation of MMIP I was commenced in April 1993 and completed in 2011, thus it took more than 17 years to be completed due to unstable peace and order in and around the Project site. The total project cost for MMIP I amounted to 3,184.34 million Php equivalent to JPY 8.43 billion, and out of which, JPY 4.541 billion was from the Japanese ODA Loan. In the same year 2011, MMIP II was started, and as of July 2018, leaving the area for which ODA Loan was originally requested, the MMIP II area has been either completed, under construction, or to be worked by already awarded contractors. For the MMIP II, the NEDA-ICC approved project cost is 5,444.84 million Php.

2.4 The Project area has a tropical wet climate being constantly moist, represented with year-round rainfall. There is not much temperature fluctuation throughout year ranging from 20 to 35 Celsius degree, with a bit of increase in March – May. The monthly basis rainfall indicates no clear demarcation between seasons; however, it is generally said that the rainy season is from May to October while the dry season is from November to April of the following year. The annual rainfall in the Project site marks only 902 mm, of which about 40% falls during the dry season, while the annual rainfall at the most upstream edge of the catchment area marks as much as 6,477 mm.

2.5 The population growth ratio in the Project area is higher than that of the national average. In 2015, the population of Cotabato province marked 1,373,962 and its land area covered 9,317 km^2, giving 148 persons per km^2 population density. The average household size was 4.29. On the other hand, the population of Maguindanao province was 1,172,381 with the land area of 9,968 km^2, showing the population density of 118 persons per km^2. The average household size was 6.03. The Census of Population and Housing 2010 estimated about 1.7% and 1.8 % population growths for Cotabato province, Region XII, while approximately 2.2% and 2.4% for Maguindanao province and ARMM.

2.6 ARMM is agriculture dominated region, while Region XII is not such, although the agriculture production dependency is decreasing in both regions. In Region XII, the primary sector of agriculture, hunting, forestry and fishing shared 26.2% of the gross regional domestic product (GRDP) in 2015, while that of ARMM did as high as 59.3% of the GRDP. It is clearly found that agriculture industry has been prevailing as the main industry as compared to the national average; accounted for around 30% and 60% as of 2015 in Region XII and ARMM respectively. Further, changes in times look differently by region.

2.7 In order to identify the impact of the MMIP I and to set baseline values for the project area, a baseline survey was conducted by JICA team in the MMIP I and MMIP II areas from June to July 2017. In all the eight barangays, farming is the primary livelihood; however, those villages belonging to LMSA tend to have larger share of non-farmer households. The average cultivated land per household is about 1.52 ha, out of which 1.48 ha is self-owned. Most of the farmers can be categorized as "small scale farmers" with 0.5 - 1.0 ha farmland. For both irrigated/ rain-fed lowlands, the major crops are rice, coconuts, corn, and sugarcane.

2.8 The average farmer household income examined through the baseline survey is Php 120,914, which is lower than the average of Region XII, PhP 198,438, while it is higher than the average of ARMM, PhP 85,514. However, the average income per capita, PhP 22,987, is only slightly higher than the 2015 poverty line of Region XII, PhP 21,025 and that of ARMM, PhP 21,563. There is a clear tendency that farmers in the area with access to water for agricultural use depend much on cropping income, while farmers in the area that is prone to flood damages have diversified their income sources. When compared, female headed households earn less income from cropping, yet more variety in income sources than male headed households.

2.9 "Damage by pest and disease" and "Bad / poor transportation road to market / millers" are the most needed issues to be addressed in farming. When disaggregated, "Unstable Rainfall" and "Occurrence of Floods" should be addressed in the rain-fed agriculture areas, while "Water shortage of irrigation" is the one in the irrigated agriculture area. In this regard, it can be said that the proposed plan has relevance to implement.

2.10 Liguasan marsh is the largest marsh in the Philippines. Its size has been reported to be 220,000 to 288,000 ha with 40 km length and 20 km width along the Pulangi river. The Project area, especially LMSA, is located at a middle part facing north-eastern side of the marsh. Liguasan marsh is a wetland ecosystem, which performs significant ecological functions. For instance, it reduces the impact of flood in the Cotabato river basin and sediment loads carried by the floods are deposited and filtered in it. Plants in the marsh absorb excess nitrogen and phosphorous from sewerage and other pollution causing effluents. The marsh also has a rich biodiversity, and it is known as a home of endemic species of flora and fauna and it provides feeding ground for various migratory birds.

2.11 Liguasan marsh is, for some Lumad people, the place of origin of lives. Not only fauna and flora, but also people are living within the area, and its population as of 2015 could be estimated as almost 582,000 with the population density of as high as 171 persons/km^2. Many people living in the marsh may know how to cope with or utilize the impact of frequent flooding. Inland fisheries activities by utilizing gill-nets are popular livelihoods for the population to catch tilapia, carp, mudfish, freshwater goby, and freshwater shrimp, and so forth. Other than the marsh areas, flat lowland is already used for paddy (palay) cultivation, especially during the dry seasons.

2.12 The production of major crops in Pikit Municipality, covering most areas of MMIP, shows that paddy and maize are the 2 leading crops in the MMIP area, since planted area of the both crops accounts for about two-thirds, 65%, of the total harvested area of the major crops. Fruits and tree crops, mainly coconut, could also be important crops after the 2 leading crops in the area. The 3 major crops, i.e. paddy, maize and coconuts, occupy as much as 87% of the total harvested area in the Municipality.

2.13 The JICA team analyzed satellite images in order to clarify cropping area in the MMIP area. According to the analysis, while cropped area of paddy in LMSA was 511 ha in rainy season and 655 ha in dry season of 2015/2016, that of maize was 1,510 ha and 1,071 ha, respectively. Though lots of farms could be seen in this area on Google Earth, the total cropped area shares only 22% in rainy season and 19% in dry season of the gross area and they are scattered over this area. It is predicted that especially in rainy season, farmers would hesitate to plant crops due to the high frequency of flooding.

2.14 Paddy rice is almost exclusively grown in irrigated areas. Two crops of paddy rice in a year is common cropping pattern in the irrigated areas as is practiced in already completed MMIP areas such as Maridagao Service Area, Upper Malitubog Service Areas (MMIP I) and parts of the Upper Malitubog Service Area developed under MMIP II. Coconuts, banana and vegetables are grown in surrounding areas of the paddy fields even on a border ridge/pass of paddy fields. Since LMSA is still under construction, rain-fed paddy rice and corn are dominant crops in wet season and also grown with residual moisture during dry period when inundation water level downs.

2.15 According to relevant statistical data of various sources, yield of rain-fed rice ranges from 2.0 ton/ha to 3.5 ton/ha and that of irrigated one does from 3.0 ton/ha to 5.63 ton/ha. Besides, the baseline survey conducted by JICA team clarified that they are 1.69 ton/ha and 3.38 ton/ha for the rain-fed paddy (palay) and irrigated paddy respectively, and yield of corn is 2.12 ton/ha. Further, the satellite image analysis conducted by the JICA team revealed that the current crop intensity in LMSA is 72% in rainy season and 47% in dry season. Upon completion of irrigation facilities, farmers can expect higher crop intensity even during dry season.

2.16 Various DA agencies including ATI, universities and colleges have been involved in providing the extension services directly to farmers. In addition, a Yen Loan Technical Assistance (YLTA) was implemented in order to increase productivity of rice in the MMIP project area through enhancement of farming skills and financial management of target Irrigator Associations (IAs). YLTA had 3 major components; namely, 1) Participatory Demonstration Farms, 2) Farm Production Input Assistance, and 3) Development of Extension Modality. On the achievement of YLTA, the productivity of rice in all the selected 7 IAs remarkably increased after the intervention and the average increase was 2.70 ton/ha from 2.93 ton/ha to 5.63 ton/ha.

2.17 The Malitubog-Maridagao Irrigation Project (MMIP) was set out with the technical assistance in the feasibility study conducted from 1985 to 1988, which was financed by ADB. MMIP was divided into two phases: the Phase-I (MMIP I) to irrigate 10,840 ha; and the Phase-II (MMIP II) to irrigate 8,760 ha. MMIP I was commenced in October 1989 with an assistance of Japanese ODA Loan, and the actual construction works was started in April 1993. However, the project was often interrupted due to recurring armed conflicts. Finally, the MMIP I had completed the MSA and a part of UMSA (upstream site) on October 31, 2011. As of April 2017, the net irrigable area for MMIP I is 7,173 ha, with a break-down of 5,562 ha in MSA and 1,611 ha in UMSA (upstream site).

2.18 MMIP II started in January 2011 aiming at generating 9,784 ha of irrigable area in UMSA (downstream site), LMSA and PESA and its target of the total irrigable area was later expanded to the

10,541 ha. As of May 2018, the irrigable area which has been generated since the commencement of the MMIP II arrives at 5,513 ha, namely, about 53% of the MMIP II target. This consists of: 2,958 ha in UMSA (downstream site), 1,567ha in LMSA and 988 ha in PESA. As of May 2018, the total area under operation of MMIP II is 1,478 ha, which is a part of UMSA (downstream side).

2.19 The total lengths of main canal and lateral canals of MMIP II are planned to be 66.8 km and 100.2 km totaling 167.0 km. The total numbers of the canal structures and the turnouts are planned at 207 and 412. For the on-farm development, construction of total 168.85 km of on-farm canals with 1,605 farm structure is planned. Total 323 steel gates are planned for water management purpose. In addition, a total length of 127 km of main and lateral drainage canals together with the total length of 94.18 km of farm drainage canals are also to be constructed. The completion date of the project was originally planned in December 2015, however it was extended to December 2019 as of May 2018. The progress rate of the Project is evaluated at 45.9% on the basis of value of accomplishment and at 40.7% on the basis of actual expenditure.

2.20 Maridagao River Irrigation System (MRIS) Management Office, which is in the Operation & Maintenance Section of Cotabato Irrigation Management Office (CIMO) under the NIA Region XII, has the responsibility of O&M for the irrigation systems such as diversion dam, siphon, main canal and lateral canals in service area of MRIS. The O&M costs for the facilities and day-to-day operation activities are covered under the CIMO’s and MRIS management office’s budgets while the NIA Central Office has a budget framework to finance major maintenance and rehabilitation works as needed. Approved corporate operating budget for MRIS is 6,472,519 Php for personal service (PS) and 3,663,373 Php for maintenance and other operation expenses (MODE) for an average of past 5 years.

2.21 Under MMIP I, there are 12 IAs within the Maridagao Service Area (MSA) and 2 IAs in the Upper Malitubog Service Area (UMSA) upstream site, totaling to 14 IAs. Under UMSA (downstream site) of MMIP II, initially 2 IAs were established and have been operating since 2013. In 2017, another 5 IAs were established and started operation. Further, additional 4 IAs, which has been already registered, will start operation within 2018, and therefore there will be total 11 IAs to be established in the UMSA (downstream site) of MMIP II. For the Pagalungan Service Area, till May 2018, 3 IAs were established and registered, and for LMSA 13 IAs were established and registered to date and another 8 IAs are to be established in the coming years of 2019 – 2020.

2.22 3. FLOOD SIMULATION

3.1 LMSA is a flood prone area and the flood is caused by water spilling over natural leaves and flowing into the hinterland on the right side of the Pulangi river in the rainy season. While in the dry season, permanent water remains only along the Pulangi river and also along the main channels in the left side of the river. In the peak period of rainy season, most of the areas are once covered by water at least one month. However, in the dry season, only several separate pond-like waters remain in such areas deeply depressed. Water extent in 50% recurrence, i.e. return period 2 year, which can be regarded as normal hydrological year, covers 34% of LMSA while leaving 66% as surface land area according to a satellite image analysis (44% water extent in case of maximum inundation).

3.2 Flood protection dike may be considered as a measure to protect LMSA from floods. Two dike alignments are considered; one along the peripheral of LMSA and the other along the right bank of Pulangi river. The latter case option, if dyke should be constructed, is selected due to economical and technical feasibility. While a foundation work is required to stabilize the dike because the basement of the dike is very soft. Finally, sand compaction pile method is selected as a suitable foundation work due to its construction cost advantage. Although the dike works in protecting LMSA from flood, it makes the flood condition of the Liguasan Marsh serious and causes inland inundation within the LMSA by rainfall originating from inside of the dike. Additionally, the dike would act as a physical border dividing the vicinity areas socially and environmentally.

3.3 Dredging of the Pulangi river may be considered as another flood protection measure as it works to increase flow capacity of the Pulangi river while reducing the flood volume spilling over natural leaves. Though dredging works would mitigate flood damages in LMSA and it would not work as a physical border like flood protection dike, it may cause; 1) drying up of parts of the Liguasan marsh, and also 2) change of ecosystem of the Pulangi river, etc.

3.4 As rough assessment of the positive/negative impacts by construction of the flood protection dike and dredging, preliminary examinations are carried out under the three cases in the table below:

Table 3.1 Summary of Simulation Cases (Preliminary Examinations)

Case		Purpose
1	Flood Simulation by Simplified Storage Model	✓ To assess maximum flood discharge, maximum flood water level and maximum inundation area
2	Inland Inundation Simulation by Simple Rainfall-Evaporation Model	✓ To assess the inundation area in the LMSA ✓ To assess the necessity of any drainage facilities
3	Dredging Simulation by the Uniform Flow Calculation	✓ To assess required dredging volume

Source: JICA Survey Team

3.5 On the Flood Simulation by Simplified Storage Model, catchment area at the bottle neck point, at which there is a narrow flow point between two hills near Datu Piang, is taken as a simplified storage reservoir and flood simulation are carried out by employing rational formula in order to assess; 1) maximum flood discharge, 2) maximum flood water level, and 3) maximum inundation area under present condition (i.e. without dike) and after construction of the dike (i.e. with dike). The results of the simulation show that water level after construction of the dike becomes 25cm and 31cm higher than those of the present condition under 30-year and 100-year return period respectively. Additionally, inundation area in the Liguasan marsh is enlarged by around 10% by the construction of the dike.

3.6 Inland Inundation Simulation by Simple Rainfall-Evaporation Model is meant to assess; 1) maximum inundation area of LMSA, 2) maximum inland flood water level of LMSA, and 3) damages on the designed irrigable area by inundation. This is because as LMSA is enclosed by a dike, inland inundation will be occurring originating in rainfall. The results of the simulation show that even in case of 2-year return period, 28.9% of the irrigable area is inundated and about half of the irrigable area is inundated in case of 10- year return period. According to these results, drainage structures should be required to reduce the inundation whereby keeping the beneficiary area. Though pumping stations are considered as a drainage measure, those are not economically feasible due to high initial cost and not technically feasible due to difficulty of the O&M including electricity unavailability.

3.7 Dredging Simulation by the Uniform Flow Calculation is conducted in order to assess the impact of the dredging which may work in mitigating flood damages in and to the LMSA due to its increased capacity of flow of the Pulangi river. As low flow capacity at the bottle neck point is considered as one of the main causes of the floods in and to the LMSA, a cross section formation at this point with enough flow capacity able to mitigate flood damages in and to the LMSA is examined. The results show that; 1) it is possible to mitigate flood damage in LMSA by dredging, however 2) dredging from bottle neck point to river mouths are required and 3) dredging volume becomes 306 MCM, indicating economically not feasible.

3.8 In addition to the simple preliminary examinations above-mentioned and further to assess in detail positive/negative impacts by the construction of the flood protection dike and also by the dredging, unsteady non-uniform flow simulations are carried out under three cases as shown in the table below:

Table 3.2 Simulation Cases for Detail Hydraulic Simulations by Unsteady Non-uniform Analysis

Simulation Cases		Purpose
1	Flood Simulation with/without Dike	✓ Determination of the inundation area and flood water level ✓ Assessment of the impact by the construction of the dike, especially impacts on the Liguasan marsh
2	Inland Inundation Simulation with/without Drainage Structures	✓ Assessment of inland inundation within the LMSA after the dike construction ✓ Examination of the necessary structures to mitigate the inland inundation
3	Flood Simulation with/without Dredging	✓ Assessment of the necessary dredging volume of the Pulangi river to protect the LMSA from the flood. Note that the dredging considers 2 cases; 1) dreading along almost whole stretches of the Pulangi river and 2) dredging or widening of the bottle neck point.

Source: JICA Survey Team

3.9 Flood Simulation with/without Dike is conducted to calculate the change in water level on the Liguasan marsh and the Pulangi river, and also change in terms of inundation area on the Liguasan marsh between with and without dike. After construction of the dike, inundation area on the Liguasan marsh would be expanded by 19% in case of 2-year Return Period (RP) and 34% in case of DPWH design RP, 100-year. In addition, maximum water level on the Marsh would become 79cm and 80cm higher than the case of without dike under 2-year and 100-year RP respectively.

3.10 Further in addition to above, current design height of the dike is based on the past maximum flood water record (flood in 2009), which is EL. 8.01m at the most downstream area of LMSA. According to the simulation result, this height corresponds to the flood of 40-year return period, and the river water level further rises by 50cm in this case as the dike works in reducing the overflow area of the flood. Since the current NIA design does not consider this additional water level rise, it is necessary to have the design height of the dike 50cm higher than the current NIA design, should the dike be constructed. The cost for the modified design is estimated to be approximately Php ([redacted] JPY).

3.11 According to the afore-mentioned preliminary examination, a measure to drain inland water is required but pumping stations are not feasible. In this Inland Inundation Simulation with/without Drainage Structures, sluices are installed as an alternative drainage measure and required numbers of those are assessed. The sluices are of flap-valve type, which stops flood coming into LMSA from the Pulangi river while releases the inland inundation when the water level of Pulangi river is lower than that of LMSA. In the simulation, 2 to 100 sluices, which are 2m height × 2m width each on the ground at EL.4.5m (the lowest elevation of the LMSA), are applied, and the sluices are set at Paidu Pulangi, the most western part of LMSA.

3.12 Inland Inundation Simulation with/without Drainage Structures shows that in case of 2-year return period, 48% of LMSA becomes inundated even if 100 sluices are installed, while 52% would be inundated without sluice. Likewise, in case of the 30-year return period, 71% becomes inundated with 100 sluices while 82% without sluice, indicating that the impact of the sluices is very limited. This is because the water level on the Pulangi river remains higher than the water level in the LMSA during most of the rainy season, unable to drain the inland inundation out to the Pulangi river. In case of 2-year return period, the result shows 30 sluices (50 sluices with 30-year RP) enable the water depth in the LMSA to be nearly zero from December and thus the farmers able to start rice cropping on the whole LMSA. However, in rainy season, almost half of the LMSA is still not possible to cultivate due to the inundation, and also the construction cost is estimated at [redacted] Php ([redacted] JPY).

3.13 In the preliminary examination, dredging formation and its required volume were assessed at the bottle neck point only. To assess dredging formation and its required volume in detail, this Flood

Simulation with/without Dredging is carried out. The simulation indicates that even to mitigate the damage on the LMSA by flood in case of 2-year return period, the required expansion width is as much as 500m all along the target river sections, i.e. from the upstream of LMSA to the bifurcation point of the Pulangi river into Rio Grand Mindanao river and Tamontaka river (total 95 km). In this case, construction cost (direct cost only) is estimated at [redacted] PHP ([redacted] JPY). Since it is only for dredging cost, the cost for the other work items such as dehydration, transportation of the dredged soil, land acquisition for disposal pit and so on are additionally required, indicating not feasible for this dredging.

3.14 According to the above-mentioned results of Flood Simulation with/without Dredging, dredging over as long as approximately 95km is required and its volume and cost are too huge. Meanwhile, low flow capacity of the bottle neck point is one of the reasons to cause flood in/towards LMSA, and therefore it is considered that dredging of only around the bottle neck point, so-called partial dredging, may contribute to mitigating the flood damages to LMSA. Based on the simulation, even in case with 500m expansion of the cross sections around the bottle neck point, flood damage in LMSA cannot be eliminated completely. Of course, a part of beneficiary area which is inundated without dredging becomes dry and possible to cultivate. However, its cost of generating one unit hector of dry land is estimated at [redacted] PhP/ha in the minimum case, which is much higher than [redacted] PhP/ha of the original unit-hector development cost of MMIP II.

3.15 According to a series of flood simulation and dredging simulation, as afore-mentioned, it could be hardly possible to construct the dike because; 1) flood protection dike makes flood condition in the Liguasan marsh serious, 2) flood protection dike leads inland flood originating in rainfall in LMSA, 3) as a drainage measure for the inland flood, pumping stations are not feasible, 4) while sluices could be selected as another drainage measure, 30 sluices are required even to eliminate inland flood in case 2-year return period and its cost come to [redacted] PhP ([redacted] JPY), and further even if 30 sluices are installed, almost the half of the LMSA is inundated during rainy season, 5) for the dredging, even in case of 2-year period, 345MCM dredging with construction cost [redacted] PhP ([redacted] JPY) is required, and 6) effect of partial dredging is also very limited and still costly.

4. DEVELOPMENT DIRECTION AND PROJECT COMPONENTS

4.1 Development Direction

4.1 MMIP II should be designed by learning from the experience of MMIP I. There are five lessons learnt from MMIP I. First, it is important to take necessary measures to avoid the inundation in lower places of the area. Secondly, the land acquisition should be well prepared to settle multiple claimers. Thirdly, the transparency and equitability in the distribution of benefits among beneficiaries should be maintained. Fourthly, responsibilities between NIA and the beneficiary farmers should be set realistic to make sure that on-farm ditches are developed. Lastly, the scale of construction packages should be large enough to attract contractors with enough capacity in order to avoid delays in the works.

4.2 On the other hand, four major impacts generated by MMIP I are recognized by local people. First, increases in the crop production and income of the beneficiary farmers are recognized. Secondly, the access to markets and any other socio-economic services for the farmers and their family members has been improved due to the roads constructed. Thirdly, food security and the sustainability in the farming of farmer beneficiaries have also been improved. Lastly, those people involved in conflicts returned and are now engaged in farming activities as livelihoods, and thus many local people affirmed that the Project (MMIP I) has contributed to maintain peace and order in the area.

4.3 As the afore-mentioned flood simulation revealed, there should be NO dike construction for the purpose of protecting the LMSA from flood. Instead, 2 cases of development of irrigation networks for the LMSA should be explored; i.e. 1) construct the irrigation network up to the peripheral delineated, within which the paddy cultivation can still be managed with allowable inundation depth (Case-1), and 2) construct the irrigation network as originally planned (Case-2). For the latter case, mid-lower parts of the irrigation network will be inundated every year during rainy season, however during dry season full beneficial area could be cultivated, on condition that damaged parts during the flood season are to be well maintained/ repaired.

4.4 In the construction remaining parts of LMSA, main canal (MC 2) and associated lateral canals of the MC 2 and MC 3 (already completed) should be constructed according to the coverage by case afore-mentioned, and main drainage canal and lateral drainage canals should be constructed as per the original plan. The construction of intra-roads, which work as farm-to-market road in order to ship agricultural produces out of the farmlands as well as to facilitate rural population’s mobility especially during rainy season will have to be done. Agriculture development and the extension service delivery should also be addressed so that the beneficiary farmers can well utilize irrigation water, whereby 2 times irrigated paddy cultivation will be established.

4.2 Agriculture and Extension Development

4.5 The Philippine Development Plan 2017-2022 was officially approved by National Economic and Development Authority (NEDA) Board on February 20, 2017. The new strategy applied to the said plan would put more focus on the strengthening of overall farm productivity and profitability on a sustainable basis. With this, corn, rice and coconut are the dominant crops planted in the Project area under the rain-fed agriculture system. As explained in the strategy, two-time cropping of rice in a year is expected in all the irrigated areas developed by the Project. The Project, however, should maintain the existing coconut trees and some other perennial crops.

4.6 On the whole, the growing area and productivity will be remarkably increased by the Project upon completion. The current annual production of rice and corn in LMSA is estimated at 5,354 tons (1,401 for rice and 3,953 for corn) and that in the MMIP II area is 8,559 ton (2,240 for rice and 6,319 for corn). After the completion of the Project, the annual rice production will be increased to 30,541 tons in the Case-1, and to 48,880 tons in the Case-2 in LMSA. The same in the entire MMIP II area will be increased to 67,633 tons in the Case-1 and to 85,972 tons in the Case-2.

4.7 Although 3,688 ha of land in LMSA is expected to be irrigated and planted in the Case-1, the area during the rainy season is to be reduced to 2,810 ha due to inundation, and 1,940 ha of land will be inundated up to 0.5m in the depth. The irrigated rice production would have some damages on its productivity due to flooding. In Case-2 where the canal network is constructed as per the NIA-PMO original plan, due to the significant production in the dry season the production through the year is much larger than that of the Case-1. In order to mitigate reduction of the productivity in the inundated area, submerge-tolerant varieties, such as NSIC RC 222, should firstly be tested on farmer fields.

4.8 To ensure positive outcome and impact of the infrastructure development in terms of farmers production and income, it is recommended that the Project should implement an agriculture and extension development program by ATI and other major stakeholders, consisting of:

- ✓ Technical assistance for irrigated rice production; MMIP II should support ATI in the continuation of the provision of technical assistance by applying the same approach of the Yen Loan Technical Assistance (YLTA) until the remaining part of the MMIP area is covered. This should concentrate on 28 IAs which have neither received supporting services from YLTA nor additional program of GOP.

- ✓ Enhancement of agriculture extension services at the municipal level; the capacity of the LGU extension workers should be strengthened so that they can fulfil their mandate of the provision of agriculture extension services. The activity should provide a step-wise training including technical and on-the-job trainings to Municipal Agriculturist and Agricultural Technologists in Cotabato Province and, Municipality Agriculture Officer and Agricultural Technologists in Maguindanao Province, those who are working at municipality level.

- ✓ Development of seed production; the production of rice seeds within the MMIP area should be further enhanced to meet increasing demand by farmers as the Project goes by. This pursues establishment of community based, meaning IA based, registered or certificated seed production system rather than building large-scale seed center producing foundation seeds.

4.9 In addition to the above-mentioned agriculture and extension development program, MMIP II is also recommended to address crop diversification and agriculture mechanization in order to ensure its positive outcome and impact on farmers. To promote crop diversification, high value and market oriented commodities such as vegetables could be promoted in upland areas, while rice cultivation should prevail in lowlands. In order to initiate crop diversification, the promotion of home gardening with vegetables should be considered, since they can contribute to balanced diet for farm households, and to additional income.

4.10 The agricultural development strategy of the Philippine Development Plan 2017-2022 stresses agricultural mechanization as an important tool to attain improvement of the agricultural productivity. As pre- and post-harvest machineries are required to improve the productivity in the irrigated agriculture, in addition to what were mentioned in above agriculture and extension development program, the Project further recommends to support the machine assembling at the local level and to enhance the knowledge and skills of farmers in the operation and maintenance of agriculture machineries.

4.3 Irrigation and Drainage Development

4.11 The lowland parts of the Lower Malitubog Service Area (LMSA) are inundated during the rainy season. Without dike for flood protection, inundation condition will be the same as the present one. Therefore, the setting of target irrigable area for the LMSA shall be made based on the inundation condition. After that, the project components should be planned based on the irrigable area planned. According to the satellite image analysis, if the dike is not constructed, 44% of LMSA would be inundated. In this case, it is impossible to develop 6,590 ha of all the irrigable area of LMSA, and only 3,688ha (about 56 % of planned irrigable area) could be available for the development. In the target area for the remaining portion from the works of year 2019, only 1,001 ha will be available for the development, while 2,133 ha could have been developed if whole LMSA were to be developed.

4.12 The area to be inundated in the rainy seasons can be irrigated during the dry seasons with the construction of all the planned irrigation canals. In this case, countermeasures of avoiding damages on the irrigation canals from flood are necessary, which could be such works as raising height of canal embankment, slope protection on the slope of embankment and introduction of concrete flume canal at the end portion of lateral canals and on-farm canals instead of the originally planned earthen canal. Accordingly the project cost will be increased and maintenance costs will also be raised. Therefore, the project should select either one from the two cases; namely, Case-1: target area is parts of LMSA with the construction of parts of the irrigation canals, and Case-2: target area is the same as all the LMSA with all the irrigation canals constructed as per the NIA-PMO original design.

4.13 NIA has conducted a survey for the assessment on the impact of the past floods within MMIP whole area in year 2010. In this survey, an interview survey was carried out to the residents of 49 Barangays within the MMIP area to confirm any information of the floods, e.g., frequency of flood occurrence, depth of flood, flooding period, etc., together with the location information by GPS. Based on these survey results, the flooded areas had been categorized in that Lower Malitubog Service Area (LMSA) has the highest record of flooded area with about 5,720 ha equivalent to about 87% inundated. It means that only 870 ha of areas can be said free from flood throughout year.

4.14 However, out of the 5,720 ha area inundated, there are total 2,940 ha of areas with flooded water depth of not more than 50 cm is possibility. This 2,940 ha of area has a potential being the part of target irrigable area since rice is resistant to certain level of flooding. Magnitude of damage of paddy by inundation varies with the timing of inundation, duration and the depth of water. Based on an estimated paddy production loss by inundation (statistic information from Divisional Agriculture and Forestry Economic Bureau) and by taking into account the fact that the planned rice would grow to 100 cm or more at the booting period, the allowable inundation depth could be set at 50 cm in order to prevent the damage mainly in the booting period. Target service area to be developed and irrigable area are set as shown in the table below:

Table 4.1 Target Irrigable Area by Case (Case-1; Partial Development, Case-2: Full Development)

Category	Case-1	Case-2	Remarks
Target Developed Service Area	3,688 ha	6,590 ha	Counted as the dry season irrigable area
Non-submerged area by flood	870 ha	870 ha	Included in the target irrigable area in rainy season
Flooded area of up to 0.5 m	1,940 ha	2,940 ha	Can/should be included in the target irrigable area in rainy season, though this area will be affected by flood.
Area of Non-submerged + Flooded area up to 0.5m	(2,810 ha)	(3,810 ha)	Total target irrigable area in rainy season.
Flooded area of more than 0.5 to 1.0 m	878 ha	2,780 ha	Excluded from the target irrigable area of rainy season.

Source: JICA Survey Team

4.15 The irrigation canal system for LMSA consists of 2 main canals, namely Main Canal No.2 (MC-2) and Main Canal No.3 (MC-3), which are branched at the end of RMC ECT-1, and total 31 lateral canals for the originally designed irrigation area of 6,590 ha. The total length of canals arrives at 107.3 km, divided into about 34.2 km for the main canals and about 84.5 km for lateral canals. The canal lining is planned only for the main canals with concrete lining; while lateral canals are planned to be of earthen canals without lining.

4.16 In case of NO dike construction, all or parts of irrigable areas to be covered by Lateral canal D, D-3, E, F, G, J, K, L, L-1, N, N-2, O, O-1, O-1-1, O-2, and O3 will be inundated during rainy season. Accordingly, those canals mentioned here should be removed totally or partially from the project components under Case-1 where the canal network will be limited only to the areas inundated not more than 0.5m. In this case, the length of main canals will be reduced to 23.0 km from 34.2 km, and the length of lateral canals is to be reduced to 57.8 km from 84.5 km, and thus the total length of canals are to be 69.4 km from the originally designed 107.3 km.

4.17 On the other hand, however, despite whichever case for the canal network establishment is decided by NIA, all the drainage canals should be constructed as per the original design for the sake of improvement of the drainage system in the LMSA. Such improvement on the drainage system will facilitate farmers not only in the irrigated areas free from flooding but also in the inundated areas to start the dry season farming immediately after the rainy season. It is noted that since the elevation of the major part of LMSA is lower than that of flood water level of the Pulangi river, drainage facilities with flap gates should be installed at connection points to the Pulangi river to prevent back-flow of water.

4.18 On Case-2 in which target area covers all the LMSA with the construction of all irrigation canals and all drainage canals, parts of the irrigation canals will be affected by flood every year. Therefore, countermeasures to mitigate damages on the irrigation facilities are necessary. The countermeasures could be such those as; 1) raising height of canal embankment, 2) slope protection on the slope of embankment, 3) concrete lining inside canal and 4) replacement to the concrete flume canal at end portion of lateral canals and field canals from earthen canal.

4.19 In order to compare the irrigation development cost per hector of both cases in LMSA, the direct cost of civil works was estimated. Unit costs of the works required are the same as the unit costs NIA-PMO has applied for the cost estimation in 2018. The total direct construction cost of irrigation development in LMSA comes to [redacted] PHP ([redacted] Japanese yen) in Case-1 whose target area covers only parts of LMSA with the construction of partial irrigation canals and all drainage system, and [redacted] PHP ([redacted] Japanese yen) in Case-2 which target area covers all the LMSA with all irrigation canals and all drainage canals as per the original design.

4.20 In Case-1, an irrigable area of 3,688 ha is to be developed, and therefore the irrigation development cost (direct construction cost only) per hector comes to [redacted] PHP ([redacted] Japanese yen). On the other hand, under Case-2, the irrigable area of originally designed 6,950 ha is to be developed, and therefore, the irrigation development cost (direct cost only) per hector arrives at [redacted] PHP ([redacted] Japanese yen). Unit development cost of Case 1 is higher than that of Case 2 since main canals and lateral canals already constructed or being constructed are already of the size corresponding to those of Case-2 (originally designed ones).

4.21 The Maridagao River Irrigation System (MRIS) Management Office, which is in the Operation & Maintenance Section of Cotabato Irrigation Management Office under the NIA Region XII, has the responsibility in the operation of the irrigation systems and the maintenance of main structures such as diversion dam, siphon, diversion canals, main canals and lateral canals in the Service Areas of MMIP I. Concerning MMIP II area, the service areas under seven IAs in UMSA were already handed over to the MRIS Management Office from the PMO. Thus, after the completion of the project, all irrigation systems and drainage systems will be handed over to MRIS Management Office from the PMO for its operation and maintenance.

4.22 According to the current staffing structure and appointment status of the MRIS Management Office, all the 21 positions were filled as planned. The executing agency has not reported any significant O&M constraints due to shortages in staffing. Routine (day-to-day) and monthly inspections based on pre-set maintenance items are conducted in order to identify probable incidences as early as possible. However, after completion of the project, the Service Area will be expanded up to almost two times of the current service area, and therefore, NIA should increase the staff engaged in the O&M based on the size of service area and work volume.

4.23 The MRIS Management Office has their own machinery for maintenance of irrigation canals and drainage canals including service road. According to the MRIS Management Office, with the existing equipment, they narrowly manage all the necessary repair works and rehabilitation works required in the operation & maintenance of the irrigation system; however, they have difficulties in rehabilitating all the present service roads including the ones within the new irrigation Service Area of 2,206 ha of UMSA. Therefore additional maintenance machinery is necessary such as back-hoe, dozer, track, etc.

4.24 The MRIS Management Office has its own O&M Manual that consists of the following three volumes: Volume I Main System; Volume II Diversion Dam O&M; and Volume III Annexes. Some revisions should be made based on the actual irrigated area, as-built (actual) canal design and irrigation facilities in order to avoid the shortage of irrigation water especially at lower areas by proper operation. In addition, it is important to reduce the excess irrigation water which flows to low ground level areas as drainage water in order to prevent damage by inundation. Therefore, the operation for reducing excess water should also be added to the manual.

4.25 With the development of the irrigation system, the operation and maintenance (O&M) of the facilities are to be another crucial issue to enhance irrigation performance, as well as, to sustain the facilities and ensure the water supply up to the end beneficiaries. The advantages of the IMT are considered as the beneficially-oriented irrigation management and the better cost and human allocation based on the reformation of the government irrigation sector. Farmers are the ones who use the water, conduct irrigated farming, and are directly benefited from the irrigation systems, and also, know the condition and the needs of the terminal irrigation facilities. Frequent minor maintenance by the end water users can reduce necessity of large-scale rehabilitation to be managed by the government.

4.26 Having seen above points, joint irrigation management is recommended as the potential breakthrough in enhancing the irrigation performance upon completion of the MMIP II. According to the IAs already established under MMIP I, average IA coverage area comes to 350 ha with 266 farmer memberships. This size of IAs could be manageable if the structure is stratified starting with TSAGs and then IA. With reference to the total number of TSAGs in Maridagao Service area, 174 in total, and also the 11 IAs in the Maridagao SA, one IA is to have 16 TSAGs.

4.27 In Lower Malitubog Service Area (LMSA), there are 16 laterals in total providing irrigation water to 6,590 ha of area. If there will be 16 IAs assigned to each of the laterals, the average coverage area arrives at 412 ha with 313 memberships, which are in fact bigger than what the farmers seem able to manage. Therefore, big laterals, e.g. Lateral-D, H, O have to be divided into smaller units, e.g. to 2 areas or even 3 areas. NIA-PMO is planning to add additional 5 IAs, and therefore there will be total 21 IAs, whereby a typical average IA is to cover 314 ha with 239 memberships.

4.28 The construction of irrigation canals and facilities under MMIP I was started in 1990 and finished in 2011. Some of the facilities which were constructed at the beginning of the project implementation period have already passed more than 20 years, and there are some damaged facilities which need rehabilitation, e.g. gate operation system for the headworks. The Maridagao River Irrigation System (MRIS) Management Office has a list for the items for rehabilitation/ improvement of the irrigation and drainage systems constructed under the MMIP I, which may be implemented as another project in future.

4.29 NIA PMO hopes to improve the earthen lateral canals to concrete lining canals for the purpose of reducing the work load of maintenance. In addition, if NIA should select the Case-2 in which all the irrigation network is to be constructed as per original plan, targeting whole 6,590 ha of LMSA, the remaining budget would not be sufficient to construct all the remaining components. The countermeasures to reduce the damages on the irrigation canals by flood may have to be canceled. Some drainage canal may have to be canceled too. Downstream portion of some irrigation canals may further be canceled to adjust construction cost within the remaining NEDA approved budget. The cancelled component including improvement may be required as another project in future.

4.4 Distribution Infrastructure Development

4.30 Roads in and around the Project area consist of national road, provincial road, municipal road and Barangay road. In addition to these roads controlled by DPWH and LGUs, there are canal maintenance roads running in parallel with the irrigation canals under NIA. In fact, the canal maintenance roads contribute to facilitating rural mobility as has been observed in the MMIP I area. The MMIP II is to construct access road, or so-called intra-site road, which can work as farm-to-market road to ship out agricultural produces from the farmlands out to major towns, e.g. Pikit, Kabacan, Midsayap, etc. and to the national and provincial roads.

4.31 NIA engineering section provides 4 typical cross sections of canal maintenance road as its NIA's design standard. The roadway width and the shoulder width of each of the cross sections are regulated by the scale of canal, which should vary according to canal design discharge. The large scaled canals need heavy equipment (e.g. back-hoe, long-armed back hoe and dump truck, etc.) for maintenance works, hence the roadway width should be sufficient for the passage of the heavy equipment. Meanwhile, the maintenance works for small scaled canals require small equipment (e.g. mini-back hoe and light truck, etc.) or human power only, so that the roadway width can be narrower than the large scaled one.

- ✓ Canal Design Discharge (Q) > 30 (m3/s): Road width = 7.00m (including shoulder)
- ✓ Canal Design Discharge (Q) = 30 to 10 (m3/s): Road width = 6.00m (including shoulder)
- ✓ Canal Design Discharge (Q) = 10 to 0.3 (m3/s): Road width = 4.00m (including shoulder)
- ✓ Canal Design Discharge (Q) < 0.3 (m3/s): Road width = 3.00m (including shoulder)

4.32 The maintenance works of access roads will be transferred to LGUs upon completion of the Project. Since the road design standards of LGUs have followed the design criteria of DPWH, the design of access roads should be conducted according to the equivalent design criteria. Since the functions of access roads are equivalent to those of farm-to-market roads, they are classified as the farm-to-market roads. The minimum design standards for the farm-to-market road are prescribed in DPWH's Department Order issued in 2014 (Order No.11) as follows:

- ✓ Road Width: Roadway Width (4.00m) + Shoulder Width (1.50m*2) = 7.00m
- ✓ Crossing Gradient: 1.50% (from road center to both side)
- ✓ Thickness of Concrete Pavement: 150mm
- ✓ Thickness of Aggregate Subbase Course: 200mm

4.33 "East to West Access Road" will intersect at 12 irrigation canals and 10 drainage canals. "North to South Access Road-1 & Road-2" will also intersect at 7 drainage canals and irrigation canals. Moreover, these 3 access roads are supposed to intersect at a large number of small scaled farm drains which are extended all over the Project area. The types and materials of the crossing structure will be e.g. concrete slab bridge, steel girder bridge, concrete box culvert, conduit (concrete pipe), etc., which will be determined based on the detailed survey.

5. PROJECT COST AND IMPLEMENTATION ARRANGEMENT

5.1 The MMIP II Project consists of 3 major components; namely, 1) irrigation and drainage development, 2) distribution infrastructure improvement, and 3) agriculture & extension development. The former 2 components should be undertaken by NIA while the last one, agriculture & extension development, is to be conducted by ATI of DA. In addition to those components, there are other related/ associated activities, e.g. Parcellary Mapping/ Survey, Institutional Development Program (IA establishment), Field Support for Supervision and Monitoring, etc.

5.2 Further in addition to above, this Survey recommends such works as; 1) Rehabilitation of MMIP I area (MSA & UMSA), 2) Improvement of MMIP II area (UMSA, LMSA and PESA), and 3) Procurement of machineries (for maintenance) for future works. Right now, there will be no ODA loan assistance, and therefore the remaining works should all be managed/ completed within the NEDA approved budget, so that these additional works are not included in the MMIP II works, and thus recommended as another project, say MMIP III, in future.

5.3 To implement the Project components and sub-components, the best implementation modality should be applied, e.g. direct force account, contractor/ supplier through local competitive bidding, contractor/ supplier through international competitive bidding, direct shopping, etc. One thing noted is that contractors interested in undertaking civil works in very much security concerned areas may be few in the Philippines as have been already experienced under the on-going construction works. With this in mind, the implementation modality for each of the sub-components could be classified as direct force account (DFA), and local competitive bidding (LCB) etc. as in the following table:

Table 5.1 Project Components and Implementation Agency/Modality

No.	Component	Sub-component	Agency	Procurement
1	Irrigation and Drainage Development	1-1. Construction of MC 2	NIA	LCB
		1-2. Construction of Lateral Canals under MC 2		LCB
		1-3. Construction of MDCs		LCB
		1-4. Construction of LDCs		LCB
		1-5. Construction of FAÇADE drain		LCB
		1-6. Flood Protection Works (canal slope protection, etc.)		LCB
		1-7. Urgent Works for MMIP I Area (gates and drainages etc.)		DFA/LCB
2	Distribution Infrastructure Improvement	2-1. Access Road (intra-site road) Construction	NIA	LCB
		2-2. Bridge Construction (along access road)		LCB
3	Agriculture & Extension Development	3-1. Technical Assistance for Irrigated Rice Production	ATI	DFA
		3-2. Enhancement of Agriculture Extension Services at Municipality Level		DFA
		3-3. Development of Seed Production		DFA
4	Other Related Activities	4-1. Parcellary Mapping/ Survey	NIA	DFA
		4-2. Institutional Development Program (IA establishment)		DFA
		4-3. Field Support for Supervision and Monitoring		DFA
		4-4. Project Service Facilities		DFA
		4-5. Detailed Engineering		DFA
		4-6. Other Administrative Works		DFA
MMIP III	In future, to be required	III-1. Rehabilitation of MMIP I Area (MSA & UMSA)	NIA	LCB
		III-2. Improvement of MMIP II Area (UMSA, LMSA and PESA)		LCB
		III-3. Procurement of Maintenance Machineries		ICB/LCB

Source: JICA Survey Team

5.4 .Total period of the implementation is defined by, in general, the biggest component undertaken in the Project in terms of work volume as well as by such activities requiring longer implementation period, e.g. institutional development (IA establishment) and agriculture and extension development. Total implementation period for the remaining works of MMIP II is therefor set at 4 years starting from 2019 onwards with reference to the implementation speed/ progress which have been experienced in the on-going MMIP II construction works.

5.5 On the seasonal implementation plan, construction woks should be conducted from September to the following year's May. Further, most south-eastern part of MC 2 and also canals/ drainages located in southern parts of LMSA will be implemented probably from December to only the following year's March since the construction sites are located along the Pulangi river, and therefore the magnitude of inundation and flooding in these areas could be bigger, resulting in shorter period of construction time. Other supportive works such as IA establishment and parcellary map updating can be done throughout year including agriculture and extension development activities.

5.6 The construction plan of "1) irrigation and drainage development", which is to construct the irrigation and drainage facilities in LMSA, has two options, so-called Case-1 and Case-2. The total project cost of Case-1 arrives at [redacted] PHP ([redacted] JPY), out of which direct cost amounts to [redacted] PHP ([redacted] JPY), and indirect cost amounts to [redacted] PHP ([redacted] JPY) composed of land acquisition, VAT, price escalation and physical contingency. On the other hand, the total project cost of Case-2 arrives at [redacted] PHP ([redacted] JPY), out of which direct cost amounts to [redacted] PHP ([redacted] JPY), and indirect cost shares [redacted] PHP ([redacted] JPY).

Table 5.2 Summary of the Project Cost (Case-1 & Case-2)

Particulars	Project Cost			
	Case-1		Case-2	
	Million PHP	Million JPY	Million PHP	Million JPY
A. Direct Cost				
1. Irrigation and Drainage Development				
1-1. Construction of the MC-2	[redacted]	[redacted]	[redacted]	[redacted]
1-2. Construction of the Lateral under MC-2	[redacted]	[redacted]	[redacted]	[redacted]
1-3. Construction of the Main Drainage (MDC)	[redacted]	[redacted]	[redacted]	[redacted]
1-4. Construction of the Main Drainage (LDC)	[redacted]	[redacted]	[redacted]	[redacted]
1-5. Construction of FAÇADE DRAIN	[redacted]	[redacted]	[redacted]	[redacted]
1-6. Flood Protection Works (canal slope protection, etc.)	[redacted]	[redacted]	[redacted]	[redacted]
1-7. Urgent Works for MMIP I Area				
(1) Supply and delivery of steel gates	[redacted]	[redacted]	[redacted]	[redacted]
(2) Drainage Structures	[redacted]	[redacted]	[redacted]	[redacted]
2. Distribution Infrastructure Improvement				
2-1. Access Road (Intra-site Road) Construction	[redacted]	[redacted]	[redacted]	[redacted]
2-2. Bridge Construction (along Access Road)	[redacted]	[redacted]	[redacted]	[redacted]
3. Agriculture & Extension Development				
3-1. Technical Assistance for Irrigated Rice Production	[redacted]	[redacted]	[redacted]	[redacted]
3-2. Enhancement of Agriculture Extension Services at Municipality Level	[redacted]	[redacted]	[redacted]	[redacted]
3-3. Development of Seed Production	[redacted]	[redacted]	[redacted]	[redacted]
4. Other Related Activities				
4-1. Parcellary Mapping/ Survey				
(1) Parcellary Survey	[redacted]	[redacted]	[redacted]	[redacted]
(2) Construction Survey	[redacted]	[redacted]	[redacted]	[redacted]
4-2. Institutional Development Program (IA establishment)				
(1) On-Farm Development	[redacted]	[redacted]	[redacted]	[redacted]
(2) IA Strengthening/Organizing	[redacted]	[redacted]	[redacted]	[redacted]
4.3. Field Support for Supervision and Monitoring	[redacted]	[redacted]	[redacted]	[redacted]
4-4. Project Service Facilities	[redacted]	[redacted]	[redacted]	[redacted]
4-5. Detailed Engineering	[redacted]	[redacted]	[redacted]	[redacted]
4-6. Other Administrative Works	[redacted]	[redacted]	[redacted]	[redacted]
Total of Direct Cost (A)	[redacted]	[redacted]	[redacted]	[redacted]
B. Indirect Cost				
Land Acquisition	[redacted]	[redacted]	[redacted]	[redacted]
VAT	[redacted]	[redacted]	[redacted]	[redacted]
Price Escalation	[redacted]	[redacted]	[redacted]	[redacted]
Physical Contingency	[redacted]	[redacted]	[redacted]	[redacted]
Total Indirect Cost (B)	[redacted]	[redacted]	[redacted]	[redacted]
Total Project Cost (A) +(B)	[redacted]	[redacted]	[redacted]	[redacted]

Exchange Rate: 2.07 JPY/ PHP, Source: JICA Survey Team

*/ Flood protection works are not considered in the Case-1 since most of the canals are to be constructed within the area less/ least affected by flood while it was well considered in the Case-2 as Case-2 is to construct all the canals as per NIA-PMO original design.

5.7 NIA had started the MMIP II project from the current year of 2011 (CY2011) with estimated total project cost of [redacted] PHP (NEDA approved project cost). Table 5.3 shows the yearly allotment of project cost from CY2011 to as at CY2018, and total allotment of the project cost amounts to [redacted] Php till the end of fiscal year 2018 (December 2018). Therefore, NIA is supposed to complete the remaining works of MMIP II project by using the balance of [redacted] Php.

Table 5.3 MMIP II Project Cost (NIA Estimation)

Construction Year (CY)	Targeted Area	Project Cost (Yearly Allotment)
CY 2011	UMSA	[redacted] PHP
CY 2012	UMSA	[redacted] PHP
CY 2013	UMSA	[redacted] PHP
CY 2014	UMSA	[redacted] PHP
CY 2015	LMSA	[redacted] PHP
	PESA	
CY 2016	LMSA	[redacted] PHP
CY 2017	LMSA	[redacted] PHP
CY 2018	LMSA	[redacted] PHP
	Total (CY2011~2018)	[redacted] PHP
	Overall Cost (NIA Estimation/ NEDA approved cost)	[redacted] PHP
	Balance	[redacted] **PHP**

Source: NIA PMO

5.8 Table 5.4 shows the project cost for the remaining civil works of the MMIP II project area, and the difference between the available remaining budget and the JICA Team's estimation for the both Case-1 and Case-2. The project cost of Case-1 estimated by JICA Team is smaller than that of the NIA's estimation while the cost of Case-2 is more than the available remaining budget. It means that NIA can complete the Case-1 components while NIA cannot undertake Case-2 works unless otherwise there should another additional budget arrangement.

Table 5.4 Estimated Project Cost for Remaining Civil Works in MMIP II Project Area

Basis of Estimation		Project Cost *1 (million PHP)	Ratio	Difference	Remarks
Remaining Budget		[redacted]	[redacted]%	-	Balance of Allotment Budget (see Table 5.4.3)
JICA Team's Estimation	Case-1	[redacted] ([redacted]) *2	[redacted]%	-	NIA Portion (Irrigation & Drainage Facilities) only *3
		[redacted] ([redacted])	[redacted]%	+[redacted] ([redacted]%)	+ Road and Bridge
		[redacted] ([redacted])	[redacted]%	+[redacted] ([redacted]%)	+ Agriculture Component
	Case-2	[redacted] ([redacted])	[redacted]%	-	NIA Portion (Irrigation & Drainage Facilities) only (without Flood Protection Works *3)
		[redacted] ([redacted])	[redacted]%	+[redacted] ([redacted]%)	NIA Portion (Irrigation & Drainage Facilities) only (including Flood Protection Works *4)
		[redacted] ([redacted])	[redacted]%	+[redacted] ([redacted]%)	+ Road and Bridge
		[redacted] ([redacted])	[redacted]%	+[redacted] ([redacted]%)	+ Agriculture Component

*1: Including "Other Related Works" and "Indirect Works (Land Acquisition, VAT, Physical Contingency and Price Escalation)"
*2: shows difference between the cost and the remaining budget.
*3: "Flood Protection Works" are not considered in Case-1
*4: Flood Protection Works: Canal Slope Protection, Concrete Flume Introduction, Sluice Gates Introduction along the Pulangi River etc.

5.9 As afore-mentioned, remaining budget is estimated at [redacted] PHP, and as a matter of fact this budget can cover the required cost of Case-1 only. Also, from the view point of maintenance of the irrigation facilities in the LMSA, Case-1 is much easier than that of Case-2 since the canal network of Case-1 is to be installed within the area less or minimally affected by flooding. Therefore, JICA team recommends NIA central office to go with Case-1 and complete the MMIP II as soon as possible with the remaining available budget. Therefore, should NIA want to complete all the LMSA as originally designed, JICA team recommend to go with step-wise development; first Case-1 investment and then Case-2 investment.

5.10 NIA MMIP II PMO is in charge of the on-going construction works of MMIP II. PMO is directly under Engineering and Operation Sector of the central office. Though the PMO structure is basically similar to that of central office, it is simplified as there are only 2 divisions under the Project Manager; Administrative and Finance Division and Engineering Division. The MMIP II PMO is located in Midsayap, opposite side of the Region XII Office, and there are as of May 30, 2017, [redacted] staff in total composed of [redacted] monthly co-terminous, [redacted] casual employment and [redacted] service/ job contracts.

5.11 In implementing the remaining works of MMIP II, there should be an institutional arrangement, which should of course be established based on the existing on-going organizational set up. To complete the remaining works of MMIP II, setting up of Steering Committee (SC) at the NIA central level, comprising of concerned divisions of NIA and ATI central office, and coordination mechanism with the PMO should be established. This SC/PMO arrangement is proposed basically with reference to that of the on-going MMIP II. The major difference from the on-going arrangement is the inclusion of ATI at the central level since ATI is to be engaged in agriculture and extension development activities to be conducted within the MMIP area.

6. PROJECT EVALUATION

6.1 The MMIP II Service Areas, total 10,536 ha, is composed of Upper Malitubog Service Area (UMSA) and Lower Malitubog Service Area (LMSA). The originally requested ODA target area was the most eastern part of LMSA (2,133ha). Then, the initial target area of this economic analysis was to cover only the eastern part of LMSA since the economic analysis aimed to evaluate the economic validity of the ODA project area requested. However, NIA decided to withdraw the MMIP II project from its proposal to be funded by Japan ODA financing. Therefore, the economic analysis as an ODA project is no longer necessary. Alternatively, the economic analysis should be done on costs and benefits generated from NIA's on-going and planned project. In this respect, the Target Area should be LMSA or the MMIP II Service Area overall.

6.2 In rainy season, parts of the Target Service Area are free from flooding. While other parts of the areas are probably affected by flood. Of them, the expected flooded areas of 0.5 to 1.0 m inundation are out of the target irrigable area in the rainy season. On the other hand, flooded areas of up to 0.5 m could still be considered as a part of target irrigable area, yet the production would be affected by floods. The losses due to this flooding are assumed based on four scenarios; 1) no damage scenario (0% loss in yield; notified as "D00"), 2) partially damaged scenario (30% loss; notified as "D30"), 3) half damaged scenario (50% loss; notified as "D50"), and 4) almost-totally damaged scenario (80% loss; notified as "D80").

6.3 As MMIP II project as a whole, the EIRR performs relatively good; 10.07% as of 30% reduction scenario in Case-1, and 10.73% as of 30% reduction scenario in Case-2. While, considering only the part of LMSA, this case is not economically viable; 6.57% even as of no reduction scenario in Case 1, and 8.19% as of no reduction scenario in Case-2, due to the large unit cost against beneficial area as compared to other areas than that of LMSA. If flooding damages of more than 50% take place in the production in flooded areas of up 0.5 m, the project is not economically viable. For example, 9.68% as of 50% reduction scenario in Case-1 and 9.07% as of 80% reduction case in Case-1 of MMIP II Areas. The result implies that economic efficiency is sensitive to hydrological situation of the sites.

6.4 If one compares "Case-1" and "Case-2", when other conditions are same, EIRRs in Case-2 are always a bit higher than those of Case1's. For example, the EIRRs are 10.07% as of 30% reduction scenario in Case-1 and 10.73% as of 30% scenario in Case-2 of MMIP II areas. These results may suggest that Case-2, in that irrigation canals are to be constructed as per the original design, could be recommendable in term of economic efficiency; however, in this Case-2 much maintenance works should be expected and therefore, NIA should well be prepared for the routine experience maintenance (maintenance cost of Case-2 is estimated at 2 times that of Case-1).

6.5 On the viewpoint of feasibility analysis of NIA, it is better to evaluate MMIP II project overall (namely, “M2” cases). According to the results, the EIRR exceeds 10% of social discount ratio in this Country in both C1-M2-D30 and C2-M2-D30 cases that the Team considers as benchmark cases. Then, the conclusion of economic analysis is that the project is economically viable as MMIP II whole.

6.6 To analyze project impacts on individual farmer’s viewpoints, farm budgetary analysis has been conducted. Upon the project implementation completed, two types of major benefits are to be accrued; 1) the yield increase owing to additional water supply and agriculture extension activities; and 2) the cultivation area increase after adequate irrigation water to be availed. Thanks to these benefits, the potential income increment upon the project implementation completed could be 70% to 89% from the present condition. Since poverty reduction is one of the central agenda of the area, the income improvement should contribute to the regional development as well as to the social unification in the area.

7. ENVIRONMENT AND INDIGENOUS PEOPLE

7.1 Components which need land acquisition are construction of main canal, lateral canals, drainages and access roads (intra-site road). NIA-PMO prioritizes irrigation canal construction, therefore, identification of Project Affected Persons (PAPs) and compensation for damage to crops and structures by canal construction is on-going. However, none of compensation for land loss due to the canal construction has been finished as of July 2018. The reason for this situation is as follows:

- ✓ An evaluation survey of land value was implemented in 2003 to estimate the compensation rates for irrigation facility construction, and it was revealed that actual land price varies from P11.3 - P12.5 per square meter, which is described in "ROW Committee Resolution No. 2003-01". However, determined compensation rates for land loss for paddy field and other crop field were P10.5 and P7.5 per square meter, respectively, which were much less than actual ones. Yet, the amounts are applied as the compensation rates even in 2018, which is not acceptable for the PAPs.
- ✓ Only one person in Upper Malitubog Area has agreed the rates and has been paid, which means that the construction works of canals in MMIP II have been started prior to the compensation payment for land loss. It is noted that any laws in Philippines do not stipulate payment timing of compensation, and such a condition may not be a big issue on the ground level, thus the PAPs are waiting for the compensation for land loss.

7.2 For the purpose of assessment of impacts on ecology in the Liguasan Marsh by the Project, fish survey and bird survey were implemented in and around the Marsh. Identified results are as follows:

- ✓ Ten fish species were identified by the spot-survey while two species were done by the interviews, in other words, 12 species in total were identified. It is unveiled that Oreochromis niloticus (Nile tilapia), Channa striata (Mudfish) and Cyprinus carpio (Common carp) are dominant, especially, the number of Oreochromis niloticus (Nile tilapia) is very big. Regarding Anguilla sp. (Eel), Mesopristes sp (Cross-Barred Grunter) and Mesopristes sp (Cross-Barred Grunter), only one was caught, respectively.
- ✓ With the Project which will not construct the dike, the conditions of Liguasan marsh will not be changed, given that inundated area of the Marsh is seasonally and annually changed drastically

even now. Under such severe condition, the fish have survived so far. The proposed construction works will not cause significant hydrological change, which leads to minor impact on the fish eco-system. However, there is a possibility that excessive fish catch and exotic fish introduction can lead to change of fish eco-system in the marsh, and balanced management is recommended.

✓ In total, 63 bird species were identified by the spot-survey, transect survey and interview to the people in July 2017. Out of identified species by the survey, Haliastur indus (Philippine duck) and Anhinga melanogaster (Oriental darter) are classified endangered species in the IUCN Red List. According to the people interviewed, Philippine duck is rarely observed recently, and they attribute the decline of the bird to hunting. The Project, construction of irrigation canal, drainage and access roads in LMSA is not expected to give a severe damage to habitat of those birds. Rather than the impacts by the Project, hunting of those bird species is probably a bigger issue to be managed, and it is requested to control such illegal activity regardless of the Project.

7.3 Some environmental impacts will be caused by the Project, for instance, air pollution, noise/vibration, traffic jam in construction stage. However, the extent of impacts is not very significant, since the proposed components will not cause dynamic change of hydrological conditions. In operation stage, as there is a possibility of conflict on water distribution, it is needed to promote even water distribution through IA initiative and cooperation with NIA.

7.4 According to results of a survey conducted by National Commission on Indigenous Peoples (NCIP), the population of Indigenous People (IPs) at the national level could be estimated at between 12 and 15 million, constituting almost 10 to 15% of the total population of the Country. The IPs are concentrated in Mindanao sharing as much as 61%. In Mindanao, it has been confirmed the presence of Muslim IPs and other IPs who are neither Muslim nor Christian (called Lumad), in addition to settlers who are mainly Christians and originally from outside Mindanao Island.

7.5 Upon contacted by the Survey Team at the end of May 2017, NCIP decided to take the Field-Based Investigation (FBI) process through its Regional Office in Region XII. The JICA Survey Team has provided technical and financial support through the FBI process. By overlaying the map of the target project site with the maps of two different Ancestral Domains (ADs) which are located nearby, it was revealed that the target project site remains away from the two ADs. Concurrently, the FBI team conducted the actual FBI process on the ground, and prepared the FBI report based on the findings.

7.6 The FBI report concluded that there are no Indigenous Cultural Communities/ Indigenous Peoples present in the area for which originally the ODA Loan was requested, and therefore, it is highly recommended that an irrigation system will be implemented in the area. The report was submitted to the NCIP Regional Director of the Region XII by the leader of the FBI team on July 5 of 2017. Thus, there is no need to prepare an Indigenous Peoples Plan (IPP) to do the construction works for the concerned area within LMSA.

8. GLOBAL ISSUES

8.1 The poverty ratios of Region XII and that of ARMM are very high, especially the ratio of ARMM/ Maguindanao is the highest in the Philippines; almost 3 times higher than that of whole nation, about 48% vs. 16.5% in 2015. There are components which can raise the income of the beneficiaries through the increase of production of agricultural produces; namely, 1) irrigation and drainage development, and 2) agriculture and extension development. For these components, increase of the farm budgets is estimated by comparing the before-after projects, showing approximately an increase of 70 - 89% in the farm budget; thus the Project will contribute to mitigating the poverty of the beneficiaries.

8.2 On the climate change issues, the major component of MMIP II, the irrigation and drainage development, can cope with or at least mitigate such impact of climate change concerning anomalies of the rainfall pattern. The change of the monsoon season could be very much associated with intensive rainfall pattern, meaning the rain tends to fall at once with severer intensity, often resulting in torrential rain and flood, as has been already observed. The component of irrigation and drainage construction would work in mitigating this climate change, rainfall and monsoon season pattern change.

8.3 Men and women share works in farming, and there is a clear division of labors by gender. The criterion applied for the division of labor is the extent, to which physical power is required. On the other hand, food processing to add value to their agricultural produce is done only by women. This criterion is common among farmer households in the Project area, irrespective of their religion. All the major decisions on farming activities are made only by men. Such division of labor by gender and concentration of decision-making power only in men should be considered in the operation and maintenance of the irrigation facilities through the formation and operation of IAs. For example, more female members in the IA board should be included as from the current only 6% to say 30%.

9. CONCLUSION AND RECOMMENDATIONS

This Survey was initiated by a request for ODA loan financing as of January 2017 on the remaining (untouched) areas of MMIP II. However, with recognition not feasible technically and financially to construct protection and ring dykes protecting the Lower Malitubog Service Area (LMSA) from the floods of Pulangi river, NIA as well as the Government of Philippines have decided to withdraw the request and instead push through the MMIP II project on its own government budget. With this decision, the JICA Team summarizes the survey results, as conclusion, given of the following:

1) The flood protection and ring dykes originally designed by NIA-PMO should NOT be constructed from the view point that;

    1.1) As the foundation, on which protection and ring dykes are planned to be constructed, is expected to be very soft, the NIA designed ring dyke having around 7 m height would require consolidation settlement, probably reaching as much as 1.5 m and, in the worst case, would cause potential circular sliding through the foundation if no foundation treatment were to be done. Even if foundation treatment were to be done, such treatment would entail huge construction cost, say approximately [redacted] PHP, which apparently indicates economic non-viability.

    1.2) In addition to above, dikes, if constructed, would give on the Liguasan March such impacts of; 1) enlarging the inundation area by 19% - 34%, and 2) raising water level by 65 – 81 cm depending on the return-period (2, 10, 20, 30, 50 and 100 years) according to the flood simulation. This would cause resettlements of the houses on the left bank of the Pulangi river, or at least should provide a means of raising the floor of the houses. The dikes, if constructed, would thus cause social and environmental issues to the existing natural conditions and also on the people’s life and livelihood.

    1.3) Further in addition, rain falling on the LMSA would cause inland ponding, inundating as much as 50% (80%) of the LMSA during rainy season under 2 (30) - year return period. With 30 nos of drainage sluice gates, each H2m x B2m, at a cost of [redacted] Php, the inundation would be released in November, enabling the dry season paddy cultivation under 2-year return period (50 gates under 30 years return period), yet large portions of the

LMSA, say 50 – 80%, would anyway have to give up the rainy season's cultivation. If drainage pumps were to be installed, even the rainy season paddy could be cultivated; however it would need an additional cost of [redacted] Php under 10 years return period, not economically feasible.

1.4) If dredging were to be tried on the Pulangi river in order to enlarge the flow capacity of the river, namely, mitigating the flood to the LMSA, a scale of 500m expansion of the river almost all along the target sections (94 km) would enable the LMSA almost free from the flooding. However, this measure would require 345 million CUM removal at a huge cost of [redacted] Php for the direct cost only. Besides, partial dredging for only the bottleneck area (13km reach), at which the width of Pulangi river becomes very narrow located at about 6-7 km downstream from the most western part of LMSA, was examined; however, it was revealed that even 500m expansion could have limited effects such as 198 ha, 206 ha, and 339 ha increases of beneficial area under 100-year, 30-year and 2-year return periods, respectively, with huge investments of [redacted] Php, [redacted] Php and [redacted] Php.

2) Without flood protection and ring dykes, there should be two options in terms of developing the canal network of the LMSA as to; 1) Case-1 limiting the canal network within the beneficial area less/least affected by inundation (2,810 ha for rainy season and 3,688 ha during dry season), or 2) Case-2 constructing the canal network as per the NIA-PMO original design (original 6,590 ha cultivable during dry season while only 3,810 ha cultivable for rainy season). This Survey recommends the first option (Case-1) with the following reasons:

2.1) In the case of constructing all the canal network in LMSA as per the NIA-PMO original design (Case-2), there should be at least some flood protection works, e.g. canal slope protection, concrete flume introduction, etc., applied to strengthen the mid-terminal points of the canal network flooded every year. This flood protection works would require an additional direct cost of [redacted] Php at least, which unfortunately would go beyond the originally NEDA approved budget. Further, maintenance cost for the Case-2 will be much higher than that of Case-1, approximately twice higher maintenance cost per unit area than that of Case-1.

2.2) In fact, EIRR showed higher return in the Case-2 than Case-1 as 11.87% vs. 10.90%, 10.73% vs. 10.07%, 10.18% vs. 9.68%, 9.32% vs. 9.07% respectively in the cases of NIL damage for wet season paddy, 30% damage, 50% damage and 80% damage for the whole MMIP II area. These EIRRs are however not much different each other, and thus the JICA Team would recommend the canal network development of Case-1 for which the canals are to be constructed mostly within the less/least flooded area and thus maintenance works would be much easier than that of Case-2. It is also indicated by comparing the maintenance costs of Case-2 and Case-1; the former unit cost per ha being almost double than that of the latter, again indicating easier maintenance works in terms of financial arrangement for the Case-1.

3) Though the JICA team recommends the Case-1 as afore-mentioned, should NIA want to develop all the LMSA with the Case-2 investment, JICA team would recommend a step-wise development, in that anyway NIA should complete MMIP II as early as possible with the Case-1 investment which is manageable within the available remaining budget, and then in future proceed to the Case-2 investment given additional budget.

4) Some of the facilities of MMIP I had been constructed already more than 20 years, requiring certain level of rehabilitation/ repair though lack of budgets has been hindering such rehabilitation works. Especially, gates installed on the headworks are out of order as of 2017,

risking the structural stability during high flood season. NIA should prepare for enough budget to carry out necessary rehabilitation and/or improvement works, which may be named as MMIP III. This MMIP III investment may be combined with Case-2 investment.

5) Concerning environmental consideration, land acquisition is necessary for the Project implementation, however, as discussed in Chapter 7, almost all of the Project Affected Persons (PAPs) have not accepted the proposed compensation rates for the land loss due to their low amounts, which were fixed in 2003 and being applied even at this moment. As a result, the construction works were started and are on-going without payment of compensation for the land loss. It is recommended to negotiate with the PAPs to fix acceptable compensation rates and to finalize the payment.

MAIN
REPORT

CONTENTS

APPENDIXES

ACRONYMS AND ABBREVIATIONS

AERR	ASEAN Emergency Rice Reserve
AFP	Armed Forces of the Philippines
AFTA	ASEAN Free Trade Area
ARMM	Autonomous Region in Muslim Mindanao
ARMMIARC	ARMM Integrated Agriculture Research Center
ATI	Agriculture Training Institute
BDA	Bangsagmoro Development Authority
CFSR	Climate Forecast System Reanalysis
DA	Department of Agriculture
DAR	Department of Agrarian Reform
DBM	Department of Budget and Management
DENR	Department of Environment and Natural Resources
DepED	Department of Education
DOF	Department of Finance
DOH	Department of Health
DPWH	Department of Public Works and Highways
DSWD	Department of Social Welfare and Development
EO	Executive Order
FAO	Food and Agriculture Organization of the United Nations
FAOSTAT	Food and Agriculture Organization of the United Nations Statistics
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GEM Program	Growth with Equity in Mindanao Program
GOP	Government of the Republic of the Philippines
IA	Irrigators' Association
ICC	Investment Coordination Committee
IMT	Irrigation Management Transfer
IRA	Internal Revenue Allotment
ISF	Irrigation Service Fee
J-BIRD	Japan-Bangsamoro Initiatives for Reconstruction and Development
LGPMS	Local Governance Performance Management System
LGSP	Local Government Support Program
LGU	Local Government Unit
LMC	Left Main Canal
LMSA	Lower Malitubog Service Area
MAG	Monitoring Advisory Group
MAG-	MMIP Monitoring and Advisory Group for the MMIP
MAO	Municipal Agricultural Officer
MDC	Main Drainage Canal
MDF	Municipal Development Fund
MDFO	Municipal Development Fund Office
MEDCo	Mindanao Economic Development Council
MILF	Moro Islamic Liberation Front
MMIP	Malitubog-Maridagao Irrigation Project

MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MPDC	Municipal Planning and Development Coordinator
MRDP	Mindanao Rural Development Project
MRIS	Maridagao River Irrigation System
MTPDP	Medium Term Philippine Development Plan
MWG	Mindanao Working Group
NCEP	National Centers for Environmental Prediction, National Weather Service, US
NCIP	National Commission on Indigenous Peoples
NEDA	National Economic Development Authority
NIA	National Irrigation Administration
NIS	National Irrigation System
NPA	New People's Army
NSCB	National Statistical Coordination Board
NWRB	National Water Resources Board
OPAPP	Office of the Presidential Adviser on the Peace Process
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PAO	Provincial Agricultural Officer
PDAP	Philippine Development Assistance Program
PEIS	Philippine Environment Impact Statement
PESA	Pagalungan Extension Service Area
PhilRice	Philippine Rice Research Center
PMC	Project Monitoring Committee
PMO	Project Management Office
PSC	Project Steering Committee
PPDC	Provincial Planning and Development Coordinator
PSA	Philippine Statistics Authority
RMC	Right Main Canal
ROW	Right-of-Way
SEC	Security and Exchange Commission
SEED MalMar	Special Economic Enhancement and Development for MMIP
SEED PIKIT	Special Economic Enhancement and Development for Pikit
STARCM	Support to Agrarian Reform Communities in Central Mindanao
SZOPAD	Special Zone of Peace and Development
TSAG	Turnout Service Area Group
TWG	Technical Working Group
UMSA	Upper Malitubog Service Area
WRFT	Water Resources Facilities Technologist
YLTA	Yen Loan Technical Assistance

UNIT CONVERSION

1 lb (pound)	0.453 592 kg
1 kilogram	2.205 pounds
1 ton (long ton)	2240 pounds
1 metric ton	1000 kilograms
	2204.623 pounds
1 pond	0.4536 kg
1 kg	2.2046 ponds
1 Gallon	4.5461 litre
1 Litre	0.2200 Gallon
1 inch (in.)	2.54 cm
1 feet (ft.)	30.5 cm
1 meter	3.279 feet
1 kilometer	0.621 mile
1 mile	1.601 kilometers
1 acre (ac)	0.40468 ha
1 hectare (ha)	2.471 ac
1 ac-ft	1233.4 cum
1 square kilometer	0.386 sq.mile

CURRENCY EQUIVALENTS（AS AT JUNE 2018）

1 US$	=	108.81 Japanese Yen (TTB)
1 PHP	=	2.07 Yen (TTS)
1 US$	=	52.57 PHP

PHILIPPINES' FINANCIAL YEAR

January 1 to December 31

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 RATIONALE AND GOAL OF THE PROJECT

Submitted herewith is the Final Report prepared for the 'Preparatory Survey on Malitubog Maridagao Irrigation Project Phase II (MMIP II)'. A survey team organized by JICA headquarters commenced a series of field surveys for the Preparatory Survey from the beginning of May 2017, and this report presents major findings of the project area, flood simulation results, identification of potential project components, feasibility study results for the Lower Malitubog Service Area (LMSA) including requested ODA loan target area, environmental and social issues including indigenous people's issues, and conclusion and recommendations. **(It is noted that non-disclose information for 3-year is included in this chapter as procurement by the Philippines government is scheduled.)**

1.1 Rationale of the Survey

The government of the Republic of Philippines has been making efforts for poverty reduction through the implementation of the "Philippine Development Plan 2011-2016". One of the plan's objectives is to achieve economic "Inclusive Growth" by creating jobs including the poor. To this end, the plan aims at addressing governance, social security reform, peace building and security, and so on, and as strategy for the infrastructure development, the plan upholds irrigation development in rural areas. The plan prioritizes improvement of agricultural productivity as well as agricultural income, and as one of the measures to be taken to achieve these priorities, irrigation development is highly counted.

Following the Plan 2011-2016, National Economic and Development Authority (NEDA) Board officially approved the Philippine Development Plan 2017-2022 on February 20, 2017. In this Plan, growth is expected to be more inclusive, where overall poverty rate is targeted to decline from 21.6 percent to 14 percent, and poverty incidence in rural areas to decrease from 30 percent in 2015 to 20 percent in 2022. Thus, the Plan puts priority on the poverty reduction in rural areas, e.g. central Mindanao area where the MMIP II site is located.

The Plan 2017-2022 is founded on three main pillars of: 1) regaining of people's trust, 2) inequality-reducing transformation through increasing opportunities for growth, and 3) increasing of potential growth through sustaining and accelerating economic growth. Under the second pillar, opportunities in agriculture sector are expected to expand. Further, under the three pillars lie four cross-cutting strategies, i.e.: 1) attaining just and lasting peace, 2) ensuring security, public order and safety, 3) accelerating strategic infrastructure development and; 4) ensuring ecological integrity and a clean and healthy environment. In this regard, MMIP I, the foregoing project to MMIP II, is well known to have contributed to the peace and order in that area.

The National Irrigation Administration (NIA), which is the implementing agency of the proposed project, has its six-year plan for the period from 2012 to 2017. According to this plan, the rate of irrigation development in central Mindanao area was as low as 41.7% compared to the national average of 55.6% in the year 2015. In order to address such under-development in irrigation and the challenge of poor maintenance for the existing irrigation facilities, among other challenges, the plan aims at accelerating the development and rehabilitation of irrigation facilities as well as a partial transfer of the O&M responsibilities of National Irrigation Systems (NISs) from NIA to Irrigators Associations (IAs).

The project site for the MMIP II has not been yet socio-economically developed enough and the poverty rate in the area is still high. The agricultural production is low in spite of its potential being high, and thus improvement on irrigation facilities and agricultural productivity is an important development issue in the area. Based on these circumstances, it is expected that MMIP II will contribute to poverty reduction and long-lasting peace of this area. MMIP II could benefit the population of this area, who has been exhausted by a long-term conflict, by bringing about a comprehensive economic development and an improvement on basic living standards through the irrigation development, hence, the MMIP II should be implemented as early as possible, and accordingly this Preparatory Survey is commenced.

1.2 Purpose of and Outputs from the Survey

The purpose of this Preparatory Survey is to formulate a sound project for its implementation of the MMIP II, towards which the Team is to review all the existing data or information and to carry out necessary studies and field surveys. The results of the studies and field surveys are to be utilized to plan and propose the implementation of MMIP II including possible funding from the Japanese ODA Loan, as requested by the government of the Republic of the Philippines (GOP).

As mentioned above, this Survey was initiated by a request for Japanese ODA loan funding to the LMSA, or to a part of the LMSA as MMIP II has been undergoing since year 2011. However, it is noted that flood simulation undertaken in this Survey revealed that dyke construction surrounding the LMSA for the purpose of protecting the area from flood coming from Pulangi river is not feasible (refer to Chapter 3 for detail). With this outcome in which dyke should not be constructed, NIA has recognized that the current NEDA approved budget could be enough to complete the remaining part of the MMIP II.

NIA issued letter to Department of Finance on May 22, 2018 stating that NIA would intend to withdraw its proposal for the funding of MMIP II through the Japan ODA financing as NIA believes that the remaining balance is too inconsequential for it to be funded by ODA loan. Following this NIA's action, government officials of the Philippines raised during a Japan-Philippines Economic Cooperation Infrastructure Joint Meeting held on June 21, 2018 that the GOP withdraws the ODA loan request for the MMIP II. With this withdrawal, this Survey places priority more on its feasibility and sound development plan formulation of the LMSA.

The outputs of the Survey are thus the recommendations of the project components, and investment scale of the MMIP II with feasibility evaluation, including measures against flooding. The Survey is therefore to investigate and analyze the different aspects of the project and consolidate the results in form of a project implementation plan taking into account the impact of Pulangi river flooding. Those aspects to be addressed by the Survey are: 1) methodologies and contents of the procurement and construction; 2) project costs; 3) organizational arrangement in executing the project; 4) institutional arrangements for operation, maintenance and management; 5) indicators to measure effect of the project operation; and 6) major issues to be examined for environmental and social considerations.

1.3 Contents of the Official Request and Scope of the Works

MMIP II is to undertake irrigation development as its major component. By tapping water through the headworks constructed at the Maridagao river during the MMIP I, it was planned to irrigate 10,541 ha of beneficiary farms, composed of 2,550 ha in Upper Malitubog Service Area (UMSA), 6,849 ha in LMSA, and 1,142 ha in Pagalungan Extension Service Area (PESA) once MMIP II is completed. Of them, the originally requested area for the possible ODA loan financing is located within the service area of Lower Malitubog; namely, only 3,581 ha was requested for the ODA loan financing out of the total LMSA of 6,849 ha (see Table 1.3.1):

Table 1.3.1 Project Area for MMIP II (as of January 26, 2017)

Site	Total Service Area (ha)	Area covered by Local Funds (ha)	Proposed Area for ODA Financing (ha)
Upper Malitubog Service Area	2,550	2,550	-
Lower Malitubog Service Area	**6,849**	**3,268**	**3,581**
Pagalungan Extension Service Area	1,142	1,142	-
Total MMIP II Area	10,541	6,960	3,581

Source: Explanatory Letter issued to Chief Representative of JICA Philippines by NIA Administrator (dated January 26, 2017)

Note: The Irrigated area indicated by the official request letter dated October 19, 2016 was 9,784 ha and it was increased in the NIA Letter issued on January 26, 2017.

According to an official letter issued to JICA Philippines Office from the NIA administrator on January 26, 2017, the total project cost for the MMIP II is estimated at PhP [redacted] (equivalent to almost [redacted] Yen). Out of the total cost, PhP [redacted] (about [redacted] Yen, with which 3,581 ha will be benefitted) is requested to invest by the possible ODA loan financing, while the balance PhP [redacted] (about [redacted] Yen, with which 6,960 ha will be benefitted) is to be invested by the government of the Republic of Philippines (see Table 1.3.1 and Table 1.3.2):

Table 1.3.2 Proposed Project Cost Breakdown (as of January 26, 2017)

Particulars	Total Project Cost (M PhP)	Cost proposed for ODA Financing (M PhP)	Cost proposed for ODA Financing (M Yen)
I. Direct Cost			
a. Civil Works			
1. Upper Malitubog Area	[redacted]		
2. Lower Malitubog Area	[redacted]	[redacted]	[redacted]
3. Pagalungan Ext. Area	[redacted]		
Sub Total (Direct, Civil)	[redacted]	[redacted]	[redacted]
b. Social Preparation	[redacted]		
c. Institutional Dev. Program	[redacted]	[redacted]	[redacted]
d. Procurement of Service Vehicle	[redacted]		
e. Right of Way Acquisition	[redacted]	[redacted]	[redacted]
f. Project Service Facilities	[redacted]	[redacted]	[redacted]
g. Detailed Engineering	[redacted]		
h. Parcellary Mapping Survey	[redacted]	[redacted]	[redacted]
i. Filed Support for Supervision & Monitoring	[redacted]	[redacted]	[redacted]
Sub Total (Direct, Others)	[redacted]	[redacted]	[redacted]
Sub Total (Direct)	[redacted]	[redacted]	[redacted]
II. Indirect Cost			
j. Management Fee (5%)	[redacted]		
k. GESA, 1/	[redacted]		
l. Price Contingency	[redacted]	[redacted]	[redacted]
Sub Total (Indirect)	[redacted]	[redacted]	[redacted]
Total Project Cost	[redacted]	[redacted]	[redacted]

Source: Explanatory in the Yen amount (as the JICA official rate of May, 2017)

Note: 1/ GESA, means for 'General Engineering Supervision and Administration'.

The total beneficiary area for MMIP II includes those where the planned civil works have been already completed or under implementation with funding from the GOP. The Survey is therefore, firstly, to define the actual area where civil works are still for implementation after 2018, by obtaining the information on the civil works that were already completed, and those that are being constructed which will be also carried out for funding in the future by the Philippine government.

Concerning the area to be developed with possible ODA loan financing, in fact, it was noted that though 3,581 ha was requested to JICA, NIA had already started tendering on the western part of LMSA by its own fund in late May 2017. Therefore, the actual service area which was originally required for Japanese ODA loan, was reduced covering probably only the eastern part of LMSA.

Though the request for the ODA loan financing was only for civil works with some appurtenant activities, there may be needs of implementing such additional works such as rehabilitation of already constructed facilities, support for farming, procurement of machineries for maintenance works, and also consulting services. With these in mind, the scope of MMIP II may have to cover the following areas:

Table 1.3.3 Potential Scopes of MMIP II for Possible ODA Loan Financing

Potential Scope	Contents
Development of the irrigation and drainage facilities in Lower Malitubog Service Area (3,581 ha requested)	To plan the development and rehabilitation of irrigation facilities in the target area. Note that though 3,581 ha was requested to JICA, in fact at the beginning of May 2017, NIA has already started tendering on the western part of Lower Malitubog service area by its own fund. Therefore, the actual service area to be funded by Japanese loan will be reduced, covering only eastern part of LMSA.
Rehabilitation of the existing irrigation facilities, which were developed by the project either in the MMIP I or in the early stage of MMIP II	To develop the rehabilitation or improvement plan based on the current situation of the already constructed facilities by the project in the total beneficiary area, irrespective of the project phase. Note that there are already damaged and/or dilapidated facilities which need rehabilitation or improvement.
Support for farming	To develop agriculture development support program/ activities for the total beneficiary area of the project. It is noted that though NIA does not directly undertake agriculture extension services, this activity of supporting farming is very essential since the beneficiary farmers are not used to irrigated farming. Therefore, supporting for faming should be one of scope, undertaken by ATI, PhilRice, or any other organizations.
Procurement of maintenance machineries	To plan procurement of machineries to be required for maintaining the irrigation facilities which, in fact, cover a total area of approximately 18,000 ha composed of both MMIP I and MMIP II. NIA regional office and NIA Cotabato Irrigation Management office do not have any equipment for maintaining the irrigation system, whereby a set of machineries should be procured for the purpose of sound maintenance.
Consulting service	To develop the plan of consulting services to be required for civil works and other “soft” components such as institutional development, e.g. IA establishment, procurement, support for farming, etc.

Source: JICA Survey Team

1.4 Schedule of the Survey

To attain the objective, the Survey was carried out in a step-wise manner divided into two: the first part deals mainly with situation analysis, identification of project scope, and formulation of preliminary project proposal, and the second part undertakes through the discussions with the relevant organizations and additional field surveys, the finalization of the project plan including project design, project evaluation, implementation arrangement, etc. Note that environmental and social consideration are, of course, undertaken in the former part, and additional surveys are to be conducted during the latter part of the Survey including, as per the need, preparation of Resettlement Action Plan (RAP) and Indigenous Peoples Plan (IPP).

The original survey period was set to complete within 6 months from May 2017 to October 2017 provided that significant environmental and social issues are not foreseen. The environmental category for the MMIP II is type ‘B’ as of the survey commencement; however, if the category is to be changed to ‘A’ which is expected to give noticeable impact on the environment and/or social conditions, additional surveys should be required and hence the survey period shall be extended accordingly. Additional surveys, here expected, are for example preparation of resettlement action plan, preparation of indigenous peoples plan, among others.

Though the original survey period was 6 months as above-mentioned, a martial law was enforced in the whole of Mindanao on May 23, 2017 by a proclamation No. 216 issued by Philippine President Rodrigo Duterte. The martial law was extended on July 23, 2017 valid until December 31, 2017. Then, the martial law was further extended until the end of year 2018. Due to this martial law, field surveys for the Preparatory Survey were suspended in late May 2017, and the JICA team has been unable to go back to the project area to date.

During the suspension, a new task which is flood simulation for Pulangi river was added in order to explore the impact of flooding of Pulangi river to the LMSA. The JICA Team had conducted river survey, longitudinal and cross-sectional surveys, and accordingly the flood simulation from September 2017 to March 2018. With this additional task, the survey period was extended to October 2018. On the way of the extended survey period, 1st interim report was produced at mid July 2017 summarizing the draft project proposal, and the 2nd interim report is presented in Mid July 2018, and then draft final report will be submitted at around August 2018, and its final version is to be produced at around October 2018 (see the table below).

Table 1.4.1 Overall Survey Schedule

Year/ Month	2017									2018									
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
Stage 1 Draft f Project Proposal																			
Flood Simulation																			
Stage 2 Finalization of Project																			
Report		ICR		ITR1								SR				ITR2	DFR		FR

Where; IC/R: Inception Report, ITR: Interim Report, SR: Flood Siulation Report, DFR: Draft Final Report, FR: Final Report

1.5 The Survey Area

MMIP is located in the municipalities of Aleosan, Pikit and Carmen in Cotabato province, and municipality of Pagalungan and Datu Montawal in Maguindanao province. MMIP is implemented in two phases, the Phase I (MMIP I) was envisioned to generate irrigation facilities on 10,840 hectares while the remaining area of 8,760 hectares for Phase II (MMIP II) was planned to commence upon the completion of MMIP I.

Despite of difficulties of project implementation in conflict area, MMIP I concluded and turned-over completed facilities of 5,562 ha in MSA and 1,611 ha of UMSA. These two areas declared the formal turn-over to Regional Office XII effective on October 31, 2011 after the completion of additional improvement works. On the other hand, the MMIP II area is composed of 3 service areas; 1) UMSA, 2) PESA, and LMSA, and the construction work of MMIP II was started in 2011.

The construction of MMIP II was commenced from the service area of Upper Malitubog in 2011, and till today construction of PESA and LMSA are on-going including the mid-eastern part which was started in 2015, central part in 2016, and whole western part with a bit of most north-eastern part which started in 2017.

Southeastern part is left untouched and is where the main survey area for the originally requested ODA loan funding. Note that the request of NIA included the most western part and the most south-eastern part of

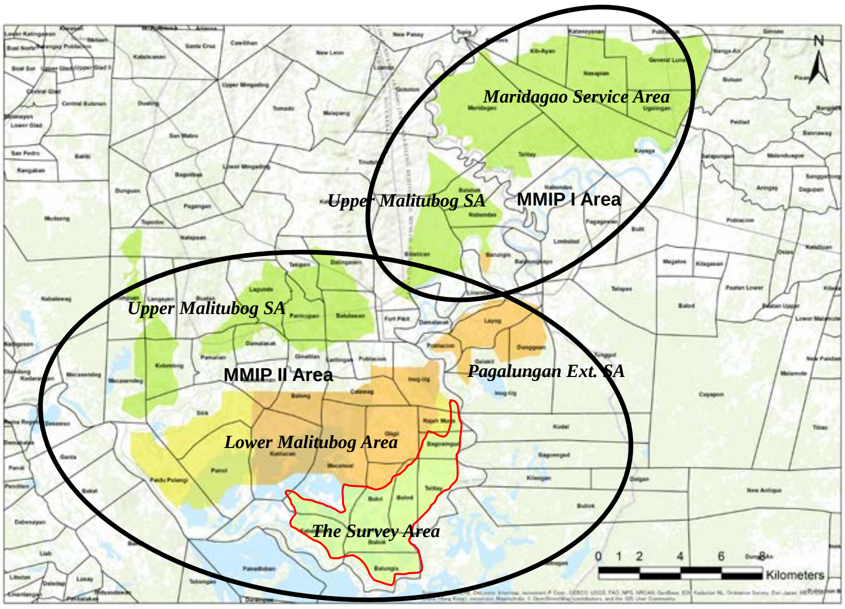


Figure 1.5.1 MMIP Service Area and the Major Survey Area

Source: MMIP II PMO, JICA Survey Team

Lower Malitubog Service Area; however, the works in the former part was starting as of July 2017. The untouched area covers approximately 2,100 ha, and the works possibly funded by loan may, aside from the establishment of irrigation network in that untouched area, include access road construction, ring dyke construction along the southern most boundary of the LMSA.

1.6 Implementation Arrangement of the Survey

The chart below shows the working structure for the Preparatory Survey. NIA MMIP Project Management Office (PMO) is the executing agency, and therefore was the main counterpart organization to the Survey. In addition, NIA Region XII office and NIA Cotabato Irrigation Management Office are support offices from which relevant data & information were furnished concerning irrigation operation & maintenance. The Team members worked with these counterpart personnel from the executing agencies in coordination with JICA headquarters and JICA Philippines office. Relevant organizations are also shown, to which the Survey Team gathered information and collected data.

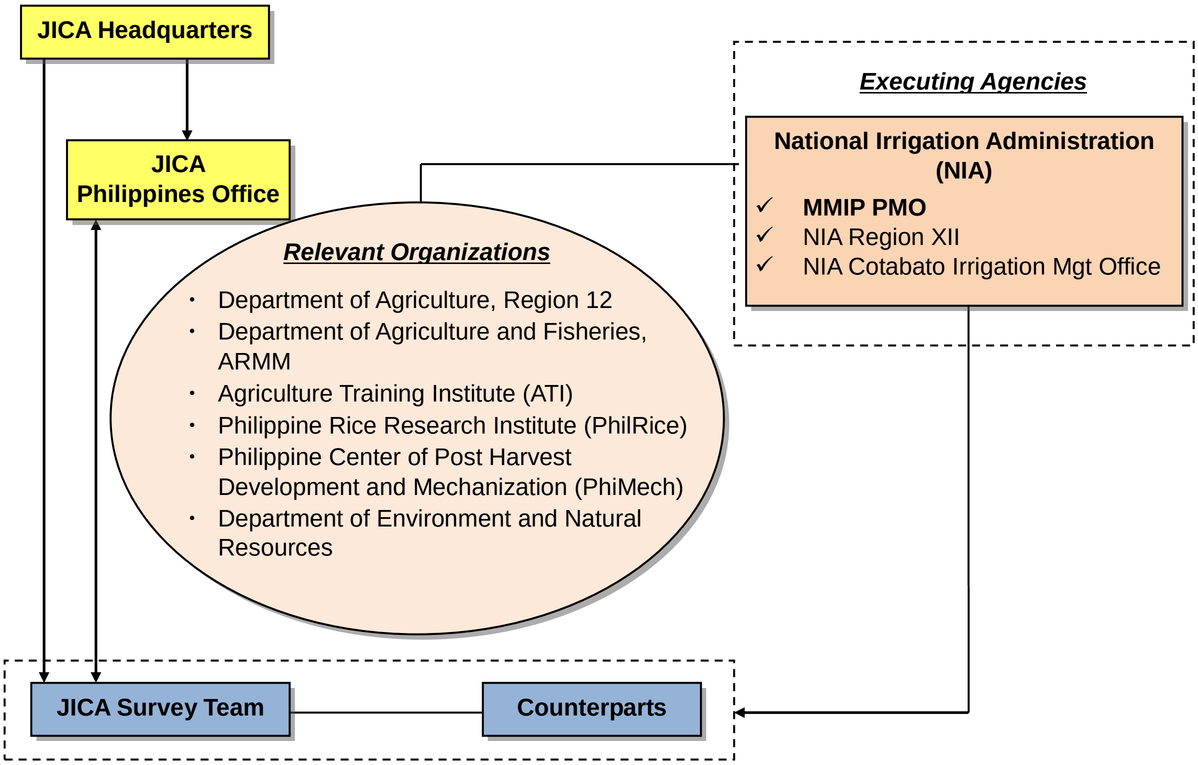


Figure 1.6.1 Working Structure for the Preparatory Survey

Source: JICA Survey Team

CHAPTER 2 THE PROJECT AREA

The Project, Malitubog Maridagao Irrigation Project (MMIP) is composed of MMIP I and MMIP II, which are located in parts of 5 municipalities of Carmen, Kabacan, Pikit, Datu Montawal and Pagalungan. The first 3 municipalities fall in Cotabato province while the latter 2 municipalities in Maguindanao province (ARMM). The JICA survey team interviewed relevant government offices, such as NIA PMO and local government units (municipalities). Further, the team conducted surveys to barangays, villagers, etc. to grasp current situation. In this chapter, the current condition of the Project area is discussed based on those interviews and surveys: **(It is noted that non-disclose information for 3-year is included in this chapter as procurement by the Philippines government is scheduled.)**

2.1 Salient Features of the Project Area

2.1.1 Spatial Settings and Contextual Positioning

The Project area of MMIP starts at the diversion point established on the Maridagao River with coordinates of 7°11'49" N and 124°43'08" E, located in Municipality of Carmen, Province of Cotabato. The diversion dam, a headworks, provides water to the Maridagao Service Area (MMIP I) extending on the left bank side of the Maridagao river, and then after crossing the river with a siphon, it further irrigates the Upper Malitubog Service Area (upstream) now extending on the right side of Maridagao river. Both Maridagao Service Area and the Upper Malitubog Service Area (upstream) were established under MMIP I.

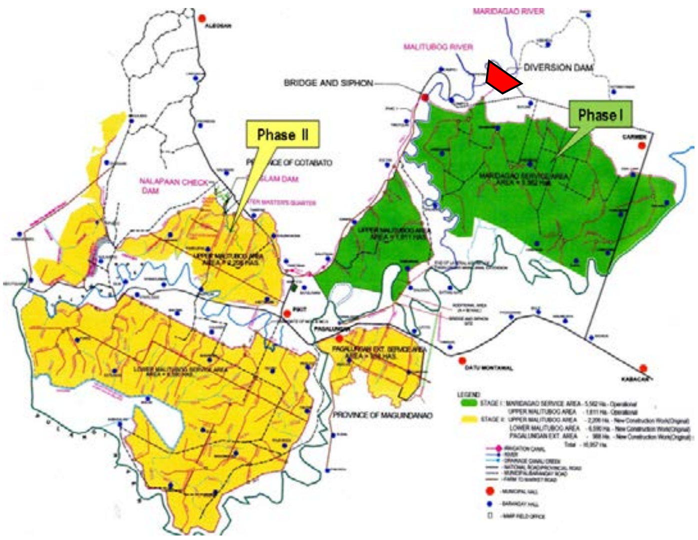


Figure 2.1.1 Project Map of MMIP I and MMIP II
Source: NIA- PMO

After the Upper Malitubog Service Area (UMSA) under MMIP I, the irrigation water is further delivered to 3 blocks which are all placed under MMIP II construction works; namely, 1) Upper Malitubog Service Area (downstream UMSA), 2) Pagalungan Extension Service Area (PESA) and 3) Lower Malitubog Service Area (LMSA). The most downstream area of MMIP is therefore located in the most southern part of the irrigable area with coordinates of 6°57'8" N and 124°40'01" E. Thus, from north to south direction, the MMIP area extends over a distance of approximately 27 km while it extends over about 30 km length from west to east direction. Concerning the elevation, the diversion point indicates 35 m as top bank elevation[1] while the most downstream point shows almost 0 meter altitude.

The Project site falls in the 2nd biggest basin in the Philippines, Mindanao river basin, which has as large area as 21,530 sq.km, and in fact it is located at the vicinity of, and partly within, a large mash, so-called Liguasan marsh (see Figure 2.1.2). Liguasan marsh occupies an area of approximately 80,000 ha[2] and the area including the surrounding ones may reach as huge area as 280,000 ha[3].

[1] The design flow level at the diversion point is 32.50 AMSL, and normal operation water level is 31.00 AMSL. Intake upper water level is 31.00 AMSL and intake mean water level is 30.08 AMSL. Intake maximum discharge is set at 35.6 cum/s.

[2] 'Liguasan marsh development master plan, November 1998.

Therefore, the project area, especially the southern parts of it, is very prone to flood taking place almost every year along the Pulangi River, a big tributary of Mindanao River.

2.1.2 History of MMIP Development

The implementation of MMIP I was commenced in April 1993. However, the construction of MMIP I had undergone very difficult situations which caused the death of more than 200 combatants, thousands of displaced families, and millions of lost personal belongings and properties, and resulted in periodical stoppages of the works. Despite those difficulties, the MMIP I had finally been completed and the project handed over the completed areas of MSA (5,562 ha) and UMSA (upstream, 1,611 ha) to the Regional Office XII on October 31, 2011. It took more than 17 years since the commencement till the completion for the MMIP I.

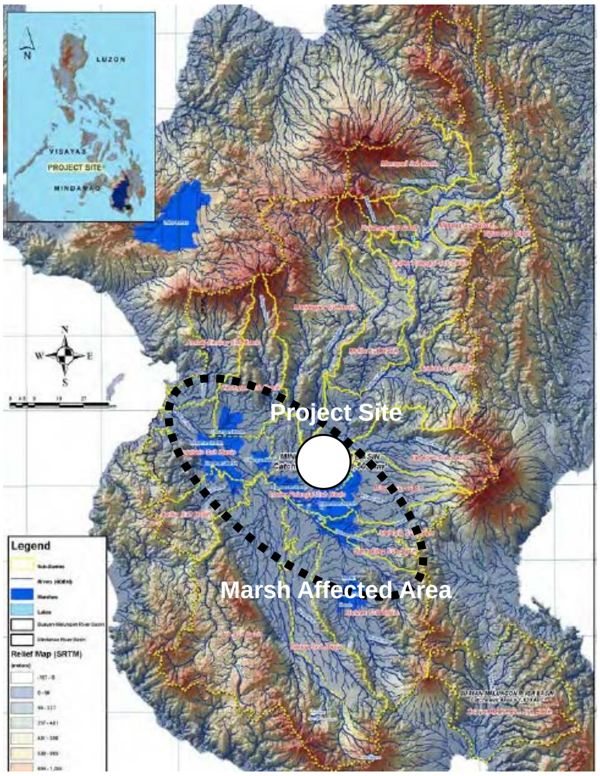


Figure 2.1.2 Project Site and Marsh Affected Area
Source: Mindanao River Basin MP, JICA Team

The contract for the construction of diversion dam, wing dikes, diversion canal, left main canal, bridge and siphon was procured through International Competitive Bidding (ICB), and it was awarded to Shinsung Corporation, a Korean firm. The contract package had the duration of 1,320 calendar days with the contract expiry date on November 14, 1996.

In the course of the implementation, the Korean firm had encountered several challenges. Among them, peace and order problem in particular was really beyond the control of NIA-PMO and the Korean firm. Due to unstable peace and order within the project area in the years 1994 to 1995, and in spite of several attempts of both NIA and the Korean firm to resume the work, the contract was terminated on April 27, 1995 by mutual agreement. All the construction works for the contract package MMIP I-C-1 were therefore suspended with only 17.4% cumulative accomplishment upon the termination.

The Department of Agriculture through the initiatives of NIA on March 24, 1997 sent a letter to the Ambassador of Japan to the Philippines to request for assistance in the project resumption with the information on the peace agreement (General Cessation of Hostilities) between GOP and MILF. Finally, on May 18, 1998, the Government of Japan (GOJ) through its embassy gave GOP the go-signal to resume works of the project. On December 7, 1999, the bidding for the remaining works was successfully conducted and China Electric Power Technology Import & Export Corporation (CETIC) was awarded. The work by the Chinese company was completed in September 2001.

After the completion of the works by the Chinese company, force account and local contractor works had been progressed and consultant also had been engaged till April 2003 in order to supervise the force account works. Even after the closure of the Yen loan for MMIP I in May 2003, after an extension, force account works with local contractor works had continued being implemented till 2011, during which the Upper Malitubog Service Area, 1,611 ha[4], was completed with the GOP fund.

[3] BirdLife International (2017) Important Bird Areas factsheet: Liguasan marsh.

[4] The original plan of MMIP I was to construct 2 blocks of Upper Malitubog Services Areas, however due to

In the same year 2011, when MMIP I had been completed, MMIP II was started with the construction of UMSA with the GOP's own budget. The construction of the UMSA had continued till 2014, and new construction was started in 2015 undertaking Pagalungan Extension Service Area as well as a mid-eastern part of the LMSA. Further in 2016, construction in the central part of the LMSA was commenced, and in 2017 the most western part of the LMSA was placed in bidding, and expected to start the construction within the year.

With respect to the cost of MMIP I, the original cost was PhP1.05-billion with scheduled project completion on December 1996. First project cost increase was approved amounting to PhP2.5-billion and extended the project to December 2002. With further additional cost of approximately PhP600-million, the project actual expenditures as of June 30, 2006 arrived at PhP3,103.35-million. However, as there were additional and improvement works needed to be done, an amount of PhP79.99-million was incurred until December 2010, hence total project cost for MMIP I amounted to PhP3,183.34-million. In terms of Yen, total expenditure amounted at 8.43 billion Yen, of which 4.541 billion Yen was disbursed by the ODA loan.

Table 2.1.1 Actual Expenditure for the MMIP I

Breakdown of Cost (Fiscal Year)	Foreign		Local		Total	
	Total Cost	OECF	Total Cost	OECF	Total Cost	OECF
	(in million yen)		(in million pesos)		(in million yen)	
1990	0	0	10		59	0
1991	121	121	7		156	121
1992	508	508	14		577	508
1993	512	512	29		632	512
1994	312	312	51		510	312
1995	112	112	42		271	112
1996	55	55	28		161	55
1997	115	115	43		290	115
1998	327	327	63		544	327
1999	12	12	114		344	12
2000	413	413	114		691	413
2001	769	769	216		1,303	769
2002	716	716	375		1,624	716
2003	569	569	124		834	569
2004			230.11		230	
2005			121.30		121.30	
2006						
2007						
2008			36.43		36.43	
2009			33.56		33.56	
2010			10		10	
2011			100			
Total	**4,541**	**4,541**	**1,761.30**		**8,427.4**	**4,541**

Source: Project Completion Report, MMIP, Stage I, November 2014

For the MMIP II, the NEDA-ICC approved project cost is PhP5,444.84-million, which started to flow in year 2011 with [redacted] allotment. Till the end 2016, total PhP[redacted] had been allotted, of which PhP[redacted] had been released to the PMO, and further out of the released budget, PhP[redacted] has been actually expensed. According to NIA original plan, construction by the government own budget will continue till 2018 with PhP[redacted] allotment per year, and thereafter loan was expected to use for the remaining works (note that as of June 2018, loan request was withdrawn).

fund shortage by the Philippine government, only the upstream UMSA, 1,611 ha, was undertaken by MMIP I and the remaining part was pushed to the MMIP II, which had started in 2011.

2.1.3 Area, Population and Beneficiaries of MMIP II

As mentioned above, the MMIP is composed of MMIP I and MMIP II, and further the MMIP I area is composed of 2 irrigation blocks while the MMIP II consists of total 3 irrigation blocks. The irrigable area of MMIP I comes to 7,173 ha while that of MMIP II arrives at 10,536 ha, totaling to 17,709 ha. It is noted that the area is basically defined as net irrigable area; however, there are coconut tree farms within the irrigable area. Coconut farmers seldom, or at least within a short period of time, do not change the coconut farm to crop farmland. Therefore, actual net irrigable area for crops should be the following area less coconut farmland area.

Table 2.1.2 Summary of the Irrigation Service Area

Project	Irrigation Block	Service Area, ha	Construction
MMIP I	Maridagao Service Area	5,562	2011 completed
	Upper Malitubog Area (upstream)	1,611	2011 completed
Sub-total		7,173	
MMIP II	Upper Malitubog Area (downstream)	2,206	Commenced in 2011
	Pagalungan Extension Service Area	988	Commenced in 2015
	Lower Malitubog Service Area	6,590	Commenced in 2015
Sub-total		10,536	
Total		**17,709**	

Source: NIA-PMO, MMIP II

MMIP II area is further categorized by the commencement year of the construction. The construction of UMSA was firstly commenced in 2011 (see brown colored part), followed by the construction of extension service area in 2013 (yellow part), and lastly the construction was started in 2013 in the eastern part (light blue color). Then, in 2015 the construction progressed to the PESA as well as to the eastern part of LMSA (light green colored parts). The construction further progressed to, e.g., the central part of LMSA in 2016, the most western part of LMSA in 2017. As of May 2017, the bidding was already held for the most western part of LMSA, whereby the untouched part is only the south-eastern part of the LMSA as of May 2017 (see light blue colored part; a part of areas originally requested for ODA loan funding).

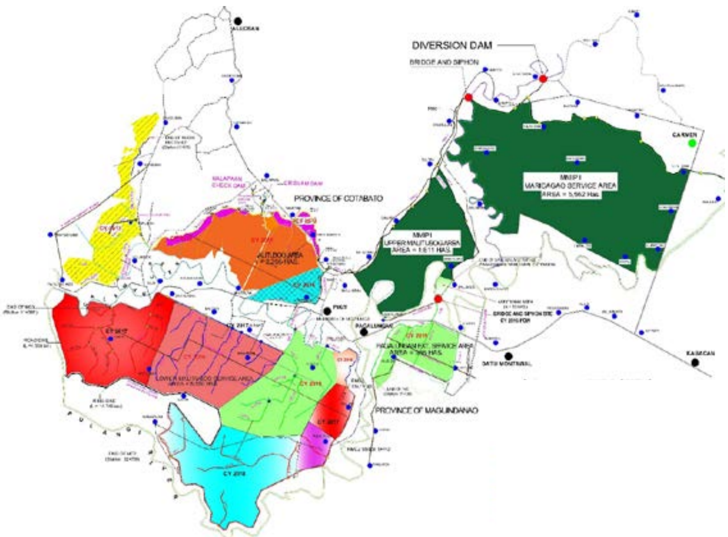


Figure 2.1.3 Project Area by Commencement Year

Source: NIA-PMO

In the project area, there are farmer households (HHs) who will directly benefit from the irrigation systems. Though the identification of beneficiaries is still on-going as the project progresses, there are already some areas where the number of beneficiaries was confirmed. Those areas where the number of beneficiaries are already confirmed, are the MMIP I areas, the UMSA of MMIP II, and the part of LMSA, where the construction was started in 2015. Based on the identified number of beneficiaries, the average farmland area can be estimated as from 1.2 to 1.7 ha per farm household approximately. Further, by applying these figures of estimated average farmland area per household, the number of beneficiaries for those un-surveyed areas can be also estimated. As a result, the number of beneficiaries of each area can be estimated as shown in Table below:

Table 2.1.3 Summary of the Irrigation Beneficiaries Farmer Households (FHHs)

Service Area	Stage	by Starting Year	Irrigable Area, ha	Beneficiary FHHs	Population	Area/ FHHs, (ha)	Status
Maridagao	Phase 1	Completed in 2011	5,562	4,278	21,521	1.30	Confirmed
Upper Malitubog	Phase 1		1,611	1,239	6,233	1.30	Confirmed
	(Phase 1) ↓ Phase 2	Started in 2011	2,958	1,782	8,963	1.66	Confirmed
Pagalungan Ext.	Phase 2	Started in 2015	988	788	3,963	1.25	Confirmed
Lower Malitubog	Phase 2	Whole	6,590	5,255	26,434	1.25	Estimated
		2015	1,303	1,039	5,227	1.25	Confirmed
		2016	1,736	1,384	6,963	1.25	Estimated
		2017-18	1,418	1,131	5,688	1.25	Estimated
		2019 (ODA)	2,133	1,701	8,556	1.25	Estimated
Total	Phase 1		**7,173**	**5,518**	27,754	**1.30**	
	Phase 2		**10,536**	**7,825**	39,360	**1.35**	
G. Total			**17,709**	**13,343**	67,114	**1.33**	

Source: NIA-PMO, MMIP II, JICA Survey Team

In the MMIP I area, it is estimated that there is a total of 5,518 farm household beneficiaries while that of MMIP II area would be 7,825 farm household beneficiaries; therefore, the total number of beneficiary HHs can be 13,343. Taking into account that the average rate of household members in Pikit municipality for 2015, namely, 5.03 persons/ household, the total number of beneficiaries can be estimated around 67,114 persons.

2.1.4 Meteorology: Temperature and Rainfall

Since the Project area is located in the N-coordinate of around 7 degrees, it has a tropical wet climate with no dry or cold season as it is constantly moist, represented with year-round rainfall. The climate data are available in Midsayap and Kabacan towns, which in fact have not been continuously recorded. There is, however, a series of simulated climate data based on satellite image analysis at a point of each 35 km x 35 km, which are provided by Climate Forecast System Reanalysis (CFSR) operated by the National Centers for Environmental Prediction (NCEP, US)[5]. The data are available since year 1979 to July 2015.

Table 2.1.4 Climate Stations (by Satellite Image Analysis)

Station No.	Elevation, m	Longitude	Latitude
S13	10	124.688	7.025
S18	399	124.688	7.337
S23	794	124.688	7.649
S24	321	125.000	7.649
S28	1,277	124.688	7.962

Source: NCEP

Table 2.1.4 and Figure 2.1.4 show the points where climate data are available provided by CFSR; namely Station No.13 located near Pikit town may represent the climate of the irrigable area while Station No. 18, No.23, No.24 and No.28 may represent climate condition within the catchment area.

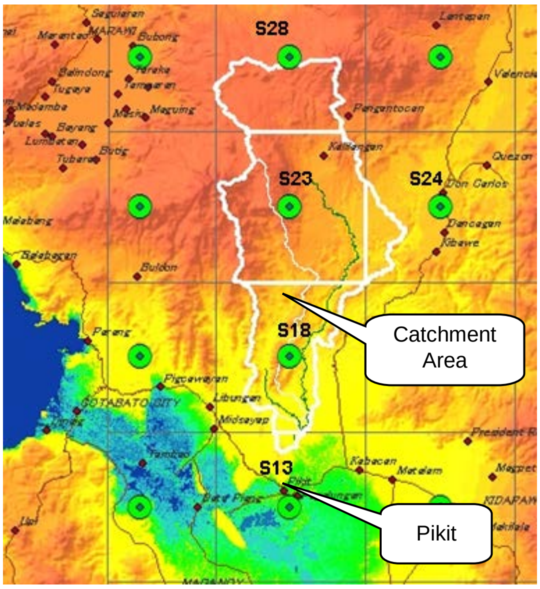


Figure 2.1.4 Climate Station Location

Source: NCEP, US

Monthly temperature and monthly rainfall at Station No.13 are indicated in Figures 2.1.5 and 2.1.6. One of the characteristics is that in fact there is not much temperature fluctuation throughout year, with a bit of

[5] All data are available and downloadable from: https://globalweather.tamu.edu/

increase in March – May which is the right before the onset of rainy season. The minimum monthly temperature hovers at around 20 Celsius degrees while the maximum one ranges from 33 to 35 Celsius degrees.

The monthly basis rainfall indicates no clear demarcation between dry season and rainy season; however, it is generally said that the rainy season is from May to October while the dry season is from November to April in the following year. The annual rainfall at Station No.13, estimated for the period from 1979 to 2015, marks only 902 mm, of which about 40% falls during the dry season.

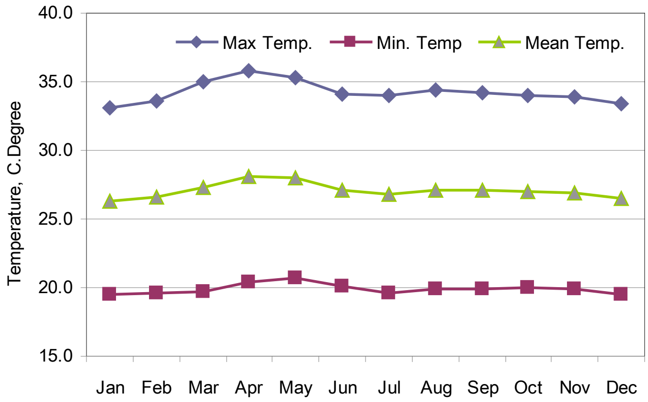


Figure 2.1.5 Monthly Temperature Trend (Pikit Area)
Source: NCEP, US

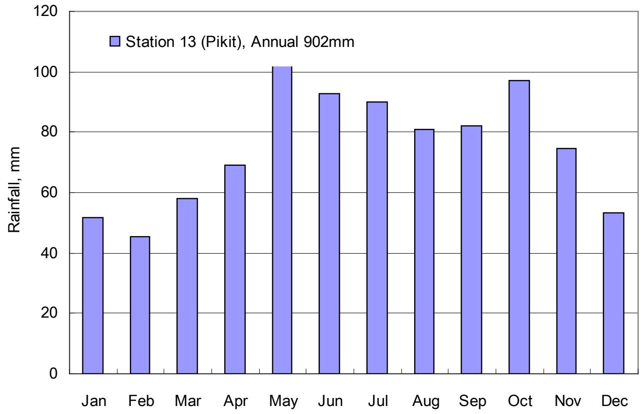


Figure 2.1.6 Monthly Rainfall Trend (Pikit Area)
Source: NCEP, US

Figure 2.1.7 shows annual rainfall trend while Figure 2.1.8 indicates only the dry season's rainfall from November to April at Station No.13 (Pikit town). The average annual rainfall, as afore-mentioned, arrives at 902 mm while the dry season's rainfall comes to 352 mm, equivalent to approximately 40% of the annual rainfall. There is a unique character in that rainfall for the last 3 years (4 dry seasons) has in fact increased to as much as double amount as compared to the past rainfalls. The long-term trend may be said that the rainfall, both annual and dry season ones, have fluctuated with an overall increase trend.

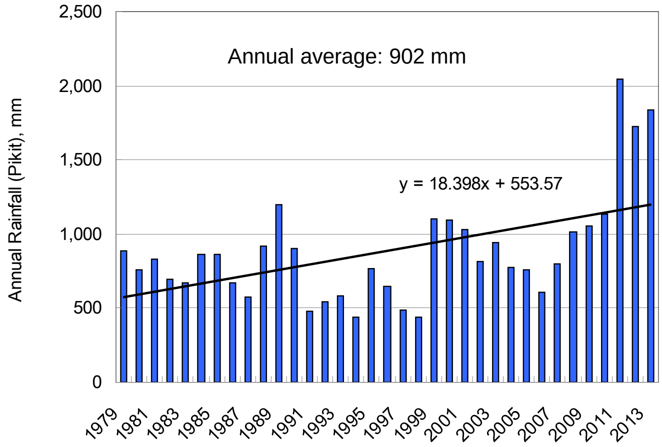


Figure 2.1.7 Long Term Trend for Annual Rainfall (Pikit)
Source: NCEP, US

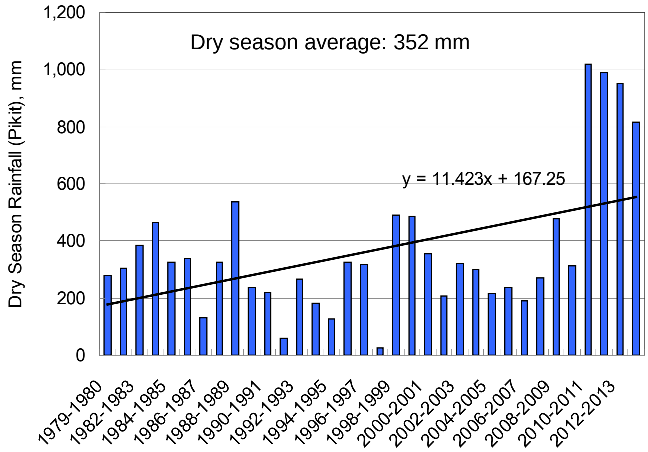


Figure 2.1.8 Long Term Trend for Dry Season Rainfall (Pikit)
Source: NCEP, US

Concerning rainfall in the catchment area of the irrigation system, Figure 2.1.9 summarizes the monthly basis rainfall for the 5 stations; one is Station No.13 (Pikit) and the rests are associated with the catchment area. As is well shown in the monthly rainfall, the amount differs by station very much; namely, the station located at lower elevation shows less amount of rainfall while such stations located in higher elevation indicate much bigger amount of rainfall. In fact, Station 13 (around Pikit town area) shows only 902 mm while the Station 28 located at the most upstream edge of the catchment area gives as much as 6,477 mm, approximately as much as 6 times rainfall.

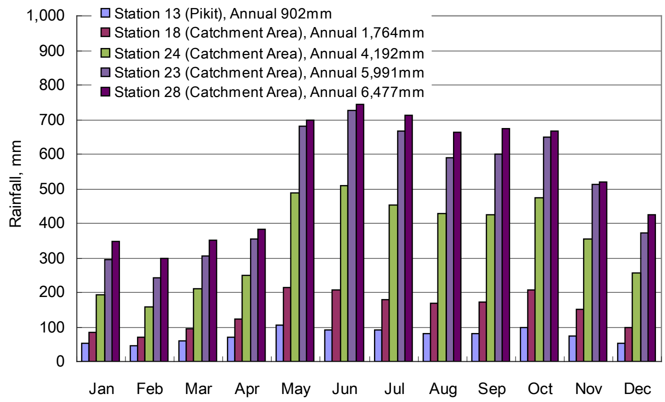


Figure 2.1.9 Monthly Rainfall Trend (Catchment Area)

Source: NCEP, US

Table 2.1.5 Climate Stations and Command Area

Station No.	Elevation, m	Area, sqkm	Ratio
S13	10	0	0.00
S18	399	375	0.27
S23	794	659	0.48
S24	321	75	0.05
S28	1,277	271	0.20
Total		1,380	1.00

Source: NCEP, and JICA Survey Team

Figure2.1.10 and Figure 2.1.11 show the weighted annual rainfall and weighted dry season rainfall (from November to April) for the catchment area of the diversion dam. The weighted rainfalls were proportionally calculated based on the catchment area covered by each of the Stations[6] of No. 18, 23, 24, and 28 as indicated in Table 2.1.5.

Figure 2.1.10 depicts the annual rainfall weighted over the catchment area ranges in most years from 3,000 mm to 6,000 mm with an average of 4,778 mm while Figure 2.1.11 indicates the dry season rainfall does from 1,000 mm to 2,000 mm with an average of 1,755 mm. Though the rainfall fluctuates year by year, the overall trend may be said on an increase, especially with the last 3-4 years much rainfall.

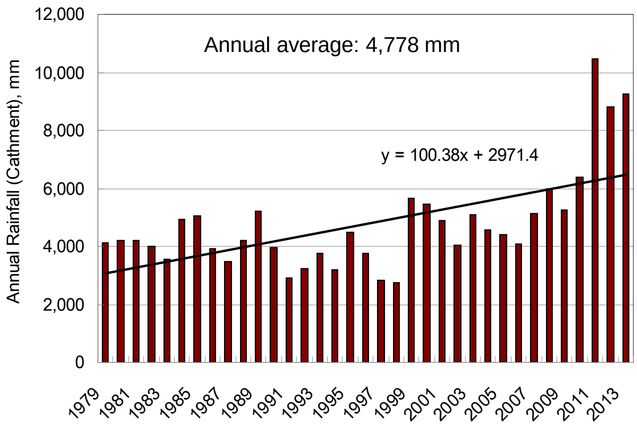


Figure 2.1.10 Long Term Trend of Annual Rainfall (CA)

Source: NCEP, US

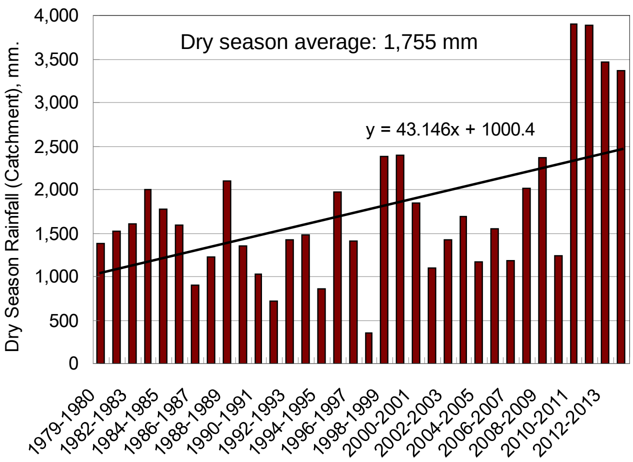


Figure 2.1.11 Long Term Trend of Dry Season Rainfall (CA)

Source: NCEP, US

2.1.5 Hydrology and Future Irrigation Water Availability

The MMIP has the diversion point on the Maridagao River at a location of 7°11'49" N and 124°43'08" E. The catchment area at this diversion point comes to 1,389 sqkm. The diversion point does not have any gauging station, and therefore during the feasibility study (June 1986), runoff records at Tinutulan gauging station were employed to estimate the river discharge at the diversion point. The Tinutulan gauging station is located about 10 km downstream from the diversion point, and the station was functioning only from 1960 to 1972 (13 years only).

The runoff from 1960 to 1972, only 13 years, were interpolated over a period from 1956 to 1987 with reference to the rainfall recorded at Midsayap ground station during the feasibility study. Thus, the runoff data became available over a period of 32 years. The catchment area at the Tinutulan gauging

6 The stations referred to by the NCEP are considered to represent each 35km x 35km rectangular area. Therefore, one NCEP station provides rainfall for an area of 35km x 35km rectangular with the station being the center.

station arrives at 2,077 sqkm, and therefore the catchment area, 1,380 sqkm, of the diversion point shares 66.4 % of that of the Tinutulan gauging station. Thus, during the feasibility study, 66.4 % of the runoff at the Tinutulan gauging station was utilized to design the system reliability on irrigation water availability for the whole command area of MMIP I and MMIP II area.

As the satellite-based rainfall data is available only from year 1979 to 2014, this data cannot be utilized to directly interpolate the actual runoff data recorded at the Tinutulan gauging station, which was closed in year 1972. Therefore, by utilizing the correlation between 1979 and 1987, during which both satellite data and interpolated runoff by using Midsayap rainfall are available, the runoff discharge at the diversion point is now estimated up to 2014. Figure 2.1.12 shows the annual runoff from year 1956 to 2013 while Figure 2.1.13 indicates the dry season runoff (November to April) by year.

Annual runoff shown in Figure 2.1.12 does not much fluctuate by year and ranges from 1,500 to 2,000 million cubic meter (MCM) in most years with an average of 2,097 MCM. As correlated with the rainfall, the runoffs for the last 3 years are much more than those as compared with the past. On the other hand, dry season's runoff fluctuates more than the annual runoff, ranging from as low as less than 200 MCM to more than 1,200 MCM. The average dry season runoff over the period of 1956/57 – 2013/14 is estimated at 777 MCM. The runoff ratio, defined as the ratio between the rainfall and the discharge, is computed at 0.321.

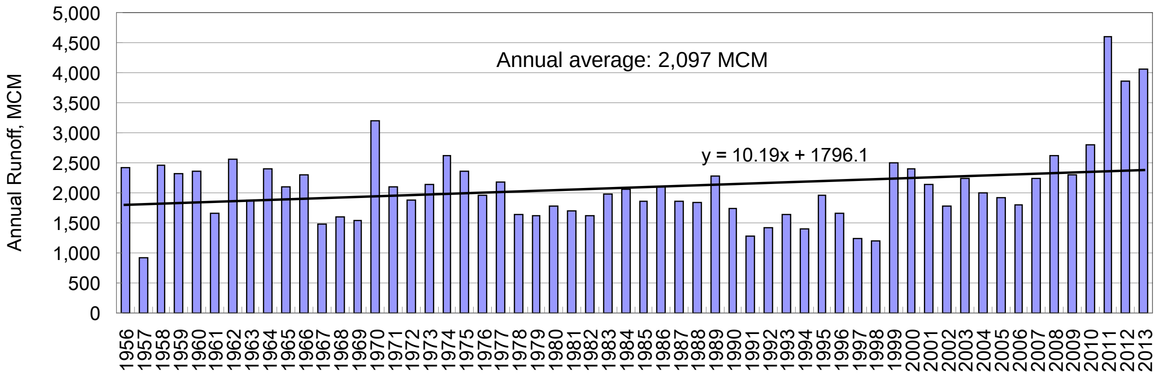


Figure 2.1.12 Annual Runoff at the Diversion Dam Point (1,380 sq. km catchment area)

Source: National Centers for Environmental Prediction (NCEP)

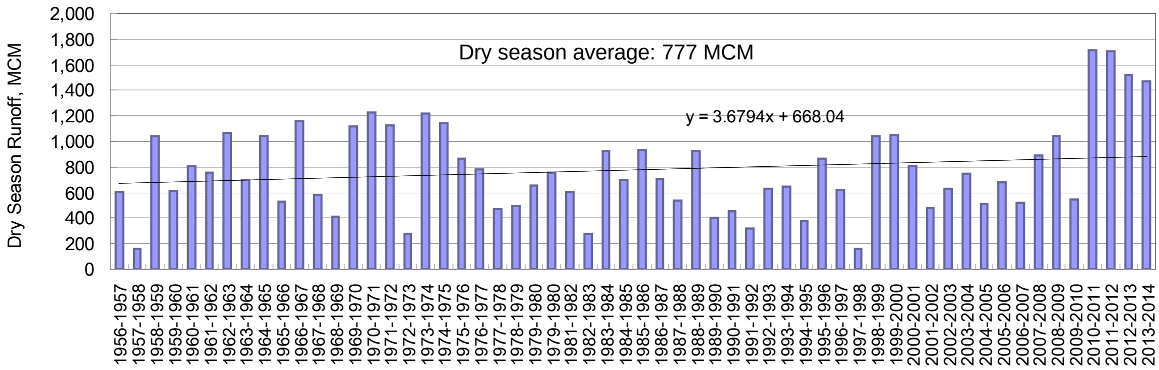


Figure 2.1.13 Dry Season Runoff at the Diversion Dam Point (1,380 sq. km catchment area)

Source: National Centers for Environmental Prediction (NCEP)

2.1.6 Regional and Barangay (Household) Economies

1) Demographic Statistics

Table 2.1.6 summarizes demographic statistics for the MMIP relevant provinces / municipalities. In 2015, there were 543 barangays in the Cotabato province. The population of the province marked

1,373,962 and its land area covered 9,317.30 sq.km, giving 148 persons per sq.km population density. The average HH size of Cotabato province was 4.29, which was in fact close to the country's average of Philippines, 4.4 persons per household.

Concerning Maguindanao province which is under ARMM, there were 508 barangays in 2015 and the population came to 1,172,381 with the land area of 9,968.31 sq.km, showing the population density of 118 persons per sq.km. The average HH size was 6.03, which was significantly larger than that of Cotabato province. The average HH size in Maguindanao Province is in fact bigger than the country's average by 1.63 persons.

Table 2.1.6 Demographic Statistics of the Relevant Provinces and Municipalities

Municipality	Number of Barangay	Population	Land Area (sq.km)	Population Density (persons per sq.km)	Number of Household	Average HH Size
Cotabato (Province)	543	1,379,747	9,317.30	148	320,567	4.29
Carmen	28	95,921	1,110.43	86	21,905	4.38
Pikit	42	154,441	604.41	255	36,099	4.27
Aleosan	19	39,405	225.44	175	8,845	4.45
Maguindanao (Province)	508	1,173,933	9,968.31	118	194,507	6.03
Datu-Montawal (Pagagawan)	11	34,820	461.10	76	5,693	6.12
Pagalungan	12	39,653	898.76	44	6,810	5.82
National	42,036	100,573,715	300,000	337	22,975,630	4.40

Source: Philippine Statistics Authority, Census of Population and Housing 2015

Census of Population and Housing 2010 estimated future population of year 2010 – 2045 as shown in Figure 2.1.14. Based on the projection, the population of Cotabato province would increase to 2,167,200 at the year of 2014, 63% increase during 2010 - 2045. On the other hand, the population of Maguindanao province was expected to be almost doubled from 1,173,933 to 1,845,500 by 95% increase, during the period of 2010 – 2045.

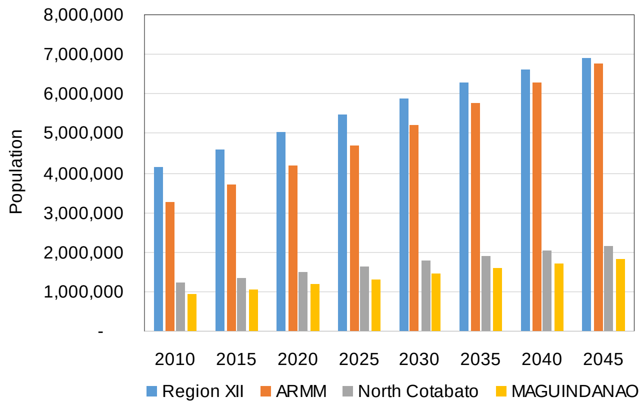


Figure 2.1.14 Projected Population by Five-Calendar Year

Census of Population and Housing 2015

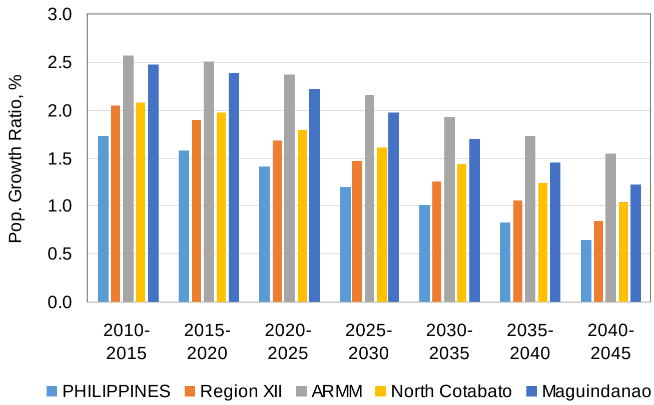


Figure 2.1.15 Annual Growth Rates by Five Calendar-Year

Census of Population and Housing 2015

Average regional and provincial annual population growth ratio by five calendar-year interval is shown in Figure 2.1.15. The expected population growth in Region XII and ARMM could be much higher than that of the national average, and especially that of the ARMM. In medium assumption as indicated in the figure, approximately 2.2% and 2.4% of the population growths are projected for Maguindanao province and ARMM respectively while about 1.7% and 1.8 % population growths are expected in Region XII and Cotabato province during the years from 2020 to 2025. Note that 2% population growth ratio per annum would double the population in 36 years.

2) Gross Regional Domestic Product (GRDP)

Table 2.1.7 shows gross regional domestic product (GRDP) as of 2016 for the 2 regions of Region XII and ARMM. In Region XII, the primary sector of agriculture, hunting, forestry and fishing shared 26.2% of the GRDP while that of ARMM did as high as 59.3% of the GRDP[7]. The industrial sectors for the 2 regions consisted of 33.3 % and 5.1% respectively for Region XII and ARMM, implying very low industrial development in the ARMM area. The service sector of the regions shared 40.6 % and 35.6 % respectively. These sector basis shares show that ARMM is very much agriculture dominated region, also as indicated by only 5.1% of share by industrial sector, while Region XII is not such.

Table 2.1.7 Gross Domestic Product by Industrial Origin, 2016 at Current Price

INDUSTRY	Region XII		ARMM	
	000' peso	%	000' peso	%
I. AGRICULTURE, HUNTING, FORESTRY & FISHING	101,214,738	26.2	61,655,650	59.3
a. Agriculture and Forestry	83,579,856	21.6	50,539,859	48.6
b. Fishing	17,634,882	4.6	11,115,791	10.7
II INDUSTRY SECTOR	128,667,035	33.3	5,302,132	5.1
a. Mining and Quarrying	690,533	0.2	363,921	0.4
b. Manufacturing	77,903,428	20.1	1,160,749	1.1
c. Construction	34,227,176	8.8	2,025,988	1.9
d. Electricity, Gas and Water Supply	15,845,899	4.1	1,751,475	1.7
III SERVICE SECTOR	156,911,343	40.6	36,973,726	35.6
a. Transportation, Storage & Communication	21,932,513	5.7	4,443,523	4.3
b. Trade & Repair of Vehicles, Motorcycles, Personal and HH Goods	41,054,351	10.6	1,359,791	1.3
c. Financial Intermediation	22,017,150	5.7	4,330,044	4.2
d. Real Estate, Renting & Business Activities	24,465,406	6.3	8,254,200	7.9
e. Public Administration & Defense; Compulsory Social Security	13,697,290	3.5	12,382,828	11.9
f. Other Services	33,744,632	8.7	6,203,340	6.0
GROSS DOMESTIC PRODUCT	386,793,116	100.0	103,931,508	100.0

Source: Philippine Statistics Authority

Figure 2.1.16 shows dependency ratio on agricultural production in the GRDP from 2001 to 2015 at current price. At a glance, it is clearly found that Agriculture Industry has been prevailing as the main industry as compared to the national average especially in the case of ARMM; accounted for around 30% and 60% as of 2015 in Region XII and ARMM respectively. Further, changes in times look differently by region. Till year 2008, the dependency on agriculture production in both regions seems to have been increasing or at least stayed at a constant level. After the year 2008, that of Region XII started decreasing while that of ARMM once jumped up to nearly about 70% in 2010, and then started decreasing.

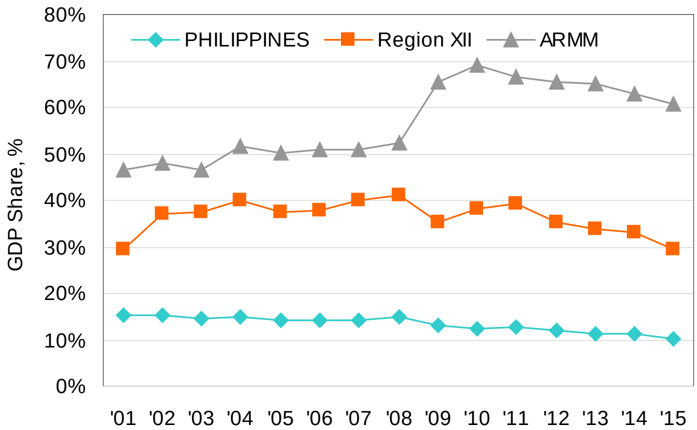


Figure 2.1.16 Percentage of Agricultural Production in GRDP, 2001-2015 at current price (Source: Philippines Statics Authority)

3) Household Income

Table 2.1.8 summarizes household income status of the 2 regions as compared with that of Philippines (Source: 2015 Family Income and Expenditure Survey Final Report). The mean household income of Region XII is 188,000 Peso, approximately 70% of the national average (267,000 Peso). On the other

[7] With reference to the Country STAT 2013, of the total agricultural output of Region XII, the crop sub-sector comprised as high as 68.0%, followed by fisheries sector (15.6%), livestock sector (10.8%), and poultry sector (5.6%). In ARMM, of the total agricultural output, the crop sub-sector shared the biggest range of 71.6%, followed by fisheries (22.4%), livestock (4.2%), and poultry (1.9%).

hand, the mean household income of ARMM is only 139,000 Peso, which consists only of 52% of the national average, implying high poverty incidence in the ARMM area.

By composition, as is expected by the mean income, the top income class out of 5 categories shares only 7.6% in ARMM while that of the Philippines does as much as 35%, and that of even Region XII shares 19%. With respect to the sum of lowest 3 classes less than 100,000-peso income, the nation's average shows a share of 20% while Region XII marks 39% and ARMM does 35%. In any case, both regions incomes are lower than that of the Philippines, and especially the income level of ARMM can be said quite low.

Table 2.1.8 Distribution of Household by Income Class and by Region, 2015

Regions		All Income Classes	Mean Income (in thousand Peso)	Income Class					
				Under 40,000	40,000 - 59,999	60,000 - 99,999	100,000 - 249,999	250,000 - and over	Class Distribution
Philippines	000' Families	22,730	267	355	901	3,268	10,318	7,888	
	%	100.0%		1.6%	4.0%	14.4%	45.4%	34.7%	
Region XII	000' Families	1,055	188	47	104	255	447	202	
	%	100.0%		4.5%	9.9%	24.2%	42.4%	19.1%	
ARMM	000' Families	616	139	1	24	187	357	47	
	%	100.0%		0.2%	3.9%	30.4%	58.0%	7.6%	

Source: Philippines Statistics Authority, 2015 Family Income and Expenditure Survey Final Report

4) Poverty Incidence at Municipality Level

Figure 2.1.17 shows the poverty incidence of the Country, Region XII and ARMM from 2006 to 2015 with 3-year interval (Source: Philippine Statistics Authority). In addition, Table 2.1.9 elaborates the poverty prevalence at the province and municipality level, which was collected through a national government funded project on small area estimates on poverty.

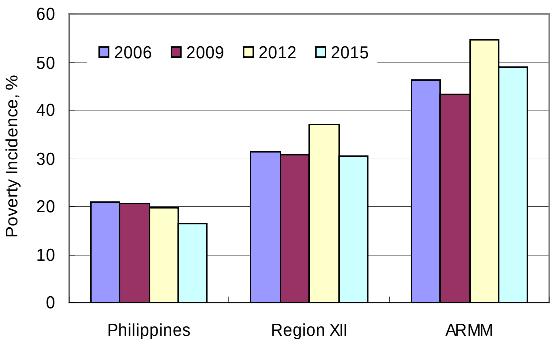


Figure 2.1.17 Poverty Estimates 2006 - 2015

Source: Philippine Statistics Authority

Table 2.1.9 Poverty Incidence (Province/ Municipality)

Area	Poverty Incidence (%)			
	2006	2009	2012	2015
Cotabato	**25.6**	**23.4**	**44.8**	**34.5**
Carmen	39.4	50.4	56.4	NA
Kabacan	30.6	35.0	38.0	NA
Pikit	51.9	48.5	57.8	NA
Maguindanao	**46.4**	**43.3**	**54.5**	**48.8**
Pagalungan	NA	NA	37.5	NA
Datu Montawal	NA	NA	76.2	NA

Source: Philippine Statistics Authority,

The national and regional level data clearly show higher poverty incidence in the 2 regions as compared to the national level. The poverty incidence of the Country is around 20% or less than that while that of Region XII marks around 30% or more and ARMM shows much worse situation, more than 40% to as high as nearly about 50-55%. It means that the share of the people falling below the poverty line in Region XII is about 1.5 times more, and that of ARMM is even more than double as compared to that of the Country.

Worse, though the national level poverty ratio shows continuous declining trend during the period from 2006 to 2015 as being from 21% to 17%, the poverty incidences for the Region XII and ARMM have not so done. The poverty incidence in Region XII once jumped up in year 2012 and same trend took place in ARMM too. The hiked poverty incidence in Region XII has dropped in 2015 to that level of 2009 or 2006; however, the increased incidence of ARMM has been kept high even in 2015.

At provincial and municipality level shown in Table 2.1.9, the poverty incidences for the both provinces can be said worse for the recent years of 2012 and 2015. For example, the poverty incidences of Cotabato province marked 44.8% and 34.5% respectively in year 2012 and 2015, both of which are higher than those of Region XII. Same tendency can be found in Maguindanao province as exampled by the incidences being 54.5% and 48.8% in 2012 and 2015 respectively. Looking into the poverty at municipality level, the ratio more than 50% was marked in such municipalities as Carmen (56.4%), Pikit (57.8%), and Datu Montawal (formerly Pagagawan; 76.2%).

5) Employment Structure

Table 2.1.10 shows the number and the percentage of employed persons by region and by major industry group in year 2014. Total 1,735,000 persons were employed in 2014 in Region XII, and approximately half (45%) of it was absorbed by agriculture, hunting and forestry industry group. Fishing and aquaculture has generated only 3% of the employment. Aside from the agriculture and fishing & aquaculture, 18% of total employment had been engaged in wholesale and retail trade, repair of motor vehicle and motorcycle industry, followed by transportation and storage industry (6%).

The employment in year 2014 in the ARMM region totaled to 1,295,000 persons, of which 52% were employed in the agriculture, hunting and forestry sector. Fish and Aquaculture accounted for another 16% of total employment, the second largest industry group in the ARMM region. Most of job opportunities were in fact generated from major four industries such as: 1) agriculture, hunting and forestry, 2) fishing and aquaculture, 3) wholesale & retail trade, repair of motor vehicles & motor cycles, and 4) transportation and storage, which together accounted for approximately 90% of total employment in 2014.

Table 2.1.10 Employed Persons by Region and Major Industry Group, 2014

Major Industry Group	Region XII		ARMM	
	000' worker	%	000' worker	%
Total	**1,735**	**100%**	**1,295**	**100%**
Agriculture, Hunting and Forestry	774	45%	676	52%
Fishing and Aquaculture	55	3%	212	16%
Mining and Quarrying	4	0%	3	0%
Manufacturing	93	5%	13	1%
Electricity, Gas, Steam and Air Conditioning Supply	3	0%	1	0%
Water Supply; Sewerage, Waste Management and Remediation Activities	1	0%	*	0%
Construction	56	3%	13	1%
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	308	18%	190	15%
Transportation and Storage	110	6%	77	6%
Accommodation and Food Service Activities	42	2%	5	0%
Information and Communication	7	0%	1	0%
Financial and Insurance Activities	15	1%	1	0%
Real Estate Activities	3	0%	-	0%
Professional, Scientific and Technical Activities	3	0%	*	0%
Administrative and Support Service Activities	20	1%	6	0%
Public Administration and Defense; Compulsory Social Security	83	5%	44	3%
Education	55	3%	40	3%
Human Health and Social Work Activities	14	1%	3	0%
Arts, Entertainment and Recreation	7	0%	*	0%
HH Activities as Employers; Undifferentiated Goods and Service-producing Activities for Own Use	61	4%	8	1%
Activities of HHs for Own Use	18	1%	1	0%
Activities of Extraterritorial Organizations and Bodies	1	0%	*	0%

Source: Averages of Three (3) survey rounds of the Labor Force Survey

Table 2.1.11 shows the numbers and percentages of employed persons by region and by class of workers in 2014. In Region XII, about half of total employed persons were wage and salary workers (49%), while self-employment and family own business accounted for another half in 2014. In ARMM, on the contrary, wage and salary workers accounted for only 18% of the employed persons. It means that more than 80% of workers in the ARMM were engaged in own-family operated farming or own-family operated businesses.

Table 2.1.11 Employed Persons by Region and Class of Worker, 2014

REGION AND CLASS OF WORKER	Region XII		ARMM	
	000' worker	%	000' worker	%
Total	**1,735**	**100%**	**1,295**	**100%**
Wage and Salary Workers	850	49%	228	18%
Worked for private household	55	3%	5	0%
Worked for private establishment	659	38%	144	11%
Worked with pay in own family-operated farm or business	5	0%	3	0%
Worked for government/government corporation	132	8%	75	6%
Self-employed without any paid employee	597	34%	695	54%
Employer in own family-operated farm or business	48	3%	12	1%
Without pay in own family-operated farm or business	240	14%	361	28%

Source: Averages of Three (3) survey rounds of the Labor Force Survey

6) Barangay Economies (Baseline Survey)

In order to investigate the positive/negative impact of the project and to set baseline values for the project area, a baseline survey has been conducted in the MMIP I and MMIP II areas. The survey was launched on June 12, 2017 and completed in late July 2017. In the following, the types of survey, survey design, sampling, results and discussions are shown:

6.1) Types of Survey

The survey includes different activities; namely, 1) barangay profile establishment, 2) focus group discussion, and 3) farmer household economic survey. Each activity has different purposes aiming at revealing a part of aspects in the target area:

1. Barangay Profile (9 Barangays): It aims at collecting general characteristics of the target barangays through interviewing barangay captains and other local key villagers,
2. Focus Group Discussion (9 Barangays): It aims at collecting in-depth/nuanced information on socioeconomic-needs, and evaluation and expectation of MMIP project. The participants include various stakeholders, at least, Barangay Captain; Barangay Councilors; Chairperson of Youth Council; Group / Organization / Association / Cooperative representatives in the Barangays to representative different ethnic and religious group, farmers, organizations, women's organizations etc.; and barangay residents who are basically selected to respond Farmer Household Economic Survey questionnaire, and
3. Farmer Household Economic Survey (200 HHs): It aims to collect agriculture and socio-economic characteristics of HHs in target barangays, by interviewing total 200 householders. The sampling method is intentional extraction method, which is based on the population by using pre-information.

6.2) Survey Design

Above surveys cover both MMIP I and MMIP II areas. In MMIP I area, the most important objective is to identify the output of the irrigation system upon completion. Hence, not only current characteristics but also changes after the commencement of the irrigation system were questioned. In addition, in order to examine the impact of YLTA, sample farmers in this MMIP I area were separately covered by enrollment for the technical assistances provided under YLTA.

On the other hand, in MMIP II area, irrigation water has not yet started coming. Therefore, the major objective of this area is to collect the baseline (initial) values in the target areas. These initial values are to be referred to setting the Operation Indicators and Effect Indicators which are the target indicators with Project. In addition, expectations to the project are asked to clarify the need of the beneficiary farmer HHs.

Three Barangays were selected from Maridagao Service Area, considering respective IA's enrollment to YLTA, and then both YLTA farmers and non-YLTA farmers were equally selected to compare (10 samples each). On the other hand, 6 Barangays were selected from Lower Malitubog Service Area. In the LMSA, there is stage-wise difference, for example, in terms of progress of construction. Therefore, the Team finally selected 1 Barangay from western part of LMSA (red colored), 1 Barangay from central part of LMSA (pink colored), 1 Barangay from eastern part of LMSA (light green colored), and 3 Barangay from south-eastern part of LMSA (purple and light blue colored).

According to the ordinary Muslim custom of Mindanao, head of household is primary inherited by son, and thus the wife generally never becomes as householder. However, as per interviewers who visited the Barangays, in some ethnic-mixed Barangays, it is possible that a woman can be the household head. Through Barangay profiling, it was revealed that there were women-headed HHs in Ugalingan (about 30), Gli-Gli (about 27), and Punol (about 7). Aside from Punol, the Team selected 10 women-headed HHs each from the two Barangays (total 20 HHs). The location (yellow circle), name of Barangay, and the number of sampled farmer HHs by Barangay are summarized in Figure 2.1.18 and Table 2.1.12.

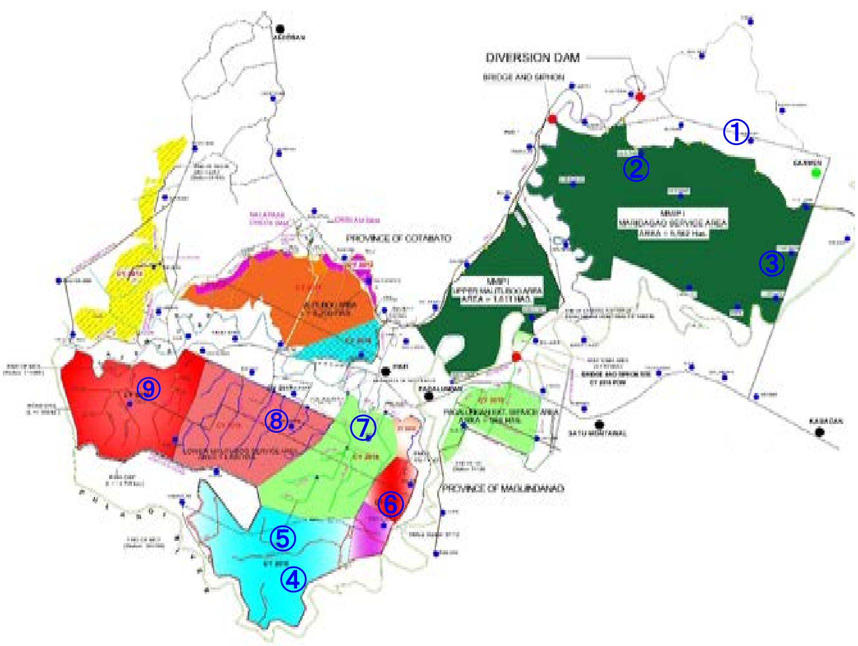


Figure 2.1.18 Location Map of Selected Barangays for Baseline Survey

Source: JICA Survey Team

Table 2.1.12 Name of Barangays and the Number of Sample Farmer Households (FHHs)

Irrigation Area	Name of Barangay		Municipality	Membership of IA	Number of Sample FHHs
Maridagao Service Area	1	Ugalingan/ General Luna	Carmen	Farmers who belongs IA of MRISIA Div.6 and received YLTA	10
				Farmers who have never received any TA	10
				HHs which headed by female	10
	2	Kibayao/ Kib-Ayao	Carmen	Farmers who belongs IA of KIPAN or NASGIA and received YLTA	10
				Farmers who have never received any TA	10
	3	Kilangan	Pagalungan	Farmers who belongs IA of Morning Light or KATINGKONGAN and received YLTA	10
				Farmers who have never received any TA	10
Lower Malitubog Service Area	4	Buliok	Pikit	Any Farmers	20
	5	Talitay	Pikit	Any Farmers	20
	6	Baguinged	Pikit	Any Farmers	20
	7	Gli-gli/Gligli	Pikit	Any Farmers	20
				HHs which headed by female	10
	8	Macabual	Pikit	Any Farmers	20
	9	Punol	Pikit	Any Farmers	20
Total					**200**

Source: JICA Survey Team

6.3) Basic Characteristics of Target Barangay

Basic Information and macro-level questions that are not suitable for household-level questionnaire were questioned in Barangay Profile to the Barangay Captains and other local key villagers. Figure 2.1.19 finds that the population in Kilangan is remarkably large, though the typical population in other Barangays is roughly 2,000 – 5,000 or approximately 700 – 1,000 HHs. Most of families belong to Muslim community, in fact, 5 out of 8 were pure-Muslim Barangays (100% of population were Muslim). The religious composition looks strongly correlated with ethnic groups; Figure 2.1.20 and Figure 2.1.21 easily find that the share of population who believes except for Islam such as Christianity is quite similar to that of ethnicity other than Maguindanaon (e.g. Cebuano, Ilocano).

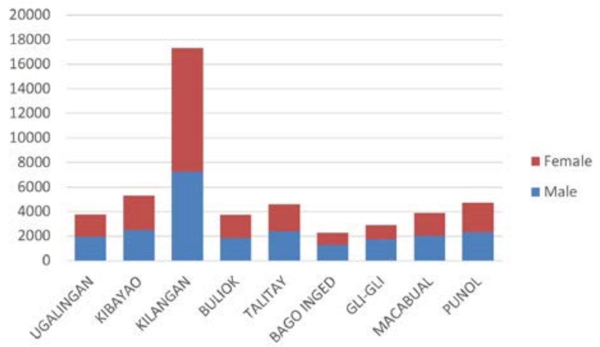


Figure 2.1.19 Population of Target Barangays by Sex
Source: JICA Survey Team, Baseline Survey

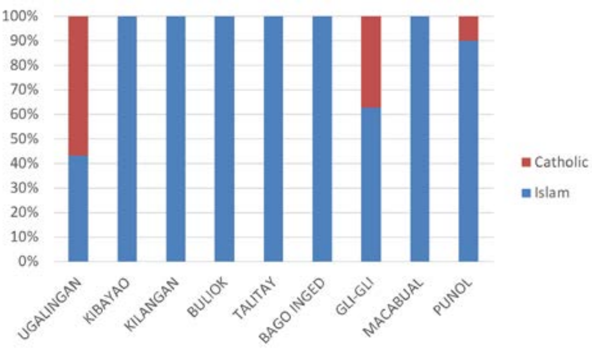


Figure 2.1.20 Population Share of Target Barangays by Selected Religion
Source: JICA Survey Team, Baseline Survey

In every barangay, the population of farmer HHs is larger than non-farmer HHs. It is certain that farming is the primary livelihood in the Barangays. However, such villages belonging to Lower Malitubog Service Area (Ugalingan, Kibayao, Kilangan) which have always suffered from floods tend to have larger share of non-farmer HHs than three villages of Maridagao Service Area. Also, shares of peasant farmer / agriculture labor in Maridagao Service Area look higher than those of Lower Malitubog Service Area. Perhaps, arable land is more scarcity in the area because the number of HHs against population is relatively large.

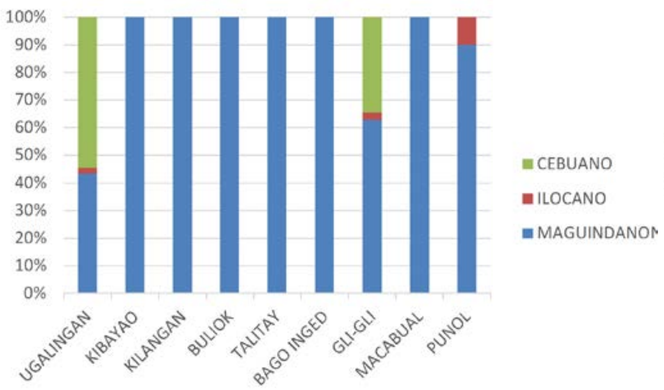


Figure 2.1.21 Composition of Primary Ethnic Group
Source; JICA Survey Team

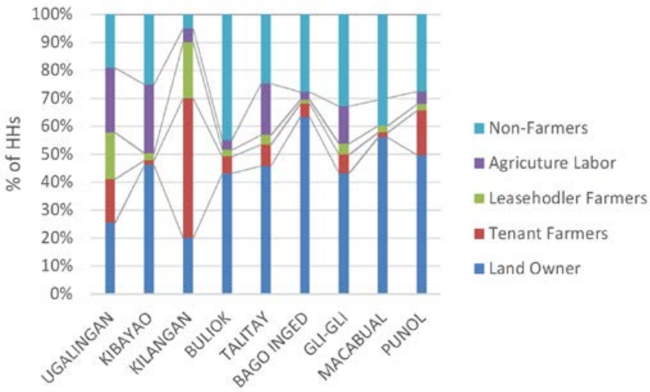


Figure 2.1.22 Composition of Employment in the Target Barangays
Source: JICA Survey Team

6.4) Arable Land per Farmer

The average cultivated land per sample 200 HHs is about 1.52 ha. Out of it, self-owned land accounts for 1.48 ha. It implies that farmland rental is not common in the area. Most of the farmers can be categorized as “small size farmer” cultivating 0.5 – 1 ha farmland. Further, 31 HHs (16%) are in fact “marginal farmers” who cultivate only less than 0.5 ha. On the other hand, 10 HHs (5%) can be categorized "medium and large size farmer" who cultivate more than 4.5 ha. Figure 2.1.23 shows histogram segmented by land scale.

Range	Frequency
0ha≦X<0.5ha	35
0.5ha≦X<1.5ha	116
1.5ha≦X<2.5ha	31
2.5ha≦X<3.5ha	6
3.5ha≦X<4.5ha	2
4.5ha≦X<5.5ha	5
5.5ha≦X<6.5ha	2
6.5ha≦X<7.5ha	0
7.5ha≦X<8.5ha	0
8.5ha≦X<9.5ha	1
9.5ha≦X<10.5ha	1
10.5ha≦X<11.5ha	0
11.5ha≦X<12.5ha	0
12.5ha≦X<13.5ha	0
13.5ha≦X<14.5ha	0
14.5ha≦X<15.5ha	1
15.5ha≦X	0

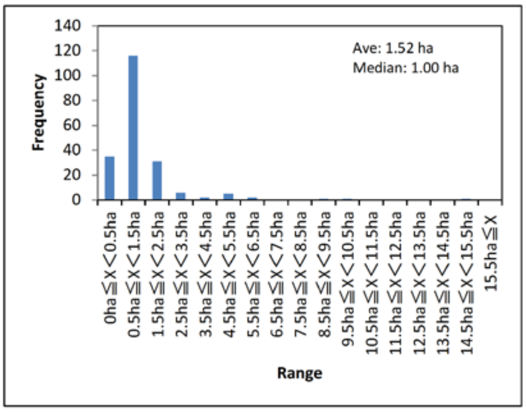


Figure 2.1.23 Histogram of Farmer HH Segmented by Farmland Size

Source: JICA Survey Team, Base Lien Survey

Table 2.1.13 shows cultivated area per farmer by crop and by irrigation access. For both irrigated / rain-fed lowlands, the major crops in the area are rice, coconuts, corn, and sugarcane. Crop intensity in irrigated lowland has already reached 200% and most of the farmers have introduced two-time cropping. On the other hand, crop intensity in rain-fed lowland is relatively low, only 102%.

Table 2.1.13 Cultivated Area of Lowland per FHHs by Crop and by Irrigation Access

Crops	Irrigated Land (Lowland)				Non-Irrigated Land (Lowland)			
	Rainy	Dry	Third	Total	Rainy	Dry	Third	Total
Rice	0.55	0.54	0.00	1.09	0.39	0.04	0.02	0.45
Coconut	0.00	0.00	0.00	0.00	0.02	0.01	0.01	0.04
Corn	0.02	0.02	0.01	0.05	0.04	0.01	0.01	0.06
Sugarcane	0.11	0.11	0.00	0.22	0.00	0.00	0.00	0.00
Others (e.g. rubber, mango)	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00
[A] Total Cultivated Area (ha)	0.68	0.68	0.01	1.37	0.45	0.06	0.04	0.55
[B] Land Size (ha)	0.72	0.72	0.72	0.72	0.54	0.54	0.54	0.54
[A/B] Crop Intensity (%)	94.4%	94.4%	1.4%	190.3%	83.3%	11.1%	7.4%	101.9%

Source: JICA Survey Team, Base Lien Survey

6.5) Farmer's Income

The average farmer household income is PhP120,914. Compared to official statistics collected by Philippines Statistic Authority (PSA) in 2015, the farmer household income is lower than the average of Region XII (198,438 Php), while it is larger than the average of ARMM (85,514 Php). That is to say, the average sample household income is not extremely higher nor lower compared to neighboring areas.

Divided by average household's size 5.26, the average per capita income comes to PhP22,987. Looking at official regional poverty line estimated by PSA, the poverty line of Region XII in 2015 (latest updated) was PhP21,025, and that of ARMM in 2015 was PhP21,563. The average sample household income slightly exceeded to these thresholds. It should be noted that the comparison is not strictly applicable since it does not consider inflation and perhaps any other important factors else. Yet, it is no doubt that poverty reduction is one of the central agenda for the areas.

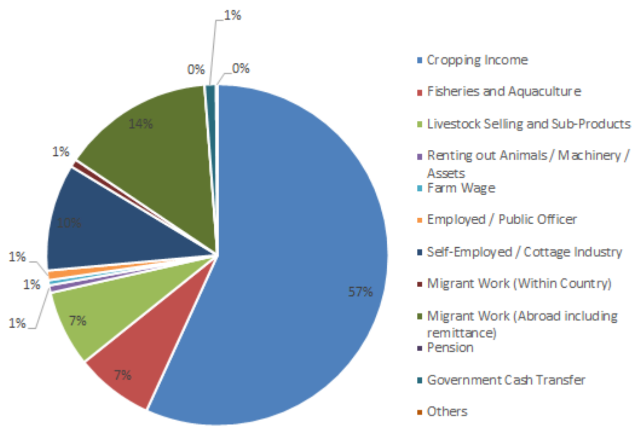


Figure 2.1.24 Shares of Farmer Household Income by Income

Source: JICA Survey Team, Base Lien Survey

Figure 2.1.24 shows share of farmer household income by income source. Cropping income accounts for 57% of total household income, followed by migrant work (abroad) and remittance (14%), self-employed / cottage industry (10%), livestock selling and sub-products (7%), and fisheries and aquaculture (7%). There is a tendency that farmers in water sufficient area significantly depend on cropping income, while farmers who usually suffer from flood in rainy season relatively diversify their income into non-crop incomes such as fishery and aquaculture.

6.6) Issues on Farm Management

The Team asked about issues to be tackled to improve agriculture productivity/ farmer's income that are summarized in Figure 2.1.25. The issues frequently answered were "Damage by pest and disease" and "Bad / poor transportation road to market / millers", so those issues must have needs to be solved. In rain-fed areas, people tend to answer "Unstable Rainfall" and "Occurrence of Floods" as their major issues. On the other hand, in irrigated area farmers tend to answer, "water shortage of irrigation". From these results, it seems that the proposed plan has certain validity to implement.

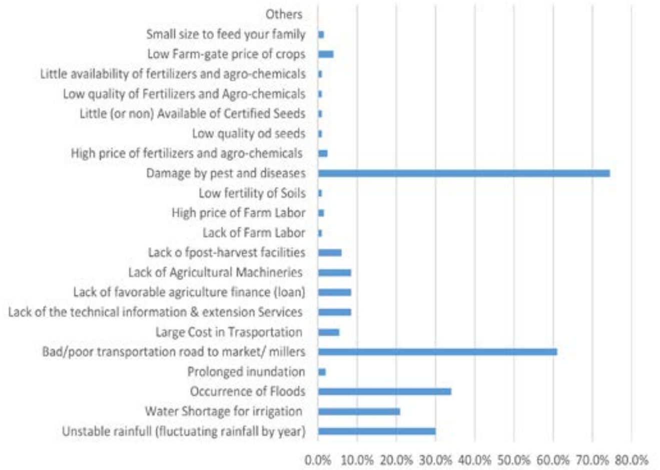


Figure 2.1.25 Recognized Issues on Farming & % of Farmers (Unit: %)
Source: JICA Survey Team, Base Line Survey

6.7) Evaluation of MMIP I and Expectation of MMIPII

Figure 2.1.26 shows evaluation of MMIP I project by local people. For a wide range of items from farming to security, most of the household heads (more than 70% to almost 100%) recognized "positive" or "very positive" impacts of MMIP I project, and therefore it can be concluded that the outcome of existing irrigation schemes are very much welcomed by the local people.

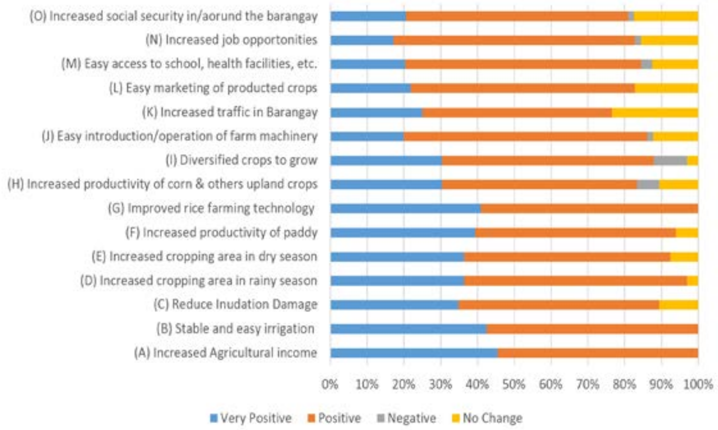


Figure 2.1.26 Evaluation of MMIP I Project & % of Farmers (Unit: %)
Source: JICA Survey Team. Base Line Survey

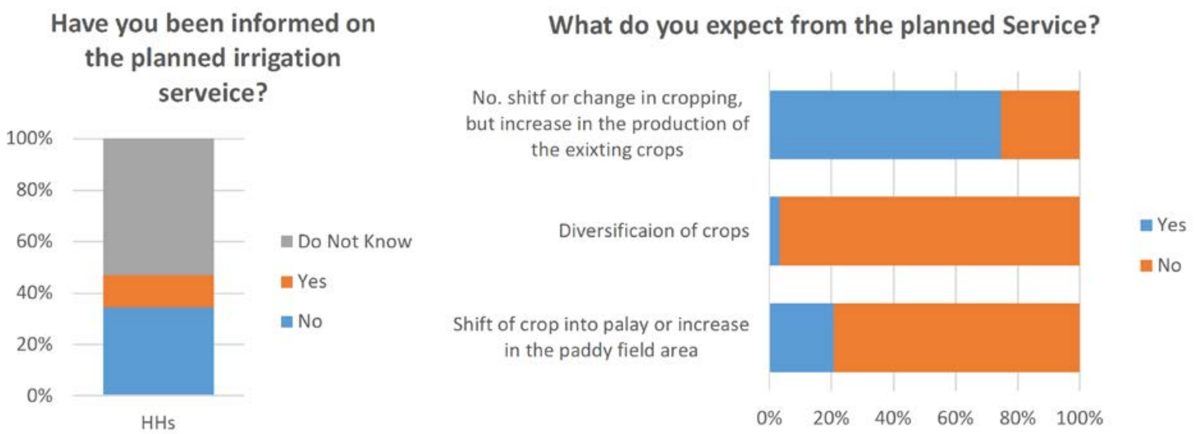


Figure 2.1.27 Expectation of MMIP II Project and Percentage of Farmers (Unit: %)
Source: JICA Survey Team, Base Lien Survey

On the other hand, the expectations to MMIP II project is summarized in Figure 2.1.27, and surprisingly only 17 HHs out of the 134 sample HHs in the MMIP II area were aware of the project. The information dissemination should be strengthened to deepen the understanding of the beneficiary farmer HHs. Among others, the expectation in the yield increase is the highest, while the expectation in crop diversification towards, e.g., rice is the lowest.

6.8) Women Headed-Households

Referring to Barangay Profile, it is confirmed that there are HHs headed by female at least 30 HHs in Ugalingan, 27 in Gli-Gli, and 7 in Punol. In order to clarify socio-economic characteristics of women headed HHs, 20 women headed HHs are additionally surveyed.

The results of income comparison between male and female headed HHs are summarized in Figure 2.1.28. Although there is no significant difference between two groups in the total income amounts, the income structures seem to be different. The Female headed household's incomes are mainly composed of crop income (40.4% of total income), livestock selling and sub products (21.5%), migrant work abroad- /remittance (17.2%), migrant work within the country (7.8%), and government cash transfer (6.6%). The result shows that even though a female headed household can earn less income from cropping, they possess multiple income sources including supports from family members and the government, which covers the income gap between the two.

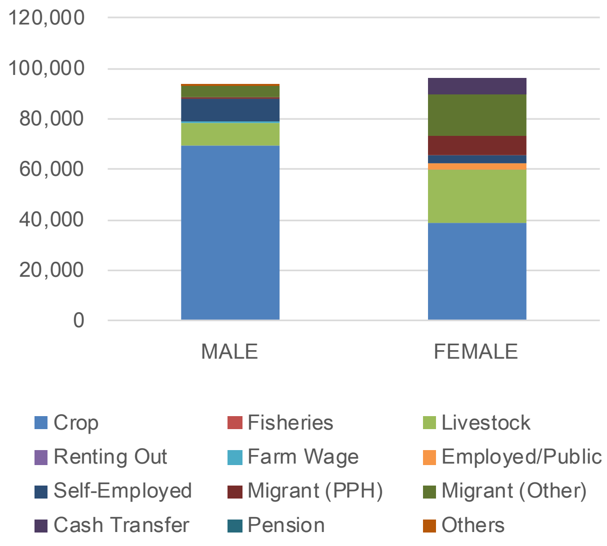


Figure 2.1.28. Income Comparison between Male and Female Headed HHs

Source: JICA Survey Team, Base Lien Survey

6.9) Observed Effect from Technical Assistance Projects

The sample farmer HHs in the Maridagao Service Area can be divided into two groups: 1) farmer HHs that belong to an IA and benefited from technical assistance (TA) projects; and 2) farmer HHs that have never benefited from any TA projects (see Table 2.1.14).

Since there is no baseline data on the initial conditions for each group farmers, the results of the comparison of the current status between the two groups should be taken as reference.

In the comparison of the yields per hectare, there is a slight difference. Those householders that have ever received TA yield 3.48 tons /ha in irrigated rice fields while those HHs that have never received TA non-recipient yield 3.30 tons/ha.

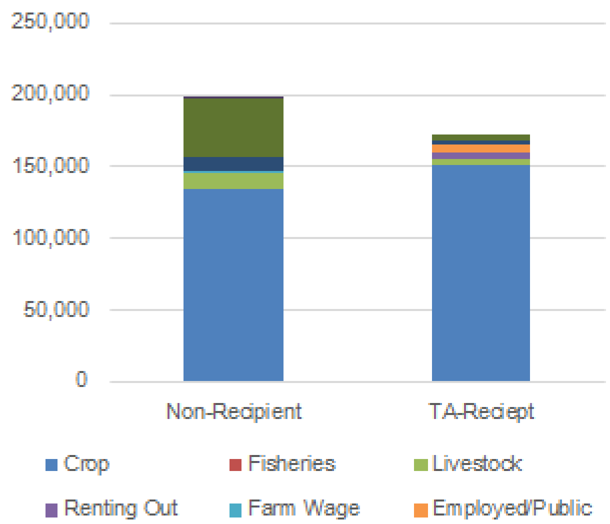


Figure 2.1.29. Income Comparison between TA Recipient and Non-Recipient

Source: JICA Survey Team, Base Lien Survey

Figure 2.1.29 compares income and income structure of the two groups. TA-recipient farmers can earn cropping income 150,907 peso per FHH that is larger than the non-recipient farmers 134,741 peso per FHH.

Table 2.1.14 Sample Size Segmented by TA Recipient and Non-Recipient

Category	Name of Service Area	Barangay	Enrollment of IA	Sample Size
TA Recipient Group	MSA	Three Barangays belong to MSA	farmers who belongs to any IA and benefited by any technical assistance project	39
Non-Recipient Group	Ditto	Ditto	Farmers never benefited from any TA	31
(Reference-Group)	(LMSA)	(Five Barangays belong to LMSA)	Ditto	(130)
Total				**(200)**

Source: JICA Survey Team

2.1.7 Social and Cultural Features

1) Ethnicity and Religion

The population of Mindanao can be classified into Christian, Muslims and Lumads, depending on their religion, and in general there still remain divisions among them created and reinforced by their history. According to the National Commission for Culture and the Arts (NCCA), Lumad are the general term for 15 Indigenous Peoples (IPs) in Mindanao, who are neither Muslims nor Christians and they are: *Subanen*, *B'laan*, *Mandaya*, *Higaonon*, *Banwaon*, *Talaandig*, *Ubo*, *Manobo*, *T'boli*, *Tiruray*, *Bagobo*, *Tagakaolo*, *Dibabawon*, *Manguangan* and *Mansaka*.

Although the Muslim population or Moro peoples are usually not recognized as IPs in Mindanao, some of the Moro ethnic groups are listed by National Commission on Indigenous People (NCIP) in the IP list. There are seven major Moro groups whose presence in the Mindanao-Sulu area is confirmed and they are: *Maranaw, Maguindanao, Tausug, Yakan, Samal, Iranun and Kalagan*.

The proportion of Christian, Muslims and Lumads to the total population seems to have been basically maintained after the implementation of massive settlement of Christians from Luzon and Visayas to Mindanao. According to Reyes et.al (2016), the proportion of Non-muslim IPs to the total population of Mindanao has increased by nearly 5% between 2000 and 2010, while that of Christians/others has decreased by nearly 6% during the same period. The total population of Mindanao has increased during the same period by nearly 24%.

Ethnicity Group	2000		2010	
	Number	Percent (%)	Number	Percent (%)
Non-muslim IPs	1,595,683	9.1	3,055,950	14.0
Muslim	3,510,569	20.0	4,816,504	22.0
Christian/others	12,469,095	70.9	13,994,061	64.0
All groups	17,575,347	100.0	21,866,515	100.0

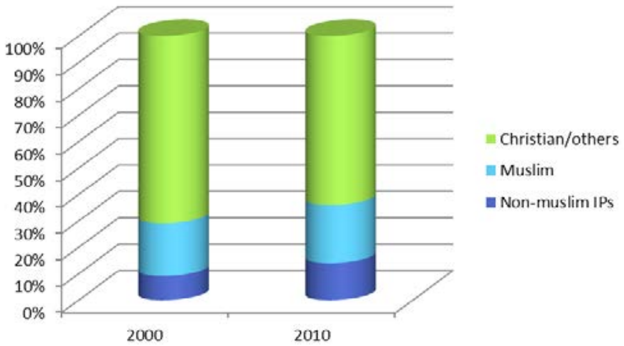


Figure 2.1.30 Ethnic proportion of the population of Mindanao

Source: Reyes et.al. 2016. "Inequality Patterns among ethnic groups in the Philippines"[8]

8 Reyes and her two co-authors analyzed and compared by themselves the data of the Population and Housing Census of the Philippines Statistics Authority for 2000 and 2010.

According to Cariño (2012), in Cotabato and Maguindanao Provinces where the entire MMIP site is located, the presence of eight IP groups is confirmed as shown in Table 2.1.15 right. Tiruray and B'laan are the common groups in both the provinces, and although they are not Muslims, they live in Maguindanao Province which is under the Autonomous Region in Muslim Mindanao (ARMM). However, at the same time, the presence of Moro groups has not been confirmed in Cotabato province, and it can be said that the people are in general living separately depending on their religion.

Table 2.1.15 IP in Cotabato & Maguindanao P.

Cotabato Province	Maguindanao Province
Tiruray	Tiruray
B'laan	B'laan
Aromanon	Maguindanao
Bagobo	Iranon
Ubo Manobo	
Karintik	

Source: Cariño. 2012. "Country Technical Notes on Indigenous Peoples' Issues: REPUBLIC OF THE PHILIPPINES"

2) History of Mindanao

Islam arrived at Sulu area in the last quarter of the 13th Century through Muslim traders, and it gradually took root in the area. The Sulu Sultanate was established in 1451, followed by the Mindanao Sultanate in the 1610s. However, there remained some tribes who did not convert into Muslims.

In 1565, the Spanish colonization of the Philippines started and the Jesuit missions also reached to Mindanao. However, Spaniards faced the resistance from some Muslim and non-Muslim tribes against Spanish ruling and Christianity. Spanish people named those Muslim tribes as Moros after Moors from whom they had recovered their land by force by the end of the 15th Century. Between the 16th and the 19th Centuries there were six wars repeated between Moros and Spaniards. It is said that a sense of hostility or discrimination against Moro people had been nurtured among those Christian Filipinos through this period.

With the Treaty of Paris of 1898, Spain ceded the Philippines to the United States, and Americans also faced resistance of Moros against American rule, yet by 1913 the United States of America unified the Philippines as one country by force. As consequence, Lumads and Moros were grouped under a tribal system, and they also started to lose their lands due to the introduction of the land registration system.

After the independence of the Philippines from the American rule in 1946, massive investment in Mindanao such as plantations of Dole and Del Monte, etc. took place, and a great deal of Lumad lands in Bukidnon-Davao area were given to foreign agribusiness firms. By experiencing development projects that made Lumads displaced from their homeland, such as the hydroelectric project in Mt. Apo, concerns of the Lumads people on their land were raised, and this led to the legislation for the protection of ancestral lands, and in the form of the 1997 Indigenous People's Rights Act (IPRA)[9].

The American rule and the post-independence Philippines government pushed mass migration of Filipino Christian settlers from the Luzon and Visayas island groups to Mindanao. This resulted in the marginalization of Moros and Lumads in the demography in Mindanao, as the proportion of Moros to the total population of Mindanao fell from 76% in 1903 to 22% in 2010. The first settler to Cotabato province came mainly from Cebu to Pikit in as early as 1913, and from Pikit their children moved west-bound to Midsayap and east-bound to Kidawapan.

There is a study which revealed that more than a half of Mindanaon believes that Muslims are probably terrorists and/or extremists (56%) and are prone to run amok (54%)[10], and this may be attributed to repeated wars and violent incidences, in which armed groups composed of members of

[9] ULINDANG, Faina. 2015. LUMAD in Mindanao. Available at: http://ncca.gov.ph/subcommissions/subcommission-on-cultural-heritagesch/historical-research/lumad-in-mindanao/ [Accessed on June 29, 2017]

[10] MONSOD, Toby. 2005. "The bias against Muslims: A creeping perception"

Moro groups have been involved. The sense of historical injustice and disadvantages as consequences motivated some Moro people to fight through the 1950s and the 1960s, and it led to the official formation of the Moro National Liberation Front (MNLF) in 1973.

Following increased violent incidences caused by MNLF, the martial law was declared by the then President on September 21, 1972, and the Mindanao Civil War got fierce. It is told that more than 160,000 were killed over the following decades. The more radical Moro Islamic Liberation Front (MILF) formally split from the MNLF in 1977, and much later, Abu Sayyaf, which seeks a complete independence for Moros, also split from MNLF in 1991.

After more than two decades of conflict period, in 1996, the Government and MNLF signed an agreement and reached a ceasefire in 1997. However, the agreement was not fully implemented, as agreed assistance from the government was not fully provided and the persistence of corruption and violence was seen on both sides. In 2000, President Estrada launched an all-out war against MILF, and it went back to the war again.

The creation of an autonomous region in Muslim Mindanao was enshrined in the 1987 Constitution, and with the enactment of the Republic Act No. 6734 in 1989, also known as Organic Act for the Autonomous Region in Muslim Mindanao, the Autonomous Region in Muslim Mindanao (ARMM) was created with the 4 provinces of Lanao del Sur, Maguindanao, Sulu and Tawi-Tawi. Cotabato Province was to be also included into ARMM, but the Province rejected to be included into ARMM by plebiscite. Later, with the enactment of Republic Act 9054 in 2001, the coverage of ARMM was expanded and it is now composed of the provinces of Basilan, Lanao del Sur, Maguindanao, Sulu and Tawi-Tawi, and the cities of Marawi and Lamitan.

On the 27th of March 2014, through the brokering efforts by foreign countries, such as Malaysia and Japan, MILF and the Government of the Philippines signed the Comprehensive Agreement on the Bangsamoro (CAB), and both MILF and the Government came to a ceasefire. Under CAB, ARMM has been experiencing the transition process toward reinforced autonomy for Moro peoples in the Bangsamoro Core Territory.

The first Bangsamoro Transition Commission (BTC) came up with a Bangsamoro Basic Law (BBL) which stipulates the new political and administrative structure, but it was not passed by Congress, affected by the clash between elite police forces and Moro rebels in Mamasapano, Maguindanao province in 2015. The incumbent President, Rodrigo Duterte, established the new BTC in February 2017 and the new BTC members came up with the new BBL. New BBL was passed by Congress at the end of May 2018 and it is expected that new BBL will be effective with the signing of the President by July 2018. Subsequently, the referendum will be held during 2018 and Bangsamoro transitional government will be established in 2019, if all goes smoothly.

2.1.8 Access to Public Services and Local Governance

1) Impact of the Project in Public Services and Local Governance

The Ex-Post Evaluation of MMIP I conducted from 2014 to 2015 indicated that there were some positive impacts of the project in public service delivery and local governance. For instance, more children going to school, easier access to health services, potable water and social welfare services were recognized by beneficiaries of the project as impact of the access roads constructed under MMIP I. In addition, beneficiaries saw MMIP I had contributed to an increase in household income and creation of employment opportunities as shown in Figure 2.1.31.

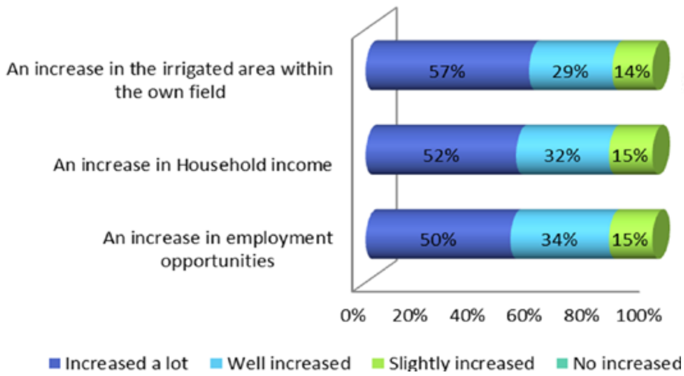


Figure 2.1.31 Positive Impact of MMIP I Confirmed at the Ex-post Evaluation

Source: JICA. 2015. Ex-post Evaluation Report

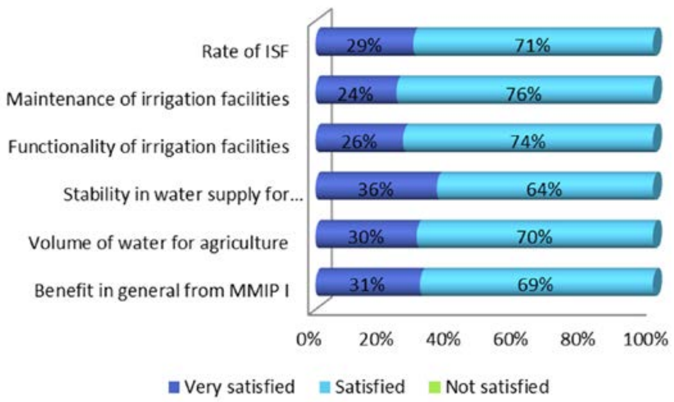


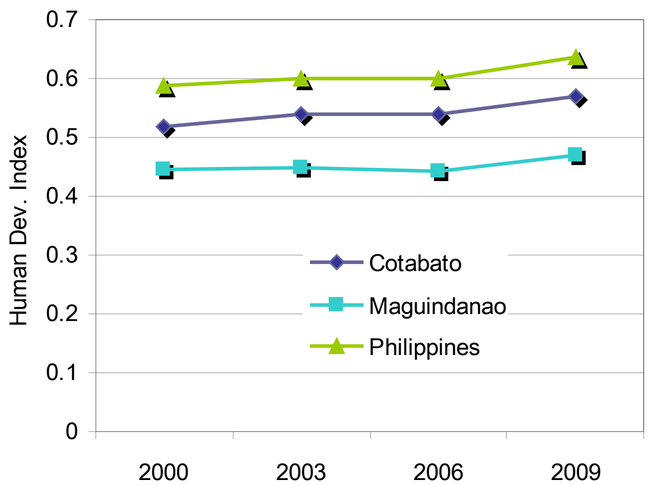
Figure 2.1.32 Degree of Beneficiaries' Satisfaction at the Ex-post Evaluation

Source: JICA. 2015. Ex-post Evaluation Report

Beneficiaries, moreover, expressed their satisfaction with irrigation services provided upon the completion of the construction works of MMIP I as shown in Figure 2.1.32. Such satisfaction among beneficiaries may have attributed to an increase in trust of the local people in the government institutions and enhanced peace and order. It was reported that there were some beneficiaries who had been combatants but stopped being engaged in activities of armed group for farming, since they saw the irrigated agriculture was promising and would satisfy their needs of livelihood.

2) Literature Review

Literatures can illustrate that public services have not yet effectively reached out to the population in the beneficiary areas of the entire MMIP I and II area. For example, according to the Philippines Statistics Authority (PSA)[11], Maguindanao Province took the 5th place (59.4%) and Cotabato Province took the 15th place (48.9%) among the eighty-one provinces in the Country in terms of the poverty incidence as of the first semester of 2015.



	2000	2003	2006	2009
Cotabato	0.518	0.538	0.538	0.570
Maguindanao	0.444	0.450	0.441	0.470
Philippines	0.588	0.601	0.601	0.635

Figure 2.1.33 Improved HD Indices of Cotabato and Maguindanao Provinces

The Human Development Index (HDI) of both Cotabato and Maguindanao Provinces and the entire Country experienced a period of stagnation between 2003 and 2006. Yet, if we compare the HDI value between 2000 and 2009, both the Province as well as the entire country marked a slight improvement (Figure 2.1.33.). However, both provinces still lagged behind from the national average, and the value of HDI of Maguindanao Province has been always worse than that of Cotabato province.

According to the Bangsamoro Development Plan which is recently developed by the Bangsamoro Development Agency upon the signing of the Comprehensive Peace Agreement between MILF and

[11] PSA 2016; 2015 First Semester Official Poverty Statistics

the Government of the Philippines, the ARMM provinces, including Maguindanao, have been ranked among those worst provinces in major social indicators, especially in education, health and WASH (Water, Sanitation and Hygiene).

The Development Plan admits that "the highly inadequate provision of social services is also a major factor in the decline in the overall welfare of the population, which disproportionately affects poor HHs". Table 2.1.16 below shows the comparison of Region XII and ARMM in the situation of the provision of safe water & sanitary toilet. The situation of the access to safe water and sanitary toilet by HHs in Cotabato province is slightly better than the average of the entire Region XII.

Table 2.1.16 Comparison of the Access to Safe Water and Sanitary Toilet in Region XII and ARMM

Area	No. of HH	HH with safe water supply		HH with Sanitary Toilet		Source
		No.	%	No.	%	
ARMM	N/A	N/A	36.60%	N/A	22.50%	Bangsamoro Development Agency. 2015. Bangsamoro Development Plan (as of 2012)
Region XII	945,190	862,040	91.20%	769,435	81.41%	DOH. 2016. FHSIS Annual Report
Cotabato Province	273,166	260,886	95.50%	224,571	82.21%	DOH. 2015. FHSIS Annual Report

Source: Bangsamoro Development Agency, DOH 2015 FHSIS Annual Report

It should be noted that in ARMM, the ARMM Office is the sole public service provider, while in other Regions, the services are provided by the Local Government Units in conjunction with the central government. The responsibility of service provision was together with necessary financial resources devolved by the central government to ARMM.

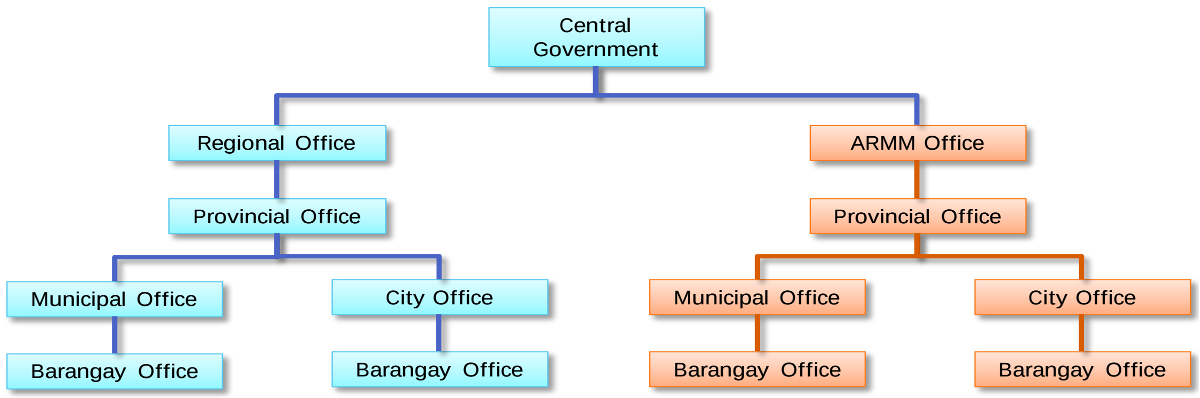


Figure 2.1.34 Government Structure: Differences between ARMM and Other Regional Offices

Source: Drawn by Survey Team based on: Sakuma. 2011. "Status quo and challenges of decentralization in the Philippines"

According to the office of ARMM, the total budget of ARMM has been almost doubled from 2010 to 2014 as seen in Figure 2.1.35 and it can be expected that more population of ARMM has access to basic public services.

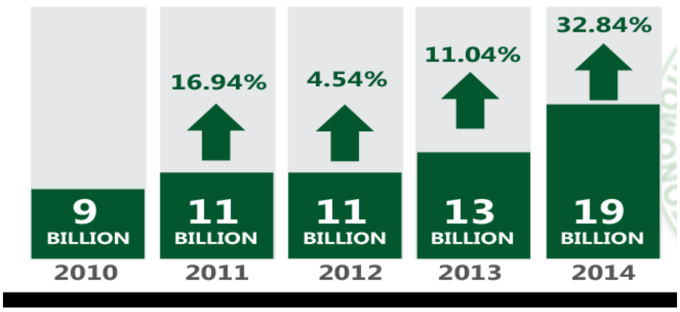


Figure 2.1.35 Budget of ARMM b/t 2010 and 2014 (Unit: PHP)

Source: ARMM. Available at : https://armm.gov.ph/discover-armm/infographics/ [Accessed on June 28, 2017]

Because of the devolution of some functions of the central government, including public service delivery of different sectors, to ARMM, the central government makes budget transfer to the ARMM, which is the portion originally allocated to the government agencies of different sectors as shown in Figure 2.1.36

below. The total transfers from different government agencies amounted to almost PHP 10.3 billion and it is equivalent to almost a half of the total budget of ARMM for the same year.

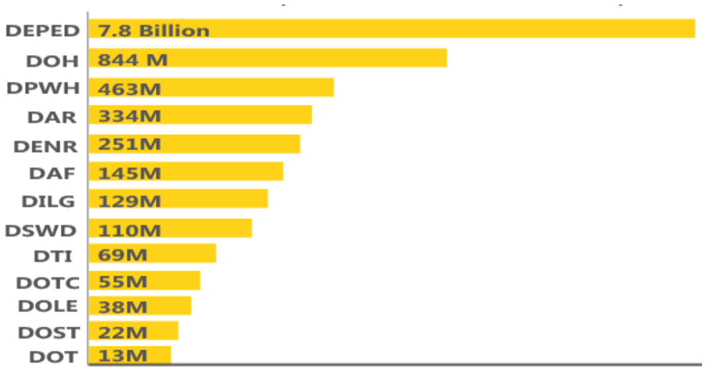


Figure 2.1.36 2014 Budget allocated to ARMM (Unit: PHP)

Source: ARMM. Available at : https://armm.gov.ph/discover-armm/infographics/

Table 2.1.17 Average Years of Schooling in the Philippines & Mindanao

Group	2000	2010
Philippines		
Non-Muslim	5.3	7.8
Muslim	5.0	6.4
Christian/Others	7.2	7.4
Mindanao		
Non-Muslim	3.9	5.1
Muslim	4.9	5.3
Christian/Others	6.7	7.5

Source: Reyes et.al. 2016. "Inequality Patterns among ethnic groups in the Philippines"

On the other hand, Reyes et.al.[12] revealed that they can see inequalities in the public service delivery among the ethnic/ religious groups and within such groups in Mindanao. They compared the situation of schooling, literacy and access to water and sanitation among the Non-Muslim Indigenous Peoples, Muslims and Christians plus others. As seen in Table 2.1.17, Figure 2.1.37 and Figure 2.1.38, inequality among the three groups mentioned above in Mindanao is more significant in schooling, followed by access to water, access to sanitation and literacy.

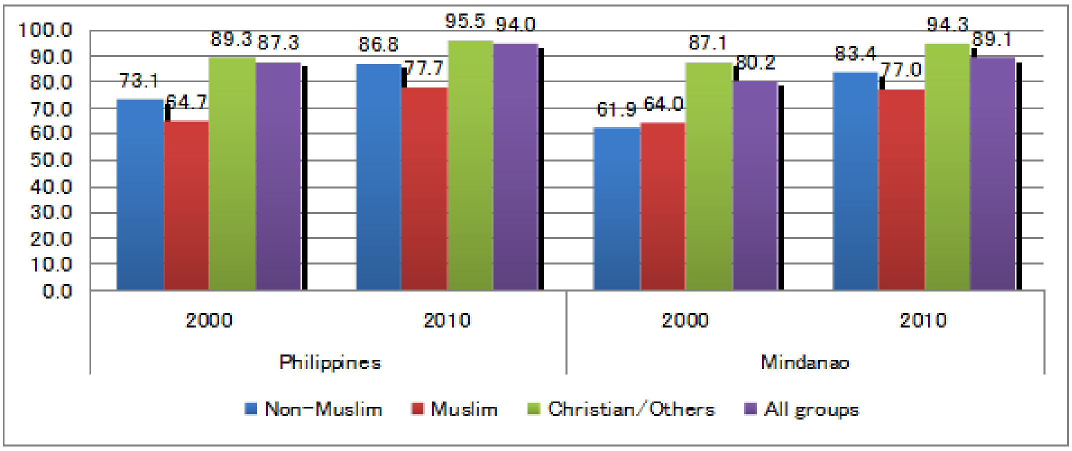


Figure 2.1.37 Inequality among Different Groups in Literacy Rate

Source: Reyes et.al. 2016. "Inequality Patterns among ethnic groups in the Philippines"

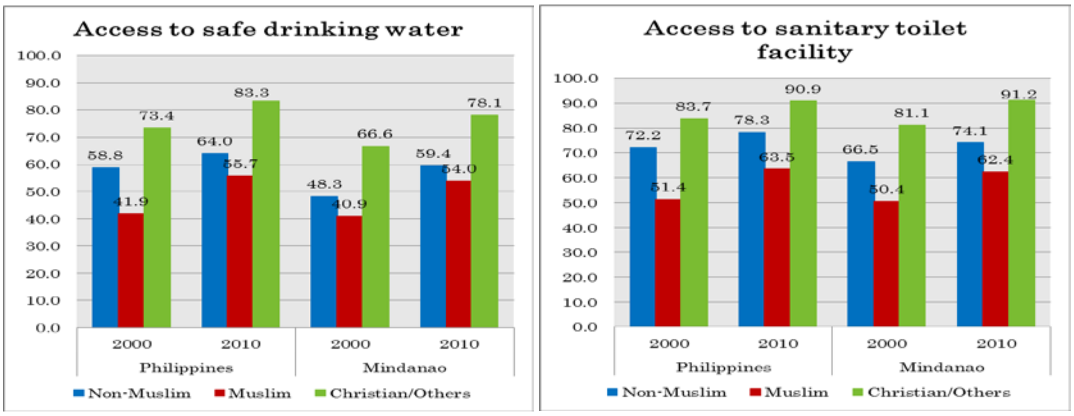


Figure 2.1.38 Inequality among Different Groups in Access to Safe Water & Sanitary Toilet

Source: Reyes et.al. 2016. "Inequality Patterns among ethnic groups in the Philippines"

12 Reyes et.al. 2016. "Inequality Patterns among ethnic groups in the Philippines"

2.2 Liguasan Marsh

2.2.1 Location and Size of the Marsh

Liguasan marsh is the largest marsh in the Philippines. Its size has been reported to be 220,000 to 288,000 ha with 40 km length and 20 km width along Pulangi River (or Mindanao River / Rio Grande). It spans the provinces of Sultan Kudarat and Cotabato in the Central Mindanao and Maguindanao in the Autonomous Region in Muslim Mindanao (ARMM). It is reported that it can serve as natural filters and the flood control for the plains of Cotabato[1] including Cotabato city.

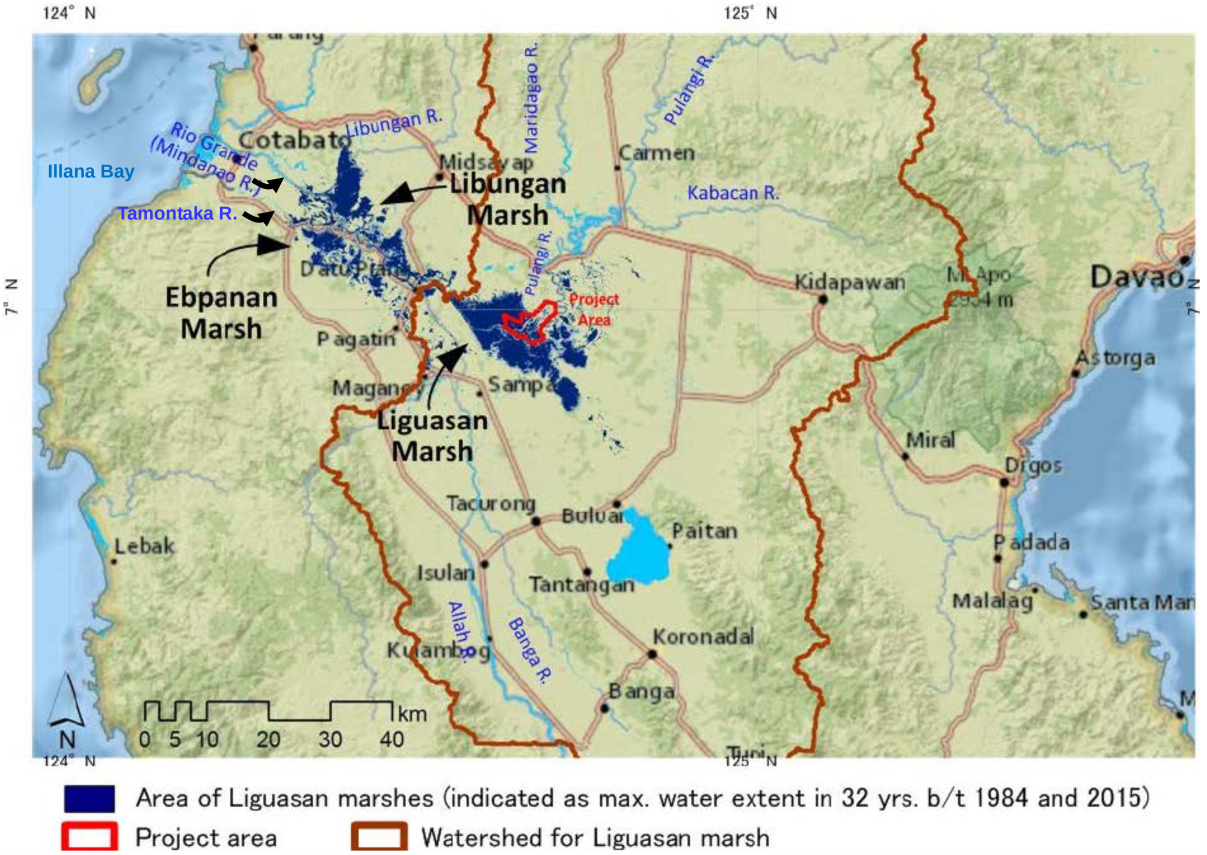


Figure 2.2.1 Marsh Area in Mindanao Basin

Source: JICA Survey Team

In view of hydro-geomorphology, this large area is divided into three adjoining marshes[2]; namely, 1) Liguasan marsh, 2) Libungan marsh and 3) Ebpanan marsh taking into account their water sources and dominant tributaries as flows:

1) Liguasan Marsh constitutes the upper arc of Mindanao river system basin (so-called Cotabato basin) and its surface water is supplied from main course of Pulangi river and its tributaries of Maridagao, Kabacan, Allah rivers and so on. The area covers the municipalities of Pikit, Pagalungan, Datu Montawal, Kabacan, Matalam, M'lang, upper Cotabato that Tulunan, Datu Paglas, Datu Paglat, Sultan sa Barongis, Rajah Buayan, Mamasapano, Datu Salibo and Datu Piang.

2) Libungan Marsh occupies the middle section of Cotabato basin and has own water body supplied by Libungan river as well as Pulangi river, which includes the municipalities of Pigcawayan, Libungan, Midsayap, Upper Kabuntalan and Talayan.

[1] 4th National Report to the Convention on Biological Diversity 2009

[2] The extent area of '220,000 to 288,000 ha with 40 km length and 20 km width' means the 3 areas combined.

3) Ebpanan Marsh is the lower part of Cotabato basin stretching from the lower reach of Allah river and adjoining small streams and covers the areas of Lower Kabuntalan, Dinaig, Sultan Kudarat and Cotabato city.

The three said marshes naturally catch flood waters when the major Pulangi river is swollen due to heavy rains as much as 3,200 mm/year as an average area rainfall in the catchment. From Datu Piang located at Ebpanan marsh, all tributaries turn into single channel i.e. Pulangi river or Mindanao river which then diverts river flow again at the upper Cotabato City into two rivers; namely, Mindanao River and Tamontaka River, and finally the two rivers pour into Illana Bay.

The Project area is located at a middle part facing north-eastern side of Liguasan marsh, which is connected with a narrow channel to Libungan marsh especially in dry season. However, in the event of flooding, marsh water is dammed-up due to the narrow channel being unable to flow out the flood water towards downstream, and thus raised water spreads over or back into the marsh area. The inundated water is then gradually discharged to the downstream Libungan marsh and further to Ebpanan marsh for long time period.

On the other hand, among the surrounding area of the marsh, forests had been cleared without much provisions of reforestation. Logging has welcomed the settlers and remaining forests have been further cut for the reclamation for agricultural use. In addition, a man-made channel from Pulangi and Kabacan river to Liguasan Marsh was constructed in Tungol in early 1980s and it redirected the river water into new agriculture land which was developed at the foreland of the original marshy area (see Figure 2.2.2).

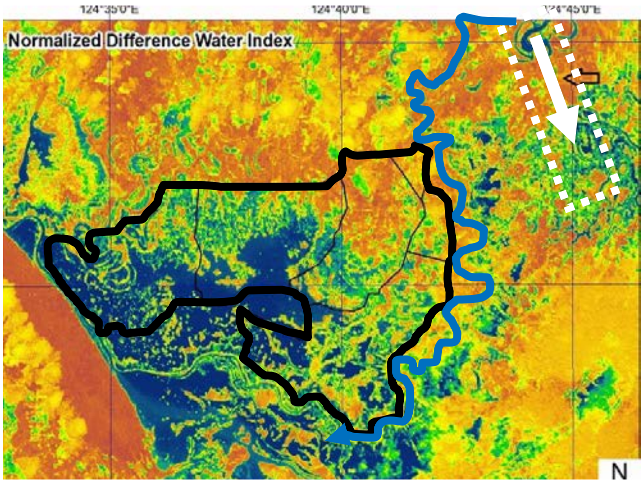


Figure 2.2.2 Diversion Channel and the Project Area

Source: JICA Survey Team

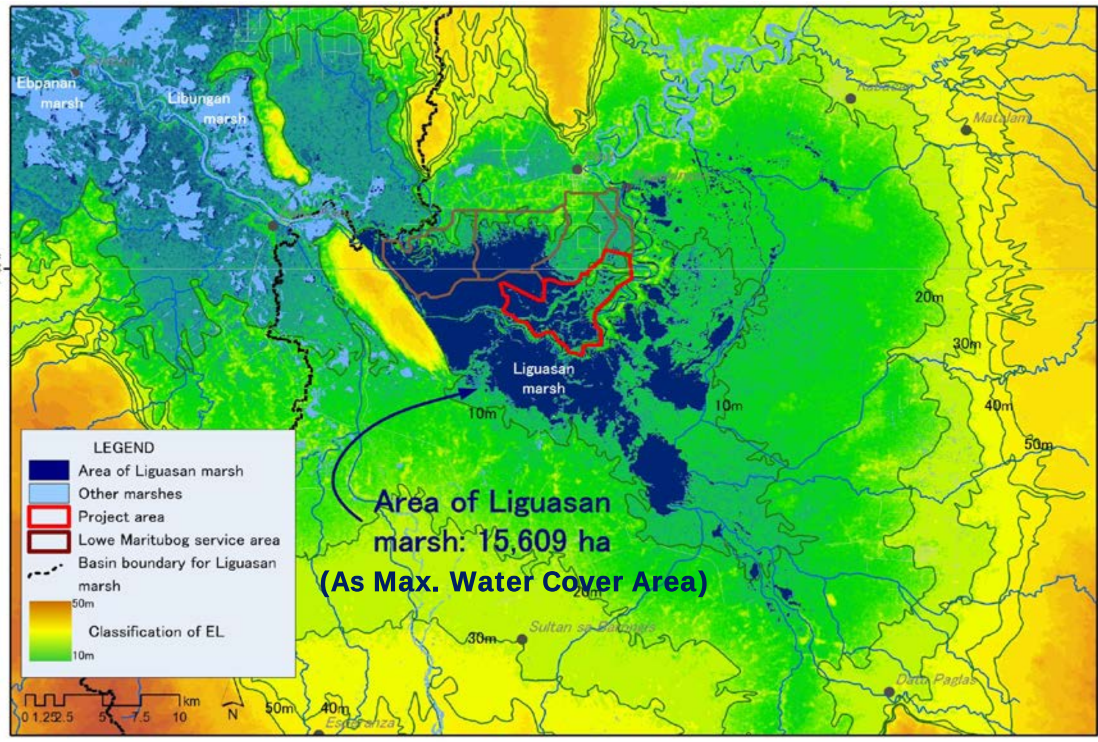


Figure 2.2.3 Location and Size of Liguasan Marsh (as max. extent of water cover)

Source: JICA Survey Team

As for the historical change around the marsh, the unpredictable water extent of Liguasan marsh is traceable with temporal 16-day interval satellite data by defining on-time extents. In Figure 2.2.3, the maximum water extent in 32 years from 1984 to 2015 is illustrated as composite image of historical extents. With the image analysis, the maximum surface water area of Liguasan marsh is estimated at 15,609 ha, which is less than 7 % of the reported whole marsh area of 220,000 to 280,000 ha. The extent of surface water will be regarded as an influencing area to the MMIP II area, especially Lower Malitubog Service Area (LMSA), and its related facilities to be constructed.

2.2.2 Ecology of the Marsh

Liguasan Marsh is a wetland ecosystem, which performs significant ecological functions. The presence of Liguasan Marsh in fact reduces the impact of flood in the Cotabato River Basin. During high flood, the marsh absorbs floodwater as a natural flood detention reservoir. The marsh also functions as natural filter. Sediment load carried by the floods are deposited and filtered in the Marsh, thus maintaining the stability of the river system. Plants in the marsh absorb excess nitrogen and phosphorous from sewerage and other pollution causing effluents.

The plant species that are native to the marsh, and of important economic value, are the sago palm (*Metroxylon*), tikog (*Fimbristylis littoratis*) and baino (Nelumbo nucifera). Sago palm is the source of sago flour tapioca gel and the tikog is a material for mats. The baino fruit is sold in Maguindanao town markets. The marsh has plenty of floating, emergent, submerged and microscopic floral wonders. Common floating vegetation is *kangkong*, *water hyacinths*, *kiapo* and *water lily*. Submerged vegetation is represented by *digman* or *hydrilla* and *chara*, among any others.

The marsh is identified as Important Bird Area (IBA) by the Bird Life International[3]. The criteria for the selection as IBA are”A1: *The site is known or thought regularly to hold significant numbers of a globally threatened species*" and ”A4iii: *The site is known or thought to hold, on a regular basis, at least 20,000 water birds, or at least 10,000 pairs of seabird, of one or more species.*” In addition, 128 sites of Key Biodiversity Area (KBA) have been identified in the Philippines, and the Liguasan Marsh is registered as a KBA also[4]. However, restriction of development or protection of the Liguasan Marsh is not legally stipulated in the Philippines. It is noted that the marsh is not registered as a Ramsar Convention on Wetlands site.

Liguasan Marsh has a rich biodiversity, and it is known as a home of endemic species of flora and fauna and it provides feeding ground for various migratory birds. The numbers of species of fish, amphibian, reptile, bird and mammal, which range in the marsh, are 33, 7, 12, 53 and 11 (see Appendix VIII). A large reptile, crocodile (*Crocodylus porosus*) or Philippine Duck (*Anas luzonica*) have been identified in the marsh. Of them, some species are endangered according to the IUCN red list, 4 species of “Near Threatened” and 6 species of “Vulnerable”, as they are shown in the following table.

Table 2.2.1 Endangered Species in Liguasan Marsh

Class	English Name	Scientific Name	IUCN Category
Fish	Tilapia Mozambique	*Oreochromis mossambicus*	Near Threatened
	Celebes eel	*Anguilla celebesensis*	Near Threatened
	Eel	*Anguilla spengeli*	Near Threatened
	Common Carp	*Cyprenius carpio*	Vulnerable
Amphibian	None	None	None
Reptile	Malay Pond Turtle	*Cuora amboinensis*	Vulnerable

3 Bird Life International: An environmental NGO for bird conservation, which was established in1922 in the UK, and the NGO has 122 partners worldwide, one per country/region.

4 Source: “Priority Sites for Conservation in the Philippines, Key Biodiversity Areas”, Conservation International Philippines

Class	English Name	Scientific Name	IUCN Category
	Sailfin Lizards	*Hydrosaurus postulosus*	Vulnerable
Bird	Philippine Duck	*Anas luzonica*	Vulnerable
Mammal	Philippine Tarsier	*Tarsius syrichta*	Near threatened
	Philippine Wild Pig	*Sus philippensis*	Vulnerable
	Philippine Deer	*Cervus marianus*	Vulnerable

Note: **Vulnerable**: it is considered to be facing a high risk of extinction in the wild (Risk is more than that of **Near Threatened**)

Near Threatened: it does not qualify for **Critically Endangered**, **Endangered** or **Vulnerable** now, but is close to qualifying for or is likely to qualify for a threatened category in the near future.

Source: National Economic and Development Authority Region XII. 1998. Liguasan Marsh Development Master Plan 1999 - 2025 Volume III, Database, Project Profiles, and Annexes.

2.2.3 People Living on the Marsh

1) Overview

Liguasan Marsh is actually a conglobation of three marshes: Liguasan, Libungan and Ebpanan. It lies in the basin of the Mindanao river in south-central Mindanao spanning the provinces of Sultan Kudarat and Cotabato in Region XII, and the Maguindanao province in ARMM. It is a natural and ecological resource rich area, and for some Lumad people is the place of origin of lives. Not only fauna and flora, but also people are living within the Liguasan marsh area, despite frequent flooding attributing to its geographical feature.

The "Liguasan Marsh Development Master Plan 1999-2025" prepared by the National Economic and Development Authority Regional Office XII estimated the total population in the Liguasan Marsh at 258,486 with 48,577 families (5.32 persons/family), based on the results of the 1995 Census of Population. The said Master Plan was developed to cover the Marsh spreading over 191 Barangays of 19 Municipalities and 1 City over 3 Provinces, namely, Cotabato and Sultan Kudarat Provinces from Region XII and Maguindanao Province from ARMM.

Based on the results of the 2015 Census of Population of the Philippines Statistics Authority (PSA), the population of the Liguasan Marsh today can be estimated at almost 582,000[5]. It is noted that in the estimation, proportional area ratio between the Liguasan marsh (280,000 ha) and that of 22 municipalities and one city as shown in Table 2.2.2 below were applied.

Table 2.2.2 Overview of the Municipalities and City in the Liguasan Marsh

No.	Province/Region	Municipality & City	Population	Land Area (ha)	Population Density (persons/km^2)
1	COTABATO/ REGION XII	KABACAN	89,161	44,809	198.98
2		LIBUNGAN	48,768	17,250	282.71
3		MATALAM	79,361	47,600	166.72
4		MIDSAYAP	151,684	29,042	522.29
5		M'LANG	95,070	31,213	304.58
6		PIGKAWAYAN	66,796	34,011	196.40
7		PIKIT	154,441	60,461	255.44
8		TULUNAN	56,513	34,308	164.72
9		COTABATO CITY	299,438	17,600	1,701.35
10	MAGUINDANAO/ ARMM	DATU PAGLAS	28,387	13,210	214.89
11		DATU PIANG	25,600	30,297	84.50
12		DATU ODIN SINSUAT (DINAIG)	99,210	46,180	214.83
13		PAGALUNGAN	39,653	89,876	44.12
14		SULTAN KUDARAT (NULING)	95,201	71,291	133.54

[5] As the Team was unable to obtain reliable secondary data on recent population in the Liguasan Marsh, estimation was done. Accordingly, the total population and the total land area of the 22 Municipalities and 1 City where the Liguasan Marsh is situated are 1,538,387 and 740,316ha, respectively, according to the 2015 Population Census conducted by the Philippines Statistics Authority. Assuming the total are of the Marsh as 280,000ha, the Marsh occupies almost 37.82% of the total land area of the said 22 Municipalities and 1 City. Applying this proportion of 37.82% to the total population of 1,538, 387, we came to estimate the today's population of the Marsh at 581,844.

No.	Province/Region	Municipality & City	Population	Land Area (ha)	Population Density (persons/km^2)
15		SULTAN SA BARONGIS (LAMBAYONG)	22,425	29,130	76.98
16		KABUNTALAN (TUMBAO)	17,276	37,108	46.56
17		TALAYAN	30,032	14,384	208.79
18		MAMASAPANO	24,800	8,531	290.70
19		PAGAGAWAN	34,820	46,110	75.52
20		PAGLAT	15,920	17,774	89.57
21		RAJAH BUAYAN	23,652	7,198	328.59
22		NORTHERN KABUNTALAN	25,232	10,677	236.32
23		DATU SALIBO	14,947	2,256	663.54
TOTAL			**1,538,387**	**740,316**	**207.80**
TOTAL excluding Cotabato city			**1,238,949**	**722,716**	**171.43**

Source: PSA. 2015 Census of Population

The average population density among the 22 Municipalities (except for Cotabato City) is as high as 171 persons/km^2, although the population density varies from 44 persons/km^2 in Pagalungan Municipality, Maguindanao Province to 522 persons/km^2 in Midsayap Municipality, Cotabato Province. Such a relatively high population density may imply that many people living in the Liguasan Marsh may know how to cope with or utilize impact of frequent flooding.

2) Livelihoods

Inland fisheries activities are popular in Liguasan Marsh and gill-nets are the common tool to be utilized by local population to catch fish, such as tilapia, carp, mudfish, freshwater goby, and freshwater shrimp6. Other than the marsh areas, flat lowland is already used for paddy (palay) cultivation, especially during the dry seasons. The impact of inland fisheries and agriculture on household income in this area has been confirmed by a household economic survey under this JICA survey (see 2.1.6 Regional and Barangay (Household) Economies).

The economic survey had covered total 9 Barangays, of which 2 Barangays e.g. Buliok and Talitay are located in most east-southern parts of LMSA where the livelihood may be similar to that of the people living in and around Liguasan Marsh. Figure 2.2.4 summarizes the percentage of income share by means of source. As is shown, what comes first is cropping with 33%, followed by self-employed/ cottage industry (27%), migrant work (19%) and then fisheries and aquaculture with 12%.

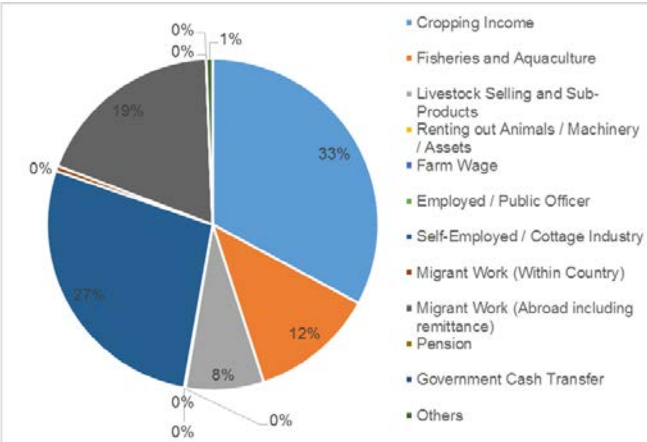


Figure 2.2.4 Income Source for Buliok and Talitay Barangays
Source: Household Economic Survey (JICA Team)

On the other hand, a high potential of the existence of some mining resource in the Liguasan Marsh has drawn attention of some people. It has been reported that there is a natural gas reserve in Maguindanao province[7], although it has not been fully explored yet, since the last known exploration work was done in 1997, by the Malaysian petroleum giant Petronas Carigali and the Philippine National Oil Company. It is also said that 108,000,000 MT coal deposits could exist in the same province[8]. If feasibility studies are conducted and economic feasibility in the exploitation of such natural resources is confirmed, it will surely affect the regional economy.

6 RECS International Inc. et. al. 2016. Final Report, Development Plan for the Bangsamoro, Comprehensive Capacity Development Project for the Bangsamoro.
7 Idem.
8 Bangsamoro Development Ageny. 2015. Bangsamoro Development Plan.

2.3 Agriculture and Extension Services in the Project Area

2.3.1 Agricultural Land Use and Soils

Comprehensive information about crop production, such as planted/harvested area and production of major crops, is not available in the project area. It is, therefore, considered that a statistical data of crop production in Pikit Municipality could be utilized as proxy data on the crop production in the project area with the following reasons:

- ✓ While the project area spreads over 56 Barangays, 39 Barangays among them are located within the Pikit Municipality;
- ✓ While there are a total of 42 Barangays in the Pikit Municipality, 39 Barangays among them are located in the project area,
- ✓ As indicated in Figure 2.3.1, most of the MMIP area falls within the jurisdiction of the Municipality, except the Pagalungan Service Area located in Pagalungan Municipality and the Maridagao Service Area in Carmen, Kabacan/ Datu Montawal and Pagalungan Municipalities.

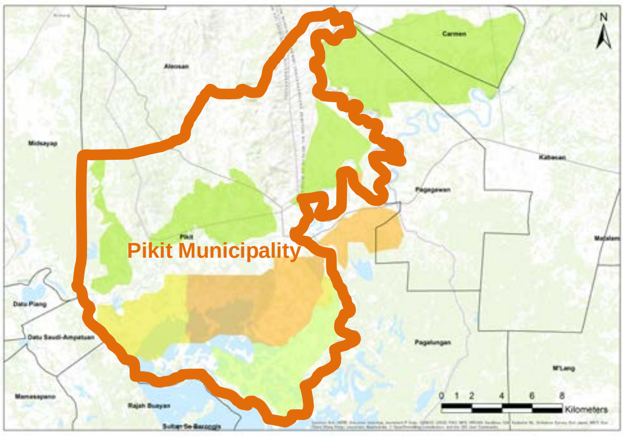


Figure 2.3.1 Pikit Municipality and MMIP Area

Source: UNOCHA, JICA Survey Team

Table 2.3.1 Crop Production in Pikit Municipality (Average between 2014 and 2016)

No	Crop	Harvested Area (ha)	Harvested Area (%)	Yield (ton/ha)	Production (ton)
1	Paddy, irrigated	1,936.4	9.4	4.5	8,772.6
2	Paddy, rain-fed	3,986.3	19.4	3.5	14,113.4
	Paddy, total	**5,922.7**	**28.8**	**3.9**	**22,886.0**
3	Corn, yellow	1,209.0	5.9	4.2	5,127.1
4	Corn, white	6,184.6	30.0	3.9	23,925.7
	Corn, total	**7,393.6**	**35.9**	**3.9**[1]	**29,052.8**
5	Root crops	76.4	0.4	-	-
6	Mung Bean	556.8	2.7	0.8	445.4
7	Squash	180.2	0.9	2.0	360.4
8	Bitter Gourd	65.3	0.3	3.3	167.0
9	Egg Plant	68.6	0.3	3.0	205.8
10	Miscellaneous vegetables	82.4	0.4	-	-
11	Sugarcane	196.8	1.0	48.0	9,446.4
	Root, vegetables, etc.	**1,226.5**	**6.0**	-	-
12	Coconut	**4,684.3**	**22.7**	**3.6**	**16,863.5**
13	Mango	820.6	4.0	2.5	2,051.5
14	Oil Palm	206.9	1.0	24.0	4,965.6
15	Rubber	109.8	0.5	2.4	263.5
16	Banana	96.0	0.5	14.5	1,392.0
17	Miscellaneous fruits	136.3	0.7	-	-
	Fruits & tree crops, total	**6,053.9**	**29.4**	-	-
	Total	**20,596.7**	**100.0**	-	-

Source: Office of the Provincial Agronomist, Cotabato Province

Table 2.3.1 shows the production of major crops in Pikit Municipality. Maize and paddy are the two leading crops planted terms of the harvested area which accounts to 65% of the total harvested area among the major crops. Coconut comes third as the most important crop cultivated in the area. The three occupy as much as 87% of the total harvested area. The other crops such as root crops, pulses, vegetables, etc. accounts for only 6% of the total area, and mung-bean, squash, eggplant, bitter-gourd

[1] This shows very high productivity of corn, for the both of white corn and yellow corn, in the area comparing to the statistical data of the Philippine Statistics Authority. An additional verification may be necessary.

and sugarcane are grown to only some extent in the area.

Corn exceeds paddy in terms of planted area by 1,472 ha. It is also interesting that the area of white corn is more than 5 times of the area of yellow corn, though the condition is in the opposite trend in Cotabato Province to which Pikit Municipality belongs. Cropping in Pikit Municipality could be influenced by adjacent areas in ARMM where white corn is widely grown. White corn is mainly consumed as food, while yellow corn is for animal feed in the Philippines.

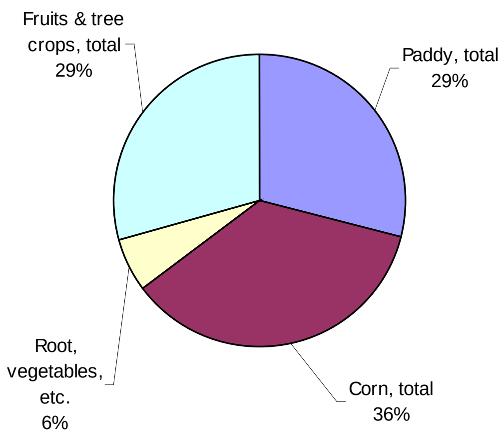


Figure 2.3.2 Share of Harvested Area

Source: Provincial Agronomist

In addition, the Christian population of Pikit, who are mainly immigrants from the Visayas region, particularly from the corn-eating province of Cebu. White corn is also likely sold at higher price as its main markets are found in the Visayas.

Coconut is fairly dominant among perennial crops in terms of harvested area, which is 4,684 ha in total, sharing 23% of the overall area. On the other hand, oil palm, rubber and banana, which are suitable for plantation farming and famous production in Mindanao, remain very weak in this area in terms of the harvested area. In fact, the harvested areas of the oil palm, rubber and banana share only 1.0%, 0.5%, and 0.5% respectively.

It is assumed that the majority of farmers depend on subsistence farming by producing mainly staple food such as rice and corn, and may earn limited cash income from surplus cereals. In addition to the surplus cereals, coconut production, which shares 23% of the crop area, may supplement the cash income to a certain extent, and further to some extent, other fruits and seasonal farm-labor works may contribute to cash income. Off-farm works may be an important cash income source for many farmers.

The crops presented in the previous table are grown on soils summarized in Table 2.3.2 showing soil types in the relevant 5 municipalities such as Carmen, Pikit, Aleosan, Datu Montawal and Pagalungan. Kabacan, Aroman and Hydrosol are major soil types in the 5 municipalities. Kabacan and Hydrosol including Kidapawan could be dominant soil types in alluvial plain where farming lands are widely developed in the area, as Aroman soils are formed in hilly to mountainous landscape such as in Carmen.

Table 2.3.2 Soil Types in 5 Municipalities in the Project Area

Soil Type	Municipality										Total	
	Carmen		Pikit		Aleosan		D. Montawal		Pagalungan			
	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Kabacan	25,865	23.3	36,829	60.9	1,520	6.2	39,848	86.4	12,641	14.1	116,703	35.2
Aroman	51,335	46.2	2,431	4.0	1,440	5.9	0	0.0	0	0.0	55,206	16.6
Tacloban	7,683	6.9	0	0.0	0	0.0	0	0.0	0	0.0	7,683	2.3
Faraon	21,940	19.8	0	0.0	2,240	9.2	0	0.0	0	0.0	24,180	7.3
Kidapawan	4,229	3.8	0	0.0	0	0.0	0	0.0	0	0.0	4,229	1.3
Hydrosol	0	0.0	10,714	17.7	0	0.0	6,262	13.6	64,240	71.5	81,216	24.5
Kudarangan	0	0.0	10,487	17.3	19,250	78.7	0	0.0	0	0.0	29,737	9.0
Clay Loam	0	0.0	0	0.0	0	0.0	0	0.0	12,995	14.5	12,995	3.9
Total	111,052	100.0	60,461	100.0	24,450	100.0	46,110	100.0	89,876	100.0	331,949	100.0

Source: 5 LGUs

Remark: In fact, “Clay Loam” is defined as one of soil texture not soil type. Since data obtained from Municipality of Pagalungan also categorized it as soil type, the table also includes it into the soil type.

The nature of the major soil types are summarized as follows:

- ✓ Kabacan soil: The soil is categorized in *Entisol*, and the texture is clay loam. It is formulated by recently deposited materials in hilly to mountainous landscape, and only weak profile has developed. Diversified crops, fruit trees, paddy rice, coconuts are grown in the alluvial plain on the hilly to the mountainous landscape areas.
- ✓ Hydrosol/Kidapawan soil: The both soils are categorized in *Hydrosol*, and the texture is clay to clay loam. They are mainly formulated in the alluvial plain along the rivers. The soils are poorly drained and a range of seasonally or permanently wet soils can be the character, subject to regular flooding. They occur on level to gently alluvial plain and derived from alluvial deposits. Nipa palm and mangroves are indigenous vegetation in marshes. Oil palm farms have been successfully developed in some areas of Mindanao including the Project area.
- ✓ Aroman soil: The soil is categorized in *Entisol*, and the texture is sandy loam to sandy. The soil properties are well drained, structure-less and slightly compacted. Diversified crops, e.g. paddy rice, corn, vegetables, beans, mung bean, cassava, sweet potato, palms, fruit are grown in the area.

2.3.2 Agricultural Land Use by Satellite Image Analysis

The JICA team analyzed satellite images in order to clarify cropping area in the MMIP area. As is mentioned in the previous section, the main crops in the MMIP area are paddy and maize, tree crops e.g. coconut tree, while production of vegetables is relatively limited. The analysis focused on detecting cropping area of paddy and maize in the rainy season and the dry season. Described in this section is the planted area of rice and maize, together with tree crop and forestry area, swampy land area and open water surface area, in the MMIP area in 2015-2016 cropping season.

1) Satellite Images Applied for the Analysis

In this satellite analysis, the Team exploited free satellite images which are available on the internet. The images were obtained from 2 types of satellites; namely, one is Landsat 8 satellites operated by National Aeronautics and Space Administration (NASA) and United States Geological Survey (USGS) and the other is Sentinel-2A satellite launched by European Space Agency (ESA).

Table 2.3.3 Wavelength and Spatial Resolution of LANDSAT8/OLI and SENTINEL-2A/MSI

Landsat 8			Sentinel-2A		
Band No	Wavelength Range, μm	Resolution	Band No	Central Wavelength, μm	Resolution
OLI 1	0.433–0.453(coastal/aerosol)	30 m	MSI 1	0.443 (aerosol)	60m
OLI 2	0.450–0.515(blue)	30 m	MSI 2	0.490 (blue)	10m
OLI 3	0.525–0.600(green)	30 m	MSI 3	0.560 (green)	10m
OLI 4	0.630–0.680(red)	30 m	MSI 4	0.665 (red)	10m
-	-	-	MSI 5	0.705 (vegetation classification)	20m
-	-	-	MSI 6	0.740 (vegetation classification)	20m
-	-	-	MSI 7	0.783 (vegetation classification)	20m
OLI 5	0.845–0.885(NIR)	30 m	MSI 8	0.842 (NIR)	10m
-	-	-	MSI 8A	0.865 (vegetation classification)	20m
-	-	-	MSI 9	0.945 (water vapor)	60m
-	-	-	MSI 10	1.375 (cirrus)	60m
OLI 6	1.560–1.660(SWIR-1)	30 m	MSI 11	1.610 (SWIR)	20m
OLI 7	2.100–2.300(SWIR-2)	30 m	-	-	-
OLI 8	0.500–0.680(Pan)	15 m	-	-	-
OLI 9	1.360–1.390(Cirrus)	30 m	-	-	-
-	-	-	MSI 12	2.190 (snow/ice/cloud)	20m

Source: https://landsat.usgs.gov/what-are-band-designations-landsat-satellites
https://earth.esa.int/web/sentinel/user-guides/sentinel-2-msi/resolutions/spatial

The imaging sensor called Operation Land Imager (OLI) is on board of Landsat 8 and Multispectral Instrument (MSI) is mounted on Sentinel-2A. Both of them are kinds of the multispectral imaging sensor. Table 2.3.3 presents wavelength and spatial resolution of each band in the OLI Level-1 product and the MSI Level-1C product. The highlighted four-band combinations shown in Table 2.3.3 were utilized for this analysis.

2) Methodology and Algorithm

The Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Water Index (NDWI) were calculated by surface reflectance of Blue, Red, Near Infrared (NIR), and Short Wave Infrared (SWIR) band. NDVI is sensitive to the active photosynthetic compounds and is therefore utilized to measure the productivity of vegetation or greenness. NDVI is calculated by using the two bands of the electromagnetic spectrum, i.e. the visible red (OLI 4 and MSI 4) and the near-infrared (OLI 5 and MSI 8). NDWI enhances the spectral reflectance of surface water bodies, which uses differences of two bands, i.e. the visible green (OLI 3 and MSI 3) and the SWIR (OLI 6 and MSI 11) in the analysis.

In the analysis, continuous change of NDVI and NDWI in the cropping season was employed. The figure below shows the assumed cropping pattern in the Project area and its NDVI change and NDWI change; namely, tree crop is existence throughout year; irrigated paddy can be seen twice a year, e.g. rainy season and dry season, and maize can be planted anytime due to availability of rain almost continuously throughout year, thus it can mostly be dense three times in the analyzed season.

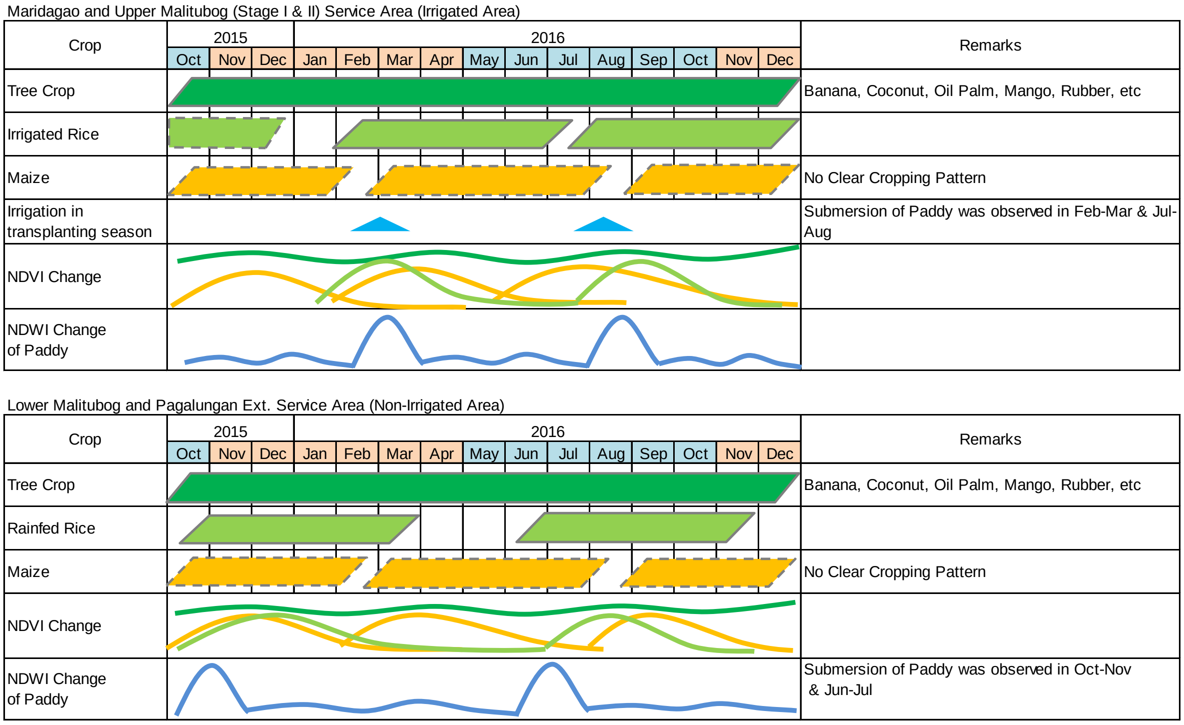


Figure 2.3.3 Assumed Cropping Pattern and Example of NDVI and NDWI Changes

Source: JICA Survey Team

During the cropping season, paddy, maize and tree crops, e.g. coconut, mango, rubber, and oil palm are planted in the MMIP area. To classify the crop, the range of NDVI change and the high NDWI, i.e. existing of water surface must be observed. Regarding tree crop and forest, its NDVI keeps high value, so its range of NDVI change becomes low. For paddy and maize area, NDVI changes from low value before planting season to high value in maturing season and low value through harvesting season.

To distinguish paddy from crop planted area including maize, the submersion of paddy field is the key factor for the distinction between the paddy and maize. If high NDWI value can be observed during the beginning of cropping period, it is most probable that paddy must be planted in the area. On the other hand, if no water body can be detected by NDWI in the area, farmers must be producing maize in that area. With regard to the non-cropped area, the change of NDVI should be middle.

To classify each area, the threshold values of NDVI and NDWI have to be set. The threshold differs in each irrigation service area and by each season. It was mainly decided by Jenks Natural Breaks algorithm, in which the threshold is set at the value of high variation on the distribution curve of NDVI or NDWI covering the target area. The threshold decided by Jenks Natural Breaks algorithm was increased or decreased slightly as required on the basis of the ground truth or the satellite images available on Google Earth. Figure 2.3.4 shows the basic flowchart in exposing each cropping area:

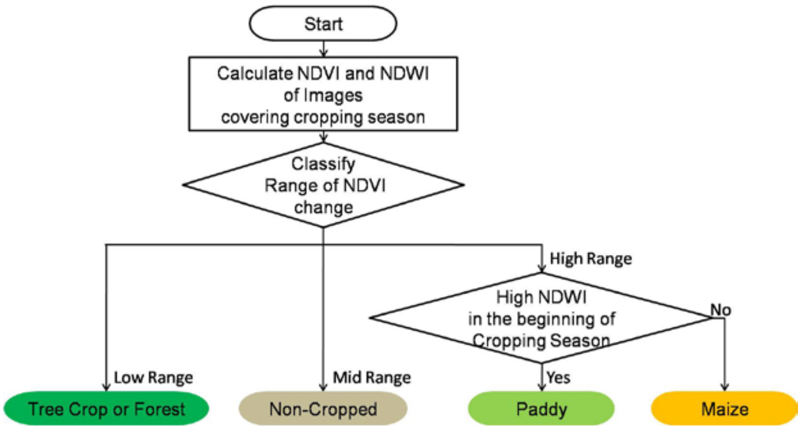


Figure 2.3.4 Basic Flowchart for Identifying Each Cropped Area
Source: JICA Survey Team

3) Quantitative Evaluation of Agricultural Land Use in the Irrigation Service Area

Table 2.3.4 below shows the result of the analysis, following which summary and the map of the agricultural land use in each irrigation service area are elaborated. Note that the map shows each of the irrigation areas plus 1,000-meter distance area (buffer area) in order for the readers to understand the spatial positioning visually.

Table 2.3.4 Agricultural Land Use Area in Each Irrigation Service Area by Satellite Image Analysis (ha)

Service Area	Stage	Starting Year	Season	Gross Area[1]	Cropped		Non-Cropped	Tree Crop, Forest	Swampy Land[2]	Open Water
					Paddy	Maize				
Maridagao	I	-	Rainy	6,433	1,863	1,394	1,615	843	706	12
			Dry	6,433	1,991	1,298	1,583	843	706	12
Upper Malitubog	I	-	Rainy	1,675	729	357	395	188	0	6
			Dry	1,674	845	235	400	188	0	6
	II	-	Rainy	3,600	789	716	1,781	291	23	0
			Dry	3,599	698	888	1,699	291	23	0
Lower Malitubog	II	Whole	Rainy	9,204	511	1,510	4,140	1,461	194	1,388
			Dry	9,203	655	1,071	5,595	1,530	337	15
		2015	Rainy	1,748	65	300	973	387	6	17
			Dry	1,748	14	246	1,097	388	3	0
		2016	Rainy	2,348	150	286	1,206	442	12	252
			Dry	2,349	209	295	1,365	454	26	0
		2017	Rainy	2,503	136	417	785	370	92	703
			Dry	2,503	245	160	1,434	394	255	15
		ODA	Rainy	2,605	160	507	1,176	262	84	416
			Dry	2,603	187	370	1,699	294	53	0
Pagalungan Ext.	II	-	Rainy	1,248	164	184	705	195	0	0
			Dry	1,248	87	273	693	195	0	0

Source: JICA Survey Team
Remark: 1) The Difference of Gross Area between rainy season and dry season was caused by the calculation process on GIS software. 2) Swampy Land of Maridagao, Upper Malitubog, and Pagalungan Service Area was visually identified on GIS with Google Earth. While, in case of Lower Malitubog SA, it was classified by NDVI change.

The availability of irrigation water in MSA and UMSA render their paddy areas to be larger than that of maize since the construction of irrigation facilities in these service areas had been completed through MMIP I. In UMSA under MMIP II, paddy area is almost equivalent to the maize area though construction of the Project had been carried out. This indicates that the irrigation water had not sufficiently reached UMSA in 2016.

On the other hand, the maize cropped area exceeds that of paddy in non-irrigated area, i.e. LMSA and PSA as the irrigation facilities are still under construction or to be constructed in 2017 and onwards. Especially in originally requested ODA target area of LMSA, the paddy cropped area is only 160 ha and 187 ha as compared to 507 ha and 370 ha of maize cropped area in rainy season and dry season, respectively.

3.1) Phase 1 Maridagao Service Area

MSA, being an irrigated area, relatively exhibits vast rice production (Figure 2.3.5) where 1,863 ha and 1,991 ha in rainy season and dry season respectively, which are covering 57% and 60% of the cropped area including paddy and maize. The major difference of cropped area between rainy season and dry season can not be seen in this area. It might be concluded that the irrigation water stabilizes the rice production of this area.

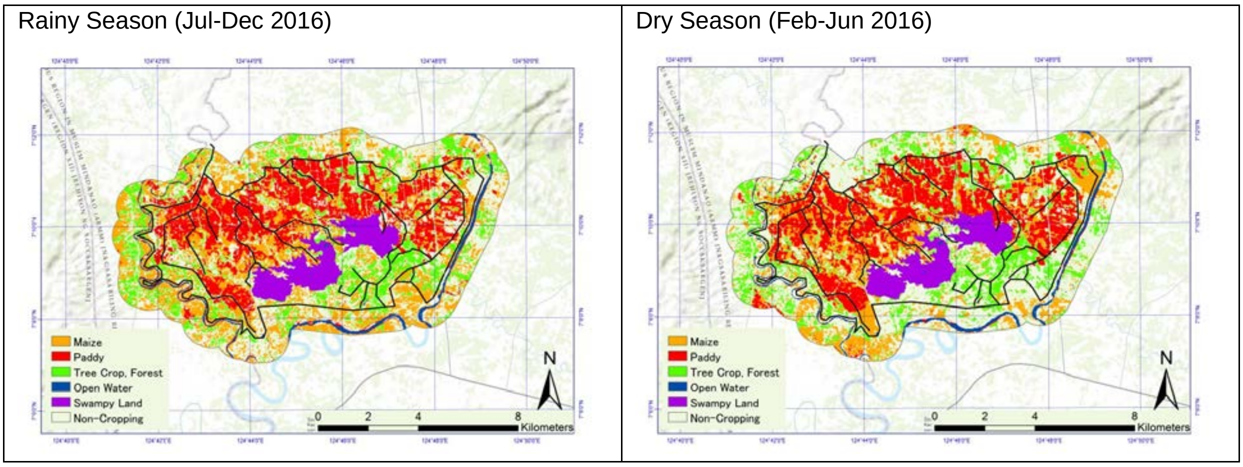


Figure 2.3.5 Agricultural Land Use of MSA in 2016
Source: JICA Survey Team

3.2) Phase 1 Upper Malitubog Service Area

The trend of UMSA under the MMIP I is almost same as that of MSA, i.e. paddy cropped area is more than that of maize and no major distinction could be observed between rainy season and dry season as shown in Figure 2.3.6. Paddy covers 67% and 87% of cropped area in rainy season and dry season, respectively. As can be also seen in the maps below, the paddy cropped area in rainy season was less than that in dry season. This may be because the scattered cloud covered the satellite images between July to August 2016 and the full extent of water submersion of paddy may not have been detected.

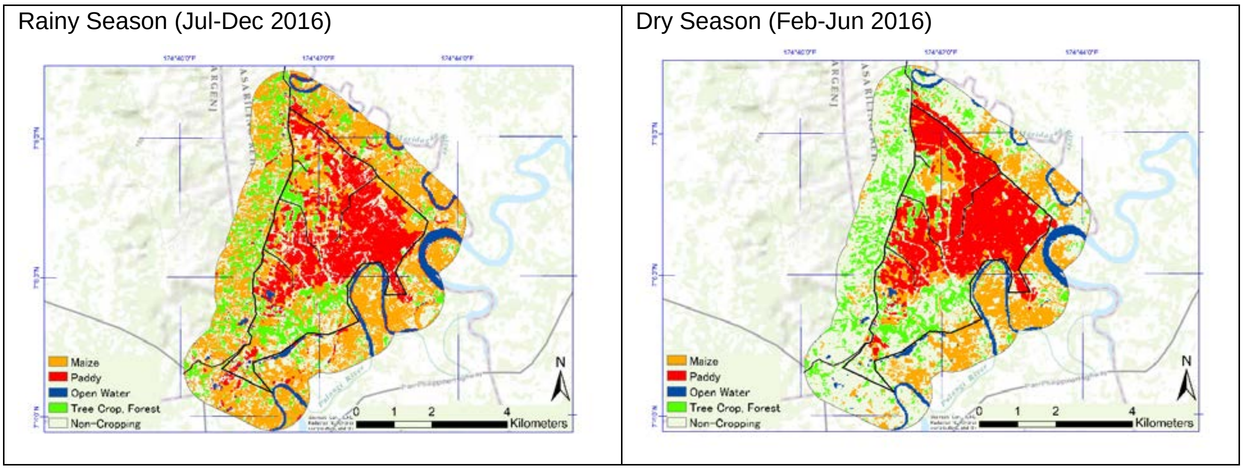


Figure 2.3.6. Agricultural Land Use of UMSA under MMIP I in 2016
Source: JICA Survey Team

3.3) Phase 2 Upper Malitubog Service Area

Though the construction of MMIP II within UMSA had been completed, the submersion of paddy field could not be clearly observed (Figure 2.3.7) from July to August and February to May as compared with MSA and UMSA under MMIP I. While the water on farms could be seen in eastern part of this area, the western part along with RMC-1 Ext.2 canal and Lat K canal must not have been irrigated in the 2016 season. Thus, because of the lack of the irrigation water, the paddy cropped area in dry season is only 698 ha which is smaller than that of rainy season i.e. 789 ha.

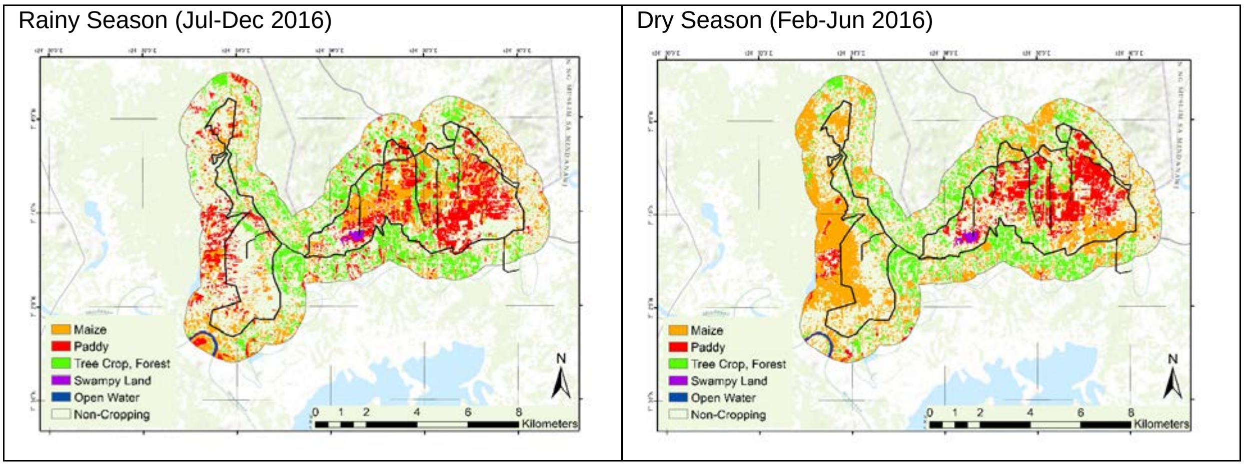


Figure 2.3.7 Agricultural Land Use of UMSA under MMIP II in 2016
Source: JICA Survey Team

3.4) Phase 2 Lower Malitubog Service Area

MMIP II within LMSA is under construction as of 2015-2016. It was assumed in this area that the rain-fed paddy was produced by utilizing the residual moisture from the previous rainy season from November and by utilizing the rain at the beginning of rainy season from June. Only 26% and 38% of total cropped area in rainy season and dry season were covered by paddy within the whole area of LMSA. Though lots of farms could be seen in this area on Google Earth, the total cropped area covers 22% in rainy season and 19% in dry season of gross area and they are scattered over this area. It is predicted that especially in rainy season, farmers would hesitate to plant crops due to the high frequency of flooding.

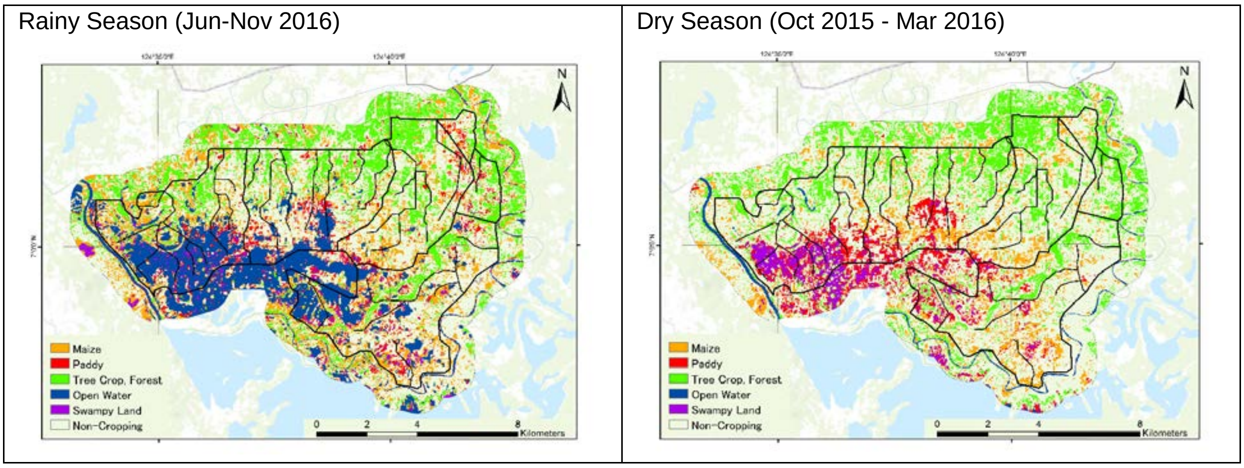


Figure 2.3.8 Agricultural Land Use of LMSA under MMIP II in 2015/2016
Source: JICA Survey Team

3.5) Phase 2 Pagalungan Extension Service Area

PESA is the smallest irrigable area among the irrigation blocks in the MMIP area. Only 28% to 29% of gross areas were cropped as of 2015-2016. In rainy season, the paddy cropped area was almost equal to the maize cropped area. On the other hand, in dry season, it was observed that the paddy cropped area is less than one third of that of maize. Due to lack of water, farmers have to plant maize instead of paddy during the dry season.

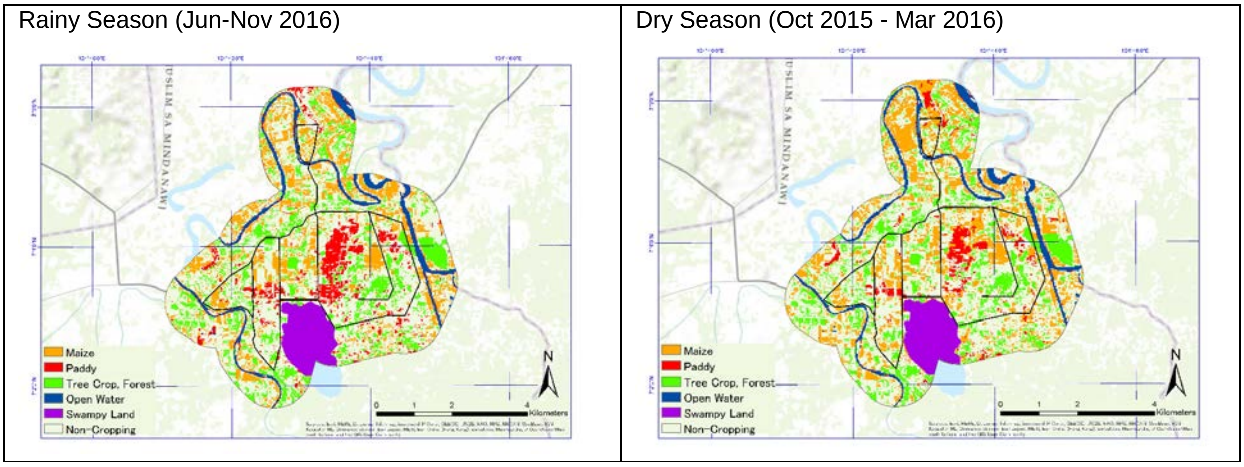


Figure 2.3.9 Agricultural Land Use of Pagalungan Ext. Service Area in 2015/2016
Source: JICA Survey Team

2.3.3 Cropping Pattern and Production

Popular crops and cropping pattern in and around the MMIP area can be demarcated by its representative agricultural ecosystem. Table 2.3.5 and Figure 2.3.10 summarize the crops and cropping pattern by municipality and by land use such as upland, lowland (rain-fed), irrigated and swampy/ marsh:

Table 2.3.5 Crops and Cropping Pattern in 5 Municipalities in the Project Area

MUNICIPALITY	CROPS/ PATTERN	AGRICULTURAL ECOSYSTEM			
		Upland	Lowland (rain-fed)	Irrigated	Swampy/Marsh
CARMEN	Crops	corn, upland rice, rubber, oil palm, fruit trees, sugarcane, coconut, banana	corn, rice, sugarcane, rubber, oil palm, vegetables, fruits, coconut, banana	rice, vegetables, coconut, banana	n/a

MUNICIPALITY	CROPS/ PATTERN	AGRICULTURAL ECOSYSTEM			
		Upland	Lowland (rain-fed)	Irrigated	Swampy/Marsh
	Cropping Pattern	corn - corn upland rice - corn	rice (one crop) rice - corn corn - corn	rice – rice rice - rice – mungbeans rice - rice&vegetables	n/a
PIKIT	Crops	corn, rubber, coconut, oil palm, fruits, banana	corn, coconut, fruits, oil palm, rubber, banana	rice, vegetables, banana, coconut	rice, corn (during long dry period)
	Cropping Pattern	corn – corn	corn - corn	rice - rice rice&vegetables - rice	n/a
ALEOSAN	Crops	corn, upland rice, rubber, sugarcane, banana, coffee, cacao, coconut, oil palm, fruits	corn, rubber, banana, coconut, rice, sugarcane, fruits	rice, coconut, banana, fruits	n/a
	Cropping Pattern	corn - corn upland rice - corn	corn - corn rice (one crop)	rice - rice rice&vegetables - rice	n/a
PAGALUNGAN	Crops	n/a	corn, coconut, fruits, banana, sugarcane, oil palm	rice, corn, coconut, banana, vegetables	rice, corn (during long dry period)
	Cropping Pattern	n/a	corn - corn	rice - rice rice - rice&vegetables	n/a
DATU MONTAWAL	Crops	n/a	corn, oil palm, coconut, banana, fruits, vegetables	rice, oil palm, vegetables, sugarcane	oil palm, rice, corn (during long dry period)
	Cropping Pattern	n/a	corn - corn	rice - rice rice&vegatables - rice	n/a

Source: 5 Municipality Offices

Diversified crops, including tree crops and fruit trees such as coconut, rubber, banana, mango, etc. are grown in upland and rain-fed ecosystems. Corn must be the major cereal crop in the ecosystems, even though rice is grown in places where a water source for supplementary irrigation is expected. Two crops per year, corn + corn or corn + paddy rice, are a common cropping pattern for annual crops in the ecosystems. As moving to lowland ecosystem from upland ecosystem, paddy rice area increases, and then the diversification of growing crops decreases simultaneously. Oil palm area is becoming to expand in some areas lowland.

Rice is almost exclusively grown in irrigated areas. Two-cropping of rice in a year is a common pattern in the irrigated areas as is practiced in already completed MMIP areas such as MSA, UMSA (MMIP I) and parts of the UMSA under MMIP II. Coconuts, banana and vegetables are grown in surrounding areas of paddy fields even on a border ridge/pass of paddy fields.

Rice and corn are also grown in swampy/marsh ecosystem with residual moisture during dry period when inundation water level downs. It means that those paddy and corn are started to plant after rainy season has gone as following up the inundated water being reduced. The planted area, therefore, widely fluctuates every year in accordance with the scale of the inundation affected by the year’s flood. The two crops have to be harvested before the onset of the monsoon season, before being affected by the inundation to come.

Following figure illustrates typical cropping calendar by ecosystem aforementioned. Reflecting small diversification of annual crops in the area, the figure shows a simple cropping calendar. However, the actual cropping calendar is a little bit complicated. With blessed weather condition for growing crops, i.e. stable warm-temperature and even distribution of annual rainfall, farmers in the area can grow some kind of crops whenever they want. Farmers in the area actually cultivate paddy or corn almost every month throughout a year. There is no definite cropping season for all crops in the area, though the overall cropping patterns have a tendency that farmers start cropping in February/March and continue growing the 2nd crop until the end of the year.

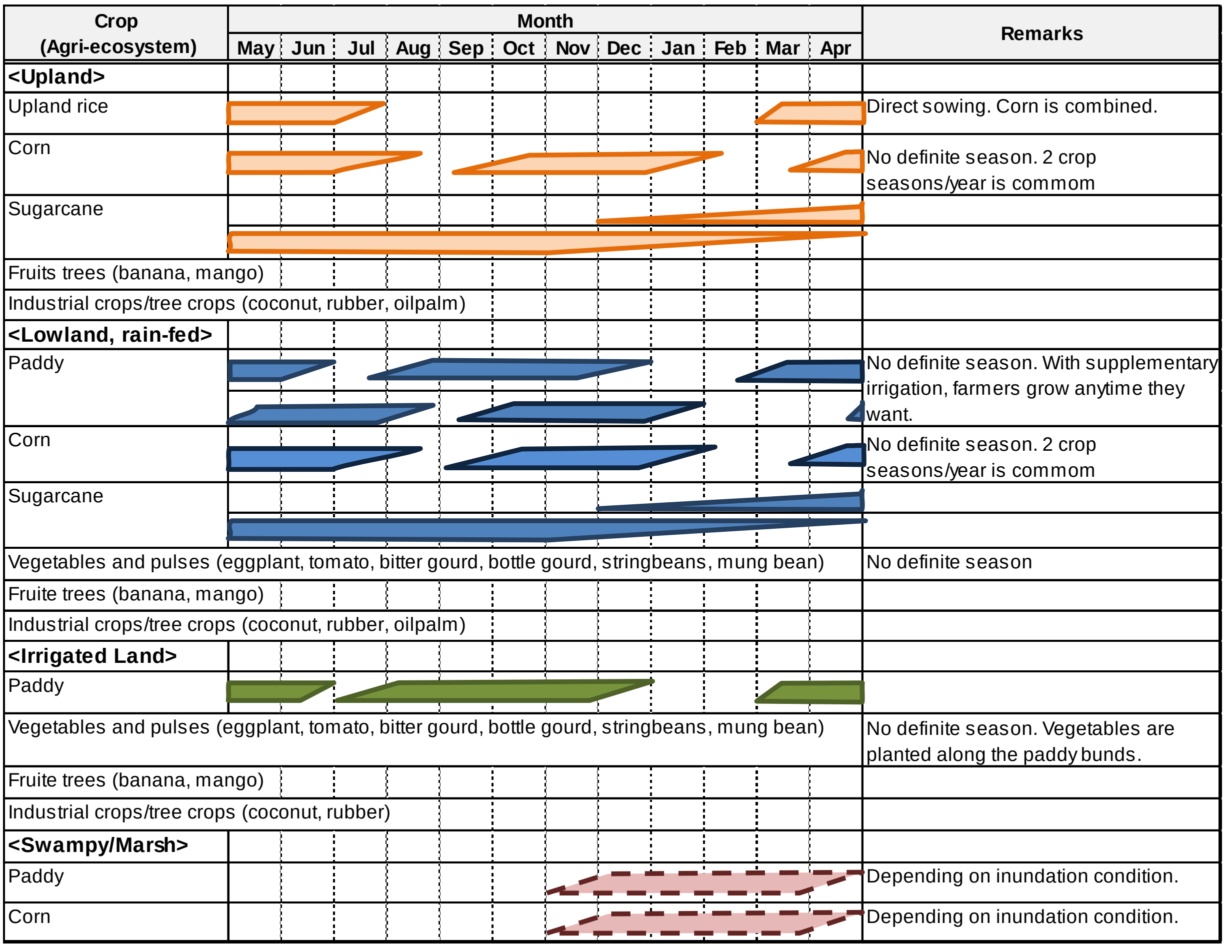


Figure 2.3.10 Cropping Calendar in the Project Area

Source: Agriculture Offices in 5 Municipalities in MMIP

Table 2.3.6 shows average productivity of rice and corn in the area from relevant statistical data of various sources, e.g. Country STAT Philippines, the Terminal Report of YLTA-MMIP, information from the OPA of Cotabato Province and DAF-ARMM. Besides, No.6 indicates a result of the Baseline Survey conducted in June and July 2017.

Table 2.3.6 Productivity (ton/ha) of Rice and Corn from Relevant Statistical Data

No	Source	Crop	Rain-fed			Irrigated			Remarks
			Dry	Wet	Year-round	Dry	Wet	Year-round	
1	YLTA Terminal Report (ATI)	Rice	NA	NA	2.93	5.52	5.63	5.63	368 farmers from 7 IAs in Phase I
2	Country STAT Philippines (Production)	Rice	NA	NA	2.95	NA	NA	4.18	Cotabato Province, 2014-16 Ave.
			NA	NA	2.36	NA	NA	3.56	Maguindanao Province, 2014-16 Ave
		Corn	White		2.30	Yellow		3.34	Cotabato Province, 2013-15 Ave.
			White		2.38	Yellow		3.36	Maguindanao Province, 2013-15 Ave.
3	Country STAT Philippines (Production Costs & Returns)	Rice	2.76	2.98	2.92	3.88	4.18	4.05	Region XII, 2013
			1.88	2.65	2.28	3.26	3.24	3.25	ARMM, 2013
4	OPA, Cotabato Province	Rice	NA	NA	3.50	NA	NA	4.50	Pikit Municipality (2014-16 Ave.)
		Corn	White		3.90	Yellow		4.20	
5	SAPROF Report (May, 2007)	Rice	NA	2.00	2.00	3.00	3.00	3.00	Before irrigation facilities completed
			NA	NA	NA	4.95	4.77	NA	After irrigation facilities completed

No	Source	Crop	Rain-fed			Irrigated			Remarks
			Dry	Wet	Year-round	Dry	Wet	Year-round	
6	Baseline Survey (JICA Survey Team)	Rice	NA	NA	1.69	NA	NA	3.38	
		Corn	NA	NA	2.12	NA	NA	NA	

Source: Various statistics, JICA Survey Team

In addition, Table 2.3.7 calculates a crop intensity to the target irrigable area of **Case-1** and **Case-2** and estimated current rice and corn production in LMSA. Compared to the planted area of rice and corn based on Satellite Image analyzed by JICA survey Team, that on NIA PMO of MMIP is larger, and therefore that of the crop intensity is also high. However, both data shows a similar seasonal difference of which the crop intensity in wet season is higher than that in dry season. Upon completion of irrigation facilities, people can expect higher crop intensity even during dry season.

Table 2.3.7 Crop Intensity and Estimated Crop Production in LMSA

Source	Case	Wet Season						
		Target Irrigable Area (ha)	Planted Area of Rice (ha)	Planted Area of Corn (ha)	Planted Area of Rice and Corn (ha)	CI (%)	Production of Rice (ton)	Production of Corn (ton)
Satellite Image Analysis	Case-1	2,810	511	1,510	2,021	72%	869	3,171
	Case-2	3,810	511	1,510	2,021	53%	869	3,171
NIA PMO of MMIP II	Case-1	2,810	367	1,087	1,454	52%	624	2,283
	Case-2	3,810	367	1,087	1,454	38%	624	2,283
Source	**Case**	**Dry Season**						
		Target Irrigable Area (ha)	Planted Area of Rice (ha)	Planted Area of Corn (ha)	Planted Area of Rice and Corn (ha)	CI (%)	Production of Rice (ton)	Production of Corn (ton)
Satellite Image Analysis	Case-1	3,688	655	1,071	1,726	47%	1,114	2,249
	Case-2	6,590	655	1,071	1,726	26%	1,114	2,249
NIA PMO of MMIP II	Case-1	3,688	457	795	1,252	34%	777	1,670
	Case-2	6,590	457	795	1,252	19%	777	1,670

Source: JICA Survey Team & NIA PMO

Note: Yield of rain-fed rice is 1.7 ton and that of corn is 2.1 ton based on the results of baseline survey (JICA survey team).
CI; Crop Intensity

1) Rice Farming[2]

1.1) Farm Size, Land Holding Status and Irrigated Farming

Average farm size of rice farmers is about 1.6 ha in Region XII and ARMM, and the rice farming size in Region XII and ARMM are 1.0 ha and 1.2 ha, respectively. Landowner farmer is the majority of rice farmers in the both regions (Region XII: 58% and ARMM: 64%), while the percentage of landowner farmer in the Philippines remains only at 37%. The percentage of share croppers is bigger than the percentage of land-leased croppers in the both region. Further, the percentage of farmers growing rice in irrigated area in Region XII and ARMM are 66% and 29%, respectively, while the percentage of the Philippines is 61%. It is noted that NIA irrigation system is not well developed in ARMM.

Table 2.3.8 Average Farm Size of Paddy Farm Parcels in 2013 (Unit: ha)

Region	Ave. Farm Size (a)	Ave. Area Planted (b)	Ave. Area Harvested	Paddy Farm % (b/a)	Remarks
Philippines	1.63	0.85	0.84	52.15	
Region XII	1.59	0.96	0.96	60.38	
ARMM	1.57	1.17	1.17	74.52	

Source: 2013 Costs & Returns of Palay Production, Philippine Statistics Authority

[2] Referred to An analysis of Costs & Returns Palay Production 2013, Philippine Statistics Authority

Table 2.3.9 Percentage Distribution of Paddy Farm Parcels by Tenure Status in 2013 (Unit: %)

Region	Fully Owned	Leased/ Rented	Tenanted	Others	Total
Philippines	37.13	7.54	34.60	20.73	100.00
Region XII	58.21	5.22	23.13	13.44	100.00
ARMM	64.10	2.56	14.10	19.24	100.00

Source: 2013 Costs & Returns of Palay Production, Philippine Statistics Authority

Table 2.3.10 Percentage of Paddy Farm Parcels Irrigated in 2013 (Unit: %)

Region	Irrigated	Non-irrigated	Total	Remarks
Philippines	61.23	38.77	100.00	
Region XII	66.42	33.58	100.00	
ARMM	29.49	70.51	100.00	

Source: 2013 Costs & Returns of Palay Production, Philippine Statistics Authority

1.2) Possession of Drawing Animals and Machinery

The percentage of rice farmers who own drawing animals (buffalo/cattle) in Region XII and ARMM are 50% and 59%, respectively, while the percentage of the Philippines is 42%. The percentage of 2-wheel tractor owners in Region XII is only 13%, which is almost half of the national average, while the percentage is only less than 4% in ARMM. Almost no rice farmers have 4-wheel tractors not only in Region XII and ARMM, but also at the national level.

Table 2.3.11 Percentage of Farmers Owned & Used Drawing Animals & Farm Machinery (Unit: %)

Region	Buffalo/ Cattle	Farm Machinery					
		2-wheel Tractor	4-wheel Tractor	Irrigation Pump	Thresher	Combine Harvester	Grain Dryer
Philippines	41.96	24.15	0.93	9.34	9.06	0.40	3.76
Region XII	49.83	12.69	NA	3.73	8.96	0.37	3.36
ARMM	58.97	3.85	NA	NA	1.28	NA	NA

Source: 2013 Costs & Returns of Palay Production, Philippine Statistics Authority

1.3) Land Preparation

Substantial number of rice farmers depends on machine power (mostly two-wheeled tractors) for the land preparation works except for leveling. Such condition implies that a two-wheeled tractor hiring service for land preparation becomes popular in many places in the Philippines. Animal power and machine power are almost equally utilized for plowing in the Philippines. Percentage of rice farmers who depend on machine power in Region XII is higher than the percentage in the Philippines, whereas the percentage is lower in ARMM.

Table 2.3.12 Percentage of Paddy Farmers by Type of Work Power Used in Land Preparation in 2013 (Unit: %)

Region	Plowing			Rotavating		Harrowing		Levelling	
	Man-Animal	2-W Tractor	4-W Tractor	2-W Tractor	4-W Tractor	Man-Animal	Man-Machine	Man-Animal	Man-Machine
Philippines	59.47	55.45	5.46	27.95	3.83	45.08	57.56	79.04	25.69
Region XII	42.91	69.78	2.24	47.39	0.75	45.52	39.18	97.39	2.61
ARMM	62.82	43.59	1.28	19.23	1.28	71.79	24.36	80.77	5.13

Source: 2013 Costs & Returns of Palay Production, Philippine Statistics Authority

1.4) Planting Method

While about 70% of rice farmers do transplanting at the national level, the farmers in Region XII and ARMM are in exact opposite trend. The percentages who go transplanting are about 30% and about 20% in Region XII and ARMM, respectively. The percentage is fortuitously similar to the percentage of rice farmers who enjoy NIA irrigation system in the both regions. According to

Table 2.3.13 Planting Methods, %

Region	Direct Seeding	Transplanting
Philippines	29.98	70.09
Region XII	70.15	29.85
ARMM	82.05	19.23

Source: 2013 Costs & Returns of Palay Production information collected from rural areas, direct sowing is still popular in rain-fed area in and around the Project area, while farmers in irrigated area, e.g. farmers in Maridagao Service Area of MMIP I, started transplanting rice in general.

1.5) Seeds and Seed Rate

The percentage of rice farmers who use quality seeds (Certified seeds/Good seeds) under irrigation in Region XII and ARMM is about 35% which is lower than the national average of about 54%. However, the percentages in Region XII and ARMM are still in acceptable range for maintaining seed quality for general cultivation at farmer level. On the contrary, the percentage under rain-fed condition is still very low in Region XII and ARMM.

Table 2.3.14 Percentage Distribution of Paddy Farmers by Ecosystem, by Type of Seed Planted in 2013, Unit %

Region	Hybrid	Open Pollinated			
		Certified Seeds	Good Seeds	Farmers' Seeds	Tradition /Native
	Irrigated				
Philippines	4.94	35.02	19.08	38.59	2.37
Region XII	0.56	20.79	15.17	63.48	0
ARMM	0.00	8.70	30.43	60.87	0
	Non-irrigated				
Philippines	1.13	17.64	23.32	53.53	4.38
Region XII	0	1.11	3.33	95.56	0
ARMM	0	3.64	7.27	52.73	36.36
	Total				
Philippines	3.46	28.28	20.93	44.38	3.15
Region XII	0.37	14.18	11.19	74.25	0
ARMM	0	5.13	14.10	55.13	25.64

Source: 2013 Costs & Returns of Palay Production, Philippine Statistics Authority

Quantity of paddy seeds used in Region XII and ARMM are about 121 kg/ha and 77 kg/ha, respectively. It is assumed that huge amounts of seeds are unnecessarily used by rice farmers in the both region, especially in Region XII, even considering the condition that direct sowing is prevailing over transplanting in the area.

Table 2.3.15 Quantity of Paddy Seeds(Unit: kg/ha)

Region	Irrigated	Non-irrigated	Total
Philippines	89.8	95.9	91.9
Region XII	117.4	133.2	121.3
ARMM	56.8	88.8	76.9

Source: 2013 Costs & Returns of Palay Production

1.6) Fertilizer Use

Urea, ammonium sulphate and NPK (14-14-14) are popular chemical fertilizers among rice farmers in Region XII and ARMM. Quite limited amounts of organic fertilizers are used by them. Many rice farmers avoid balanced nutrition application, as the farmers much depend on nitrogen fertilizers, and don not pay serious attention to apply the phosphate and the potash. It is, however, considered that the present level of nitrogen provided by the fertilizers might not be sufficient, if farmers aim to get higher productivity, e.g. 5 – 6 ton/ha. The amount of chemical fertilizers used in ARMM is much lower than the national average.

Many rice farmers apply chemical fertilizers in several times, for example before planting, in vegetation phase and in reproductive phase. However, the percentage of farmers who practice basal application of fertilizer in Region XII and ARMM are only 6% and 55%. The fertilization technique heavily depending on top-dressing is popular among farmers in Region XII and ARMM, as well as in the Philippines.

Table 2.3.16 Average Quantity of Chemical Fertilizers Applied for Paddy in 2013 (Unit: kg/ha)

Region	Urea	Ammonium Sulphate	Ammonium Phosphate	NPK	NPK	NPK	Muriate Potash
	(45/46-0-0)	(21-0-0)	(16-20-0)	(12-12-12)	(14-14-14)	(16-16-16)	(0-0-60)
	All Paddy						
Philippines	97.67	18.13	21.57	1.07	70.15	1.54	1.21
Region XII	106.48	31.02	6.57	0.78	35.44	0.19	0.78
ARMM	46.80	1.09	3.83	0.55	12.32	NA	NA
	Irrigated Paddy						
Philippines	118.04	19.08	24.22	1.23	83.23	1.58	1.40
Region XII	113.54	25.10	5.56	1.03	41.25	NA	0.78
ARMM	50.00	2.94	NA	NA	20.59	NA	NA
	Non-irrigated Paddy						
Philippines	60.31	16.39	16.71	0.79	46.15	1.47	0.86
Region XII	84.95	49.08	9.66	NA	17.74	0.79	0.79
ARMM	44.90	NA	6.10	0.87	7.41	NA	NA

Source: 2013 Costs & Returns of Palay Production, Philippine Statistics Authority

Table 2.3.17 Percentage of Paddy Farmers by Method of Fertilizer Application in 2013 (Unit: %)

Region	Basal	Side Dressing (vegetative phase)	Top Dressing (reproductive phase)
Philippines	29.59	58.90	68.12
Region XII	5.97	91.04	87.31
ARMM	55.13	30.77	34.62

Source: 2013 Costs & Returns of Palay Production, Philippine Statistics Authority

1.7) Marketing of Rice Paddy

Conventionally, most rice farmers in the MMIP area are financed by trader-lenders those who are working as input suppliers, traders and processors in rice production. Prior to the planting season, the farmers get their input supplies including seeds, fertilizers, chemicals, and even cash from the lenders. A monthly interest for the total amount of supplies and cash provided is being charged by those trader-lenders. A classic example is that; farmers shall repay a principal amount, either in cash or kind, and an interest of 1 bag of paddy rice for every PHP 1,000 per season.

For example, in Carmen, a farmer-borrower is obligated to pay back the amount of paddy equivalent to debt cash and/or inputs to a trader-lender. An interest of PHP 500 is charged for every PHP 1,000 worth of cash and/or inputs by the trader-lender. Meanwhile, the farmer-borrower has to pay an interest of 1 bag of paddy rice for every PHP 1,000 cash borrowed to an individual lender who dealing only cash transaction in the municipality. On the other hand, 5% to 10% of the interest per month is charged by the trader-lender for cash advances and/or cost of inputs used by the farmer-borrower in Pikit.

Prior to the harvest of the rice crop, the farmer informs their respective trader of the harvest and ask her/him to bring her/his hauling vehicle, and collect the paddy rice based on the computed amount financed plus the interest. If farmers still have surplus after subtracting the amount of such a debt and home consumption, they can sell the paddy rice to the trader. Such a relationship discourages the rice farmer-borrower to practice “pole-vaulting”, meaning selling his produce to other traders.

A “suki” system prevails between such a farmer-borrower and a trader-lender. “Suki” is a Filipino term which means a regular and casual farmer-trader transaction relationship wherein trust is the common denominator. This is common and informal form of transaction wherein cash and non-cash withdrawals by farmers are just written in a notebook. Farmers with cash advances from the traders, including the inputs used in the farm, usually get a lower buying price as compared to farmers without debt.

There are two types of deliveries of farmers’ product to the market; either delivered to the market by farmers or picked-up by traders. Considering very poor condition of roads between markets and farms, farmers either use a single motorcycle and a hand tractor with trailer or hire a vehicle able to penetrate the almost inaccessible road. This results in a very high transport cost of the product. Meanwhile, the traders usually pick-up the farmers' produce using 4WD vehicles. The transportation cost to the traders' place is deducted from the proceeds.

Those big traders[3] are mostly found in the Poblacion of Kabacan, Pikit and Carmen because of its proximity from the MMIP areas. Poblacion is a Barangay functioning as a center of municipality and usually located along a national highway. Then, the traders usually process the rice paddy at commercial rice millers, mostly located in Kabacan. There is another commercial rice miller in Carmen. Those rice millers also act as traders, and regularly cater to their "suki" farmers. The farmers of Datu Montawal and Pagalungan deliver their produce either to Kabacan or to Pikit traders. After milling the rice, the traders sell it at big cities such as Kidapawan, Davao and Cotabato.

Note that although there are 25 small-scale rice mills in 13 Barangays of Pikit Municipality, no commercial rice millers are found there. Therefore, these existing rice mills are presumed to be either stationary or mobile rice mills serving for home consumption rice.

2) Corn Farming[4]

2.1) Farm Size and Land Holding Status

Average farm size of corn farmers and corn farming size in Region XII are 2.2 ha and 1.5 ha, respectively, while the sizes in ARMM are 1.8 ha and 1.3 ha. All the farm sizes are bigger than the sizes of rice in the both region. As with the case of the national average, planted area of yellow corn is bigger than the area of while corn in Region XII. The areas of white and yellow corn are, however, almost equal in ARMM.

Table 2.3.18 Average Farm Size of Corn Farm Parcels in 2013, ha

Region	Ave. Farm Size (a)	Devoted to Corn (b)	Corn Farm % (b/a)
Philippines	2.14	1.14	53.27
Region XII	2.24	1.50	66.96
ARMM	1.80	1.30	72.22

Source: 2013 Costs & Returns of Corn Production, Philippine Statistics Authority

Table 2.3.19 Average Area Planted and Harvested of Corn Farm Parcels in 2013, ha

Region	White		Yellow	
	Planted	Harvested	Planted	Harvested
Philippines	0.67	0.67	1.05	1.05
Region XII	0.83	0.83	1.03	1.03
ARMM	1.12	1.10	1.15	1.15

Source: 2013 Costs & Returns of Corn Production, Philippine Statistics Authority

Landowner farmer is the majority of corn farmers in ARMM (70%), while the percentage of the farmer in Region XII is only 35%. The percentage of share croppers is lower than the percentage of rice farmers in the both region, though the percentage is still bigger than the percentage of land-leased croppers. Relatively high percentage of other growers, who might be large-scale commercial farms, is seen for corn farmers. The percentages are 37% in Region XII and 28% in ARMM.

[3] Aside from the big traders, there are middle-men of rice paddy. They purchase the paddy from the farmers and sell to the big traders.
[4] Referred to An analysis of Costs & Returns Corn Production 2013, Philippine Statistics Authority

Table 2.3.20 Percentage Distribution of Corn Farm Parcels by Tenure Status in 2013, %

Region	Fully Owned	Leased/ Rented	Tenanted	Others	Total
Philippines	36.11	3.65	25.00	35.24	100.00
Region XII	35.09	4.39	23.68	36.84	100.00
ARMM	70.41	0.00	2.04	27.55	100.00

Source: 2013 Costs & Returns of Corn Production, Philippine Statistics Authority

2.2) Possession of Drawing Animals and Machinery

The percentage of corn farmers who own drawing animals (buffalo/cattle) in Region XII and ARMM are 41% and 90%, respectively, while the percentage of the Philippines is 56%. Limited corn farmers have farm machinery not only in Region XII and ARMM, but also in the Philippines.

Table 2.3.21 Percentage of Farmers Owned & Used Drawing Animals & Farm Machinery in Corn Farm, %

Region	Buffalo/ Cattle	Farm Machinery				
		2-wheel Tractor	4-wheel Tractor	Irrigation Pump	Sheller	Grain Dryer
Philippines	56.11	3.65	0.48	4.60	1.59	0.08
Region XII	41.23	2.63	0.88	0.88	2.63	NA
ARMM	89.69	NA	NA	NA	NA	NA

Source: 2013 Costs & Returns of Corn Production, Philippine Statistics Authority

2.3) Land Preparation

Majority of corn farmers depend land preparation works on animal power. It is interesting that a relatively high percentage of corn farmers use 4-wheel tractors for the works comparing to rice farmers. This may be caused by the activity of large-scaled commercial farms.

Table 2.3.22 Percentage of Corn Farmers by Type of Work Power Used in Land Preparation in 2013, %

Region	Plowing			Rotavating		Harrowing			Furrowing	
	Man-Animal	2-W Tractor	4-W Tractor	2-W Tractor	4-W Tractor	Man-Animal	2-W Tractor	4-W Tractor	Man-Animal	Man-Machine
Philippines	58.25	1.19	14.24	0.48	2.70	40.32	3.49	2.30	63.73	2.94
Region XII	64.91	1.75	14.04	NA	NA	46.49	0.88	4.39	70.18	2.63
ARMM	57.14	NA	22.45	NA	6.12	72.45	1.02	NA	74.49	NA

Source: 2013 Costs & Returns of Corn Production, Philippine Statistics Authority

2.4) Varieties of Corn

In case of white corn, most farmers grow OPV (Open Pollinated Varieties). While the majority of farmers in Region XII grow improved varieties of white corn, the farmers in ARMM prefer much native varieties. On the contrary, hybrid varieties are popular in yellow corn cultivation among farmers. In Region XII, the percentage of farmers growing hybrid yellow corn is just 50%, whereas no farmers grow hybrid varieties even in yellow corn cultivation in ARMM. 40% of the yellow corn farmers still grow OPV native varieties in ARMM.

Table 2.3.23 Percentage Distribution of Corn Farmers by Corn Type by Type of Seed in 2013, %

Region	White			Yellow		
	Hybrid	Modern OPV	Native OPV	Hybrid	Modern OPV	Native OPV
Philippines	0.55	40.37	59.08	74.86	21.97	3.18
Region XII	0.00	88.57	11.43	50.00	47.73	2.27
ARMM	0.00	26.14	73.86	0.00	60.00	40.00

Source: 2013 Costs & Returns of Corn Production, Philippine Statistics Authority

2.5) Seed Sources of OPV and Seed Rate

Majority of corn farmers still use own produced-seeds or procure seeds from neighbor farmers for growing improved OPV and native OPV. However, a certain percentage of the farmers buy seeds of the both OPVs from traders or seed-growers. Percentage of the farmers who buy OPV seeds from traders or seed-growers in Region XII and ARMM are higher than the percentage of national average.

Table 2.3.24 Percentage of Corn Farmers by Source/s of Modern and Native OPV Seeds in 2013, %

Region	Modern OPV			Native OPV		
	Govt.	Trader/ Seed Grower	Co-farmer/ Own produce	Govt.	Trader/ Seed Grower	Co-farmer/ Own produce
Philippines	3.59	13.03	84.49	1.09	5.99	93.11
Region XII	0.00	15.66	85.54	0.00	22.22	77.78
ARMM	0.00	37.93	62.09	0.00	17.39	84.06

Source: 2013 Costs & Returns of Corn Production, Philippine Statistics Authority

Quantity of corn seeds used in Region XII and ARMM are 18.7 kg/ha and 19.4 kg/ha, respectively. Though the both seed rates per hector are higher than the average of the Philippines, they still remain within the reasonable level.

Table 2.3.25 Seed Ratio of Corn, kg/ha

Region	White	Yellow	Total
Philippines	15.73	18.11	16.61
Region XII	19.31	17.87	18.67
ARMM	19.22	20.57	19.37

Source: 2013 Costs & Returns of Corn Production,

2.6) Fertilizer Use

As same as the case of rice farmers, urea, ammonium sulphate and NPK (14-14-14) are popular chemical fertilizers among corn farmers in Region XII and ARMM. Trends of chemical fertilizer use, such as very limited use of organic fertilizers, heavily nitrogen-conscious application, low dependency on the basic dressing and very low volume use in ARMM are also similar to rice farmers.

Yellow corn growers tend to use much more volume of fertilizers than white corn growers. In terms of nutrients amount, fertilizer volume applied for yellow corn is higher than the volume for rice. Most farmers intend to get a higher level of productivity from yellow corn production by combining hybrid varieties and chemical fertilizers.

Table 2.3.26 Average Quantity of Chemical Fertilizers Applied for Corn in 2013, Kg/ha

Region	Urea	Ammonium Sulphate	Ammonium Phosphate	NPK	NPK	NPK	Muriate Potash
	(45/46-0-0)	(21-0-0)	(16-20-0)	(12-12-12)	(14-14-14)	(16-16-16)	(0-0-60)
	All Corn						
Philippines	84.02	14.20	28.35	0.15	44.11	1.48	0.10
Region XII	97.87	20.27	5.07	NA	65.20	NA	NA
ARMM	28.54	NA	0.46	NA	35.56	NA	NA
	White Corn						
Philippines	37.59	14.95	15.71	0.16	23.93	0.40	NA
Region XII	60.19	14.55	5.57	NA	45.03	NA	NA
ARMM	23.17	NA	0.51	NA	32.57	NA	NA
	Yellow Corn						
Philippines	162.18	12.93	49.63	0.14	78.08	3.30	0.28
Region XII	146.57	27.65	4.42	NA	91.26	NA	NA
ARMM	73.91	NA	NA	NA	60.87	NA	NA

Source: 2013 Costs & Returns of Corn Production, Philippine Statistics Authority

Table 2.3.27 Percentage of Corn Farmers by Method of Fertilizer Application in 2013, %

Region	Basal	Side Dressing (vegetative phase)	Top Dressing (reproductive phase)
Philippines	30.79	53.41	27.14
Region XII	11.40	48.25	50.88
ARMM	12.24	25.51	14.29

Source: 2013 Costs & Returns of Corn Production, Philippine Statistics Authority

2.3.4 Agricultural Mechanization

A presentation paper[5] prepared in 2013 depicts an outline of the agricultural mechanization in the Philippines. According to the paper, the mechanization for popular crops is still less developed in the Philippines except for land preparation, threshing/shelling and milling of rice and corn (Table 2.3.28).

Table 2.3.28 Agricultural Mechanization by Crops in the Philippines

Works/Operation	Mechanization Status		
	Rice/Corn	Vegetables, legumes & root crops	Coconut/Fruits/ Fiber crops
Land preparation	Intermediate to high	Low	-
Planting/transplanting	Low	Low	Low
Crop care/cultivation	Low	Low	Low
Harvesting	Low	Low	Low
Threshing/shelling	Intermediate to high	Low	-
Drying	Low	Low	Low
Milling/village level processing	High	Low	Low

Source: "Status of Agricultural Mechanization in the Philippines", Delfin C. Suministrado of Agricultural Machinery Testing and Evaluation Centre, University of the Philippines Los Baños, 2013

It is may be assumed that the present condition in the Project area is similar to those of above table according to available secondary data and collected information. Table 2.3.29 and Table 2.3.30 show percentages of rice and corn farmers who owned or used farm machineries in 2013 in Region XII, ARMM and the Philippines. The tables imply that mechanization of plowing and threshing/shelling of rice and corn has progressed to a certain level even in the Project area, while manual labors still play an overwhelming role in the other agricultural works.

Table 2.3.29 Percentage of Rice & Corn Farmers Owned & Used Farm Machinery in 2013 (unit: %)

Region	2-W Tractor		4-W Tractor		Thresher/ Sheller		Grain Dryer	
	Rice	Corn	Rice	Corn	Rice	Corn	Rice	Corn
Philippines	24.15	3.65	0.93	0.48	9.06	1.59	3.76	0.08
Region XII	12.69	2.63	NA	0.88	8.96	2.63	3.36	NA
ARMM	3.85	NA	NA	NA	1.28	NA	NA	NA

Source: Philippine Statistics Authority

Table 2.3.30 Percentage of Rice & Corn Farmers Used Farm Machinery in 2013 (unit: %)

Region	Plowing 2-W Tractor		Plowing 4-W Tractor		Threshing/ Shelling		Drying	
	Rice	Corn	Rice	Corn	Rice	Corn	Rice	Corn
Philippines	55.45	1.19	5.46	14.24	81.65	33.57	0.48	0.08
Region XII	69.78	1.75	2.24	14.04	92.54	52.63	NA	NA
ARMM	43.59	NA	1.28	22.45	65.38	41.87	NA	NA

Source: Philippine Statistics Authority

Above tables also show that percentages of rice and corn farmers who used farm machinery for plowing and for threshing/shelling. They are much higher than the percentages of the farmers who owned relevant farm machinery not only in the Philippines, but also in Region XII and ARMM. Such condition implies that a business of farm mechanization service for plowing and threshing/shelling of rice and corn is well developed or developing in the whole country including the Project area. Comparing rice and corn, mechanization of rice farming is more progressed than that of corn farming. ARMM is less developed in terms of farm mechanization, however, if compared by region.

During the Baseline Survey carried out in June and July 2017, the farmers queried about possession of

[5] "Status of Agricultural Mechanization in the Philippines", Delfin C. Suministrado of Agricultural Machinery Testing and Evaluation Centre, University of the Philippines Los Baños, prepared for the Regional Forum on Sustainable Agricultural Mechanization in Asia and in the Pacific at Quingdao in China in 2013.

draft animals and agriculture machineries in the project area. While some of the farmers owns the machineries in the MSA, where irrigation paddy production has been widely spread, few farmers own them in the LMSA.

Table 2.3.31 Percentage of Farmers Own Farm Machinery Identified at the Baseline Survey (unit: %)

Barangay	Area	Draft Animal	Warehouse	4-Wheel Tractor	Hand Tractor	Floating Tiller	Thresher	Water Pump	Rice Mill	Dryers
UGALINGAN/ GENERAL LUNA	MSA	23	3	0	10	10	10	3	0	0
KILANGAN	MSA	45	10	5	10	30	15	15	0	0
KIBAYAO	MSA	15	5	10	15	20	15	5	0	10
BOLIOK	LMSA	25	0	0	0	0	0	0	0	0
TALITAY	LMSA	55	0	0	5	5	0	0	0	0
BAGO-INGED	LMSA	20	0	0	0	0	0	0	0	0
GLI-GLI	LMSA	33	0	0	0	0	0	0	0	0
MACABUAL	LMSA	25	0	0	0	0	0	0	0	0
PUNOL	LMSA	15	0	0	0	0	0	0	0	0

Source: JICA Survey Team

In addition, an inventory of pre- and post-harvest facilities are summarized in APPENDIX IV, those for beneficiary Barangays of MMIP I and MMIP II in Pikit, Aleosan, Carmen, Pagalungan and Datu Montawal Municipalities.

2.3.5 Agricultural Extension Service to Farmers

1) Outline of the National Extension System

The Agriculture and Fisheries Modernization Act (AFMA) of 1997, or Republic Act No. 8435, stipulates the formulation of a National Extension System for Agriculture and Fisheries (NESAF) with three sub-systems; namely, national government sub-system, local government sub-system, and private sector sub-system. The local government units (LGUs) are mandated to deliver extension services to farmers, fisher folks, and agribusiness entrepreneurs. Provincial governments are mandated to integrate the operations for the agriculture extension services within the province and undertake continuous and periodic annual evaluation of all municipal extension programs.

2) Agricultural Training Institute (ATI)

The Agricultural Training Institute (ATI), a bureau of the Department of Agriculture (DA), is the extension and training arm of the national government sub-system. By an administrative order of DA in 2015, ATI has streamlined operations based on its role as indirect provider of extension and training services to LGU extension workers. This is to complement the LGUs responsibility to deliver direct agriculture and fisheries extension services to the beneficiary farmers and fisher folks. ATI is given the following mandate according to ATI’s web-homepage:

- ✓ To lead in the formulation of the national Agriculture and Fisheries Extension (AFE) agenda and budget,
- ✓ To prepare an integrated plan for publicly-funded training programs in agriculture and fisheries,
- ✓ To formulate and issue guidelines in planning, implementing, monitoring and evaluating AFE programs,
- ✓ To assist, in coordination with state universities and colleges, the local government units extension system by improving their effectiveness and efficiency through capability building and complementary extension activities such as technical assistance, training of LGU personnel, improvement of physical facilities, extension cum research and information support services, and

✓ To lead in the provision of e-extension services in collaboration with the various agencies, bureaus and organizational units of the DA. This is to integrate and harmonize ICT-based extension delivery system for agriculture and fisheries.

ATI is one of 8 bureaus under the control of DA and have 4 divisions and 16 training centers in the country. Out of 16 training centers, one is the International Training Center on Pig Husbandry, while remaining 15 centers are regional training centers scattered all over the country. Figure 2.3.11 shows ATI's organizational diagram, and Table 2.3.32 shows annual budgets of ATI from 2014-2017. Note that increase in the 2017 budget is due to a special fund to alleviate poverty in the poorest 22 provinces.

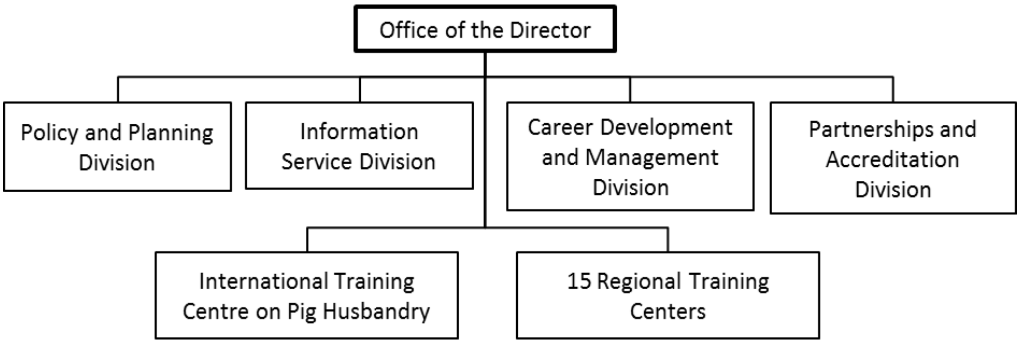


Figure 2.3.11 ATI Organizational Structure
Source: Agriculture Training Institute

Table 2.3.32 Annual Budget of ATI from 2014-2017 (unit: 1000 Pesos)

Budget Item	2014	2015	2016	2017
General Administration and Support Services	[redacted]	[redacted]	[redacted]	[redacted]
Operations	[redacted]	[redacted]	[redacted]	[redacted]
Projects	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]

Source: Agriculture Training Institute Headquarters

ATI has 15 regional centers, same as the regional ATI office, and one of them is located in Tantangan, called ATI Regional Training Centre XII. The organizational structure set up of the ATI Regional Training Centre XII is shown in the following figure and tables. There are total 55 staff under the Regional Center Director, and the annual budget ranges from [redacted] to [redacted] pesos for the last 3 years. The regional center has outreach offices, one of which is Kabacan Outreach Office, which have been engaged in the agriculture extension services within the MMIP area.

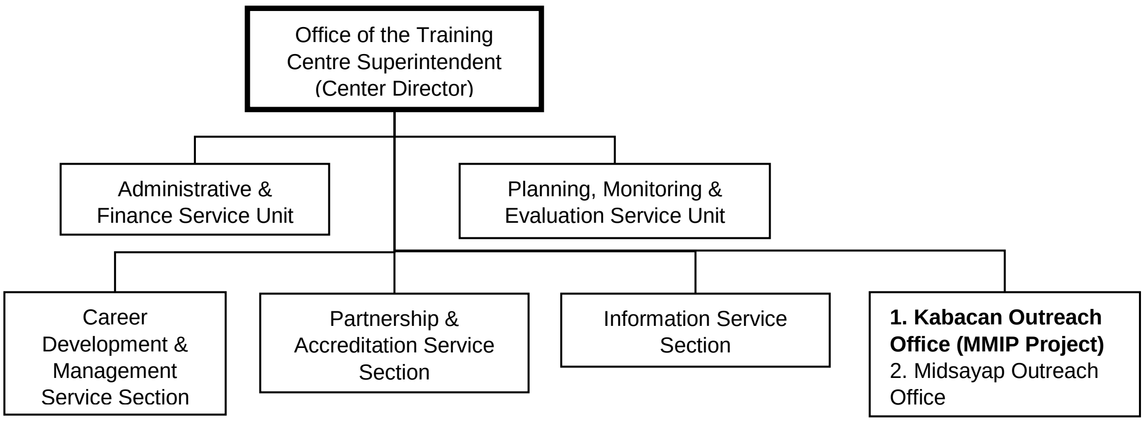


Figure 2.3.12 Organization of ATI Regional Training Centre (XII)
Source: ATI Regional Training Centre (XII)

Table 2.3.33 Number of Staff of ATI Regional Training Centre (XII)

No	Office/Unit/Section	Number	Remarks
1	Office of the Training Centre Superintendent	[redacted]	Director & 1 Superintendent
2	Administrative and Finance Service Unit	[redacted]	
3	Planning, Monitoring and Evaluation Service Unit	[redacted]	
4	Career Development and Management Service Section	[redacted]	
5	Partnership and Accreditation Service Section	[redacted]	
6	Information Service Section	[redacted]	
7	Technical Staff for the Centre	[redacted]	
8	Administrative Support Staff for the Centre	[redacted]	
9	Kabacan Outreach Office (MMIP Project team)	[redacted]	1 Project Officer, 10 Tech. Staff (3 vacancy) & 3 Admi. Staff
	Total	[redacted]	

Source: ATI Regional Training Centre (XII)

Table 2.3.34 Annual Budget of ATI Regional Training Centre (XII)

Year	2015	2016	2017
Budget (thousands Peso)	[redacted]	[redacted]	[redacted]*

Note: * Increase in the 2017 budget is due to a special fund to alleviate poverty in the poorest 22 provinces including Cotabato province and Maguindanao province.
Source: Agriculture Training Institute (Region XII)

3) Agricultural Extension System in the Project Area

Agricultural extension system in the Philippines is decentralized and LGUs, i.e. municipality governments, are the responsible agency to deliver agriculture and fisheries extension services directly to farmers under the present administrative system. The extension system in the Project area is, however, slightly different between the municipalities in Cotabato Province of Region XII, i.e. Carmen, Pikit and Aleosan and municipalities in Maguindanao Province of ARMM, i.e. Datu Montawal and Pagalungan, as general administration systems between Region XII and ARMM are not the same. While the administration system in Region XII is decentralized, same as other regions in the Philippines, ARMM has a centralized governance structure.

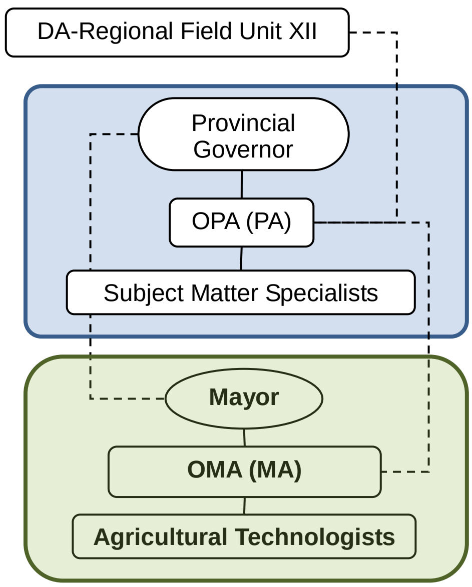


Figure 2.3.13 Agricultural Extension Setup in Cotabato Province
Source: Cotabato Province Agriculture Office

Figure 2.3.13 illustrates the extension setup in Cotabato Province. Municipality is a local autonomous unit down the Province in the Philippines. Each municipality government in Cotabato Province has an Office of Municipal Agriculturist (OMA) represented by Municipal Agriculturist (MA) who reports directly to the Mayor. OMA handles all matters of agricultural development within the municipality jurisdiction, and thus provides agricultural extension services directly to farmers. Agricultural Technologists are positioned to OMA as extension service providers at field level. Office of Provincial Agriculturist (OPA) represented by Provincial Agriculturist (PA) supervises and coordinates municipal extension programs within the province. Subject Matter Specialists in OPA undertake a technical consultation and guidance with Agricultural Technologists of OMAs.

The extension setup in Maguindanao Province shown in Figure 2.3.14 is slightly different from that of

Cotabato province. DAF (Department of Agriculture and Fisheries) of ARMM Government has strong authority and responsibilities for agriculture administration within the ARMM. While agricultural officers are assigned at provincial level called as PAO (Provincial Agriculture Officer) and at municipality level called as MAO (Municipality Agriculture Officer), they are directly controlled and supervised by DAF-ARMM. Although the administrative management system is different from other regions, Agricultural Technologists are positioned as extension service providers at field level, and Subject Matter Specialists are positioned at provincial level as senior technical staff supporting the Agricultural Technologists.

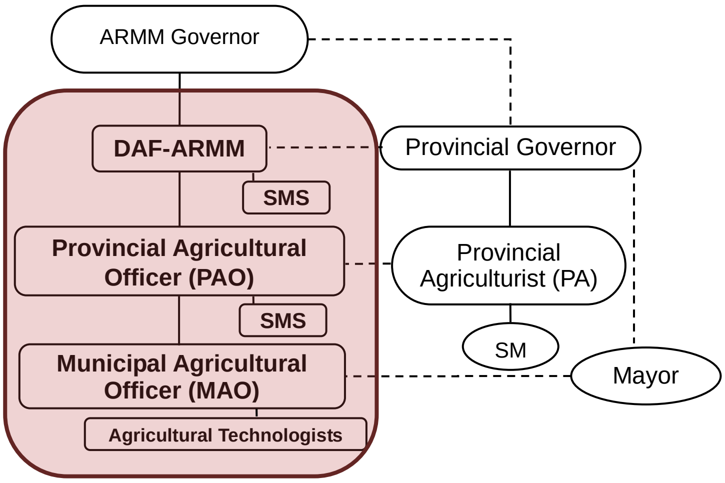


Figure 2.3.14 Agricultural Extension Setup in Maguindanao Province

Source: Maguindanao Province Agriculture Office

Note that the PAO and the PA on Figure 2.3.14 are not the same, but coordinate with each other to implement agricultural programs and projects within the province. The national government programs/projects are coursed through the PAO while the provincial government funded ones are done by the PAO. Also, the PAO has her/his subordinate at municipal level, which is a MAO, whereas the PA has no personnel at that level.

Table 2.3.35 Staff in Office of Municipal Agriculturist (in Cotabato Province) and Allocated DAF Staffs to Municipality (in ARMM) as of 2017

No.	Title/Position	Cotabato Province								
		Carmen			Pikit			Aleosan		
		Filled	Vacant	Total	Filled	Vacant	Total	Filled	Vacant	Total
1	Municipal Agriculturist	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2	Senior Agriculturist	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
3	Agriculturist/Agri. Technologist	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
4	Veterinarian	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
5	Coop. Dev. Specialist	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
6	Assistant Workers	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

No.	Title/Position	ARMM					
		Datu Montawal			Pagalungan		
		Filled	Vacant	Total	Filled	Vacant	Total
1	Municipal Agriculturist	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2	Senior Agriculturist	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
3	Agriculturist/Agri. Technologist	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
4	Veterinarian	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
5	Coop. Dev. Specialist	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
6	Assistant Workers	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

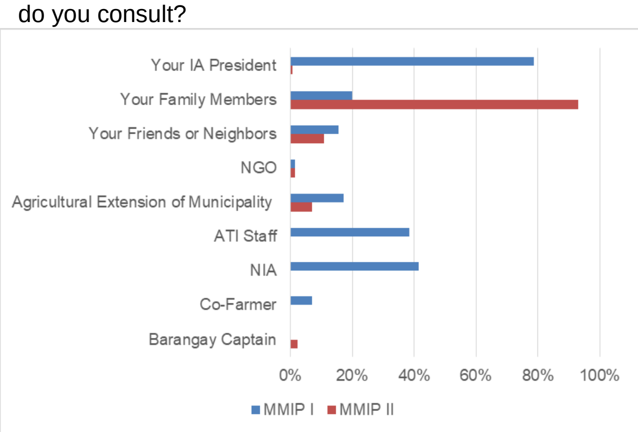
Source: 5 Municipal Agriculture Offices Concerned

Table 2.3.35 shows the number of staffs concerned with agriculture administration allocated to 5 municipalities in the project area. The numbers of staffs in an OMA in Cotabato municipalities are [redacted] – [redacted], while only [redacted] DAF staffs are assigned to each of the municipalities in ARMM. As all the staffs participating in the agricultural administration are counted in the numbers, the actual number working for extension services must be smaller. Even if all the staffs in the table exclusively work for extension services, the services are not able to cover all the farm households. The number of the households in the municipalities is estimated to be at least several thousand or more than ten thousands depending on the population size.

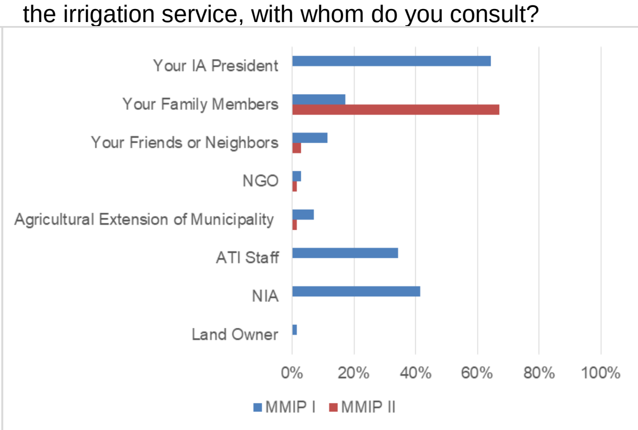
Figure 2.3.15 shows results of the Baseline Survey inquiring agricultural extension services in the MMIP area. While information source on farming is rather casual and considered limited to family members and neighborhood in the MMIP II area, it is diversified and includes official sources such as government officers and IA leaders. The Question 3 also indicates that much more attentions are given to the MMIP I area by the extension officers.

This may be attributed to the progress of the project intervention by YLTA and the government so far and none of farmers in LMSA have joined the projects yet. In addition, as already discussed, farmers in LMSA are considered engaged in more extensive farming and farming puts only 43% contribution on the farmers' total gross income according to a result of the Baseline survey. On the other hand, 82% of the gross income come from agriculture in MMIP I and the farmers conduct more intensive farming requiring more frequent technical consultation from the experts.

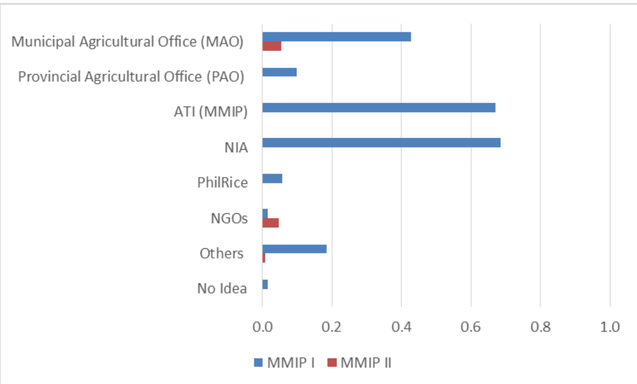
Q1. When you have problems in your farming, with whom do you consult?



Q2. In case of Irrigation Area, when you have problem in the irrigation service, with whom do you consult?



Q3. How many times did you meet with the extension workers in/around your Barangay for technical consultation in 2016??



Q4. What kind of extension services did you get in 2016?

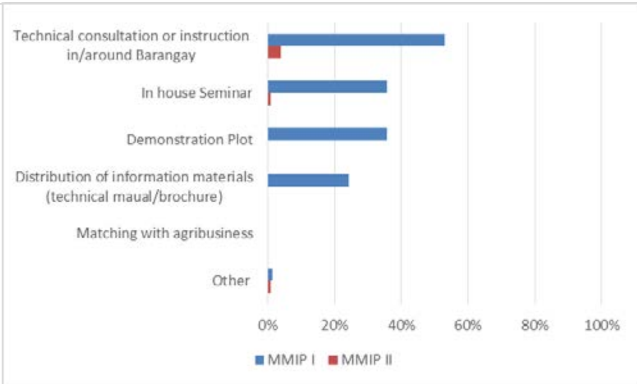


Figure 2.3.15 Farmers' Observations on Agriculture Extension Services in the MMIP Area

Source: Baseline Survey

4) YLTA (Yen Loan Technical Assistance) of MMIP I

A Yen Loan Technical Assistance (YLTA) was implemented in order to increase productivity of rice in the MMIP project area through enhancement of farming skills and financial management of target IAs. YLTA selected 7 Irrigators Associations (IAs) from Cotabato Province of Region XII and

Maguindanao Province of ARMM from 2014 to 2016 as shown in Table 2.3.36. Note that actual field intervention was carried out only for 2 years, in 2014 and 2015.

Table 2.3.36 Target IAs of YLTA

IA	Year of YLTA implementation	Irrigation Area (ha)	Members Before YLTA	Province	Municipality	Barangay
KIPAN	2014	376.89	318	Cotabato	Carmen	Kibayao
NASGIA	2014	211.14	155	Cotabato	Carmen	Kibayao
MORNING LIGHT	2014	377.67	201	Maguindanao	Pagalungan	Kilangan
MRISIA Div.6	2014	515.58	331	Cotabato	Carmen	Ugalingan/ General Luna
BASBIA	2015	437.12	260	Cotabato	Carmen	Nasapian
KATINGKONGAN	2015	394.86	318	Maguindanao	Pagalungan	Kilangan
MANSAPA	2015	202.27	153	Cotabato	Carmen	Nasapian
Total	-	2,515.53	1,746	-	-	-

Source: NIS Profile (as of Dec. 31, 2014), NIA and YLTA-MMIP Terminal Report 2017, ATI

A steering committee was set up at national level for coordination and supervision of the implementation. Members of the committee are ATI (Chairman of the committee), NIA, DA and JICA. A Project Management Team (PMT) was also set up with the following members in order to coordinate an interest of stakeholders on the project site. Other relevant agencies had also participated in PMT meetings when necessary, such as PhilRice (Philippine Rice Research Institute), PhilMech (Philippine Center for Postharvest Development and Mechanization), PCIC (Philippine Crop Insurance Cooperation), universities and colleges, etc. ATI Regional Training Centre (XII).

1. NIA Regional Management Office (XII) (Vice-chairman of PMT)
2. NIA MMIP PMO (Project Management Office)
3. NIA CIMO (Cotabato Irrigation Management Office)
4. NIA MRIS (Maridagao River Irrigation System)
5. DA Regional Office (XII)
6. DAF (Department of Agriculture & Fisheries) ARMM
7. DA Maguindanao Province
8. Municipality offices in Cotabato Province (Pikit, Carmen & Aleosan)

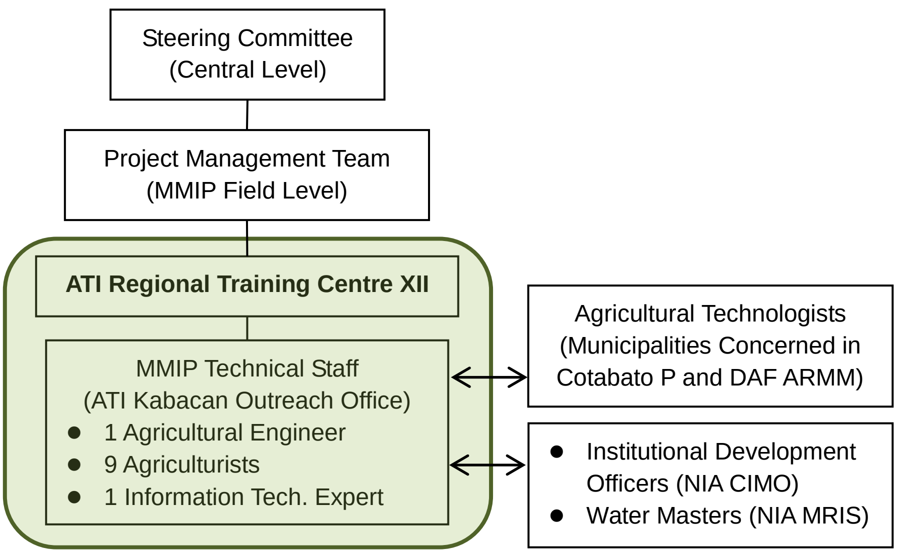


Figure 2.3.16 Implementation Setup of YLTA
Source: YLTA-MMIP Terminal Report 2017, ATI

ATI was a leading implementer of YLTA. ATI provided whole necessary assistance through ATI Regional Training Centre (XII). ATI Regional Training Centre (XII) assigned a technical team exclusively for YLTA in its Kabacan outreach office located in the campus of the University of Southern Mindanao. The technical team has 11 technical staffs and still they are working for an additional technical assistance program in the MMIP project area funded by the Philippine Government. Figure 2.3.16 shows the implementation setup of

YLTA.

YLTA has the following 3 major components; namely, 1) Participatory Demonstration Farms (PDF), 2) Farm Production Input Assistance (FPIA), 3) Development of Extension Modality. Besides, YLTA had agricultural machinery intervention, yet it was limited to just lending a set of floating tiller, rotavator, hand tractor with trailer, thresher and welding machine to the respective target IAs on the condition that it is returned after a certain period of utilization. Under these 3 major components, there have been a series of trainings to which following participants had participated:

Table 2.3.37 Number of Participants/Beneficiaries of YLTA

No	Components	Participants/Beneficiaries
1	**Participatory Technology Demonstration (PTD)**	14 sites in 7 IAs
2	**Farm Production Input Assistance (FPIA)**	368 beneficiaries
3	**Trainings, Seminars and other Training Related Activities**	
3-1	Technical Briefing on Rice Production	467 participants
3-2	Benchmark Survey and Focus Group Discussion	467 participants
3-3	Soil Sampling and Analysis	467 participants
3-4	Climate Smart Field School	467 participants
3-5	Values Re-orientation and Islamic Culture Appreciation	120 participants
3-6	Rice Production and Seed Certification Training	120 participants
3-7	Financial Management Training	120 participants
3-8	Enterprise Development Training	120 participants
3-9	Farmer-led Extension	60 participants
3-10	Farmer's Field Day (FFD)	14 sites in 7 IAs
3-11	Expository Tour	140 participants
3-12	TOT on Rice Production	30 participants
3-13	Capacity Enhancement Training	30 participants
4	**Extension Materials**	
4-1	Extension Manuals	-
4-2	Audio Visual Materials	-
4-3	Information Education Campaign (IEC) Materials	-
5	**Farm Machineries***	4 units each

Note; * Machineries are power tillers with trailer, floating turtle, thresher, welding machine, etc.
Source: YLTA-MMIP Terminal Report 2017, ATI

On the achievement of YLTA, the productivity of rice in all the 7 IAs remarkably increased after the intervention as shown below. The average increase was 2.70 ton/ha from 2.93 ton/ha to 5.63 ton/ha. In the YLTA-MMIP Terminal Report 2017, ATI noted that there were damages of stem-borers in dry season of 2015. It implies that the productivity in the season dropped due to the damages.

Table 2.3.38 Paddy Yield Comparison with-YLTA and without-YLTA

No.	IA	YLTA Year	No. of Farmers	Yield (ton/ha)			
				Without YLTA	With YLTA		
					Dry Season	Wet Season	Ave.
1	KIPAN	2014	54	2.45	5.92	6.80	6.36
2	NASGIA	2014	55	3.10	6.06	6.85	6.46
3	MORNING LIGHT	2014	57	3.20	6.45	6.00	6.23
4	MRISIA Div.6	2014	52	3.20	5.40	6.65	6.03
5	BASBIA	2015	50	3.30	4.05	4.62	4.34
6	KATINGKONGAN	2015	50	2.80	4.85	4.89	4.88
7	MANSAPA	2015	50	2.50	4.66	5.56	5.11
Total			**368**	**2.93**	**5.52**	**5.55**	**5.63**

Note: 368 farmers are beneficiaries of Farm Production Input Assistance (FPIA)
Source: YLTA-MMIP Terminal Report 2017, ATI

An additional technical assistance program similar to YLTA started in 2014 wet season after a request from IA members in the MMIP project area. The Department of Budget and Management (DBM) of the President Office has approved a special fund to implement the additional program covering the areas which were not involved in YLTA. The special fund is valid for 5 years. Table 2.3.39 shows an allocated annual budget from the special fund for the additional program from 2014 – 2018.

Table 2.3.39 Annual Budget of Additional Program Funded by GOP

Year	2014	2015	2016	2017	2018 (Proposal)
Budget (thousands Peso)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Source: ATI Headquarters

With the special fund allocated by the Government, ATI Regional Training Centre (XII) also carried out additional program in parallel with the YLTA through the MMIP technical team in Kabacan outreach office. In total, 18 IAs benefited from the additional program until the end of 2017 as shown in the table below. Total numbers of IAs involved by the end of 2017 as well as the number of beneficiaries were higher than the number benefitted by YLTA.

Table 2.3.40 Number of Beneficial IAs and Farmers of YLTA and Additional Program Funded by GOP as of June 2018

No.	SA	Project (I or II)	NAME OF IA	Total No. of Beneficiaries per Year & by Source of Fund								
				YLTA		Subtotal	Government Fund				Subtotal	Total
				2014	2015		2014	2015	2016	2017		
1	MSA	MMIP I	BASBIA*1	0	60	60	0	0	30	0	30	**90**
2	MSA	MMIP I	MANSAPA	0	60	60	0	0	0	0	0	**60**
3	MSA	MMIP I	MRISIA DIV 5	0	0	0	60	0	0	0	60	**60**
4	MSA	MMIP I	NASFIA	0	0	0	60	0	30	0	90	**90**
5	MSA	MMIP I	KIPAN	65	0	65	0	0	0	0	0	**65**
6	MSA	MMIP I	NASGIA	66	0	66	0	30	0	0	30	**96**
7	MSA	MMIP I	MRISIA DIV 6	63	0	63	0	30	0	0	30	**93**
8	MSA	MMIP I	EDUFIA	0	0	0	0	60	30	0	90	**90**
9	MSA	MMIP I	GAGDANEN BAYA	0	0	0	60	30	30	0	120	**120**
10	MSA	MMIP I	KATINGKONGAN*1	0	60	60	0	0	0	0	0	**60**
11	MSA	MMIP I	MORNING LIGHT	68	0	68	0	0	60	0	60	**128**
12	MSA	MMIP I	TAFIA	0	0	0	60	0	60	0	120	**120**
19	UMSA	MMIP I	BAGONABATI*1	0	0	0	60	0	30	0	90	**90**
20	UMSA	MMIP I	BALATIKAN*1	0	0	0	0	60	30	0	90	**90**
13	UMSA	MMIP II	DALFIA*1	0	0	0	0	0	0	60	60	**60**
14	UMSA	MMIP II	TAMCIA*1	0	0	0	0	0	0	60	60	**60**
15	UMSA	MMIP II	LAGUNDE PAMBUA*1	0	0	0	0	0	0	60	60	**60**
16	UMSA	MMIP II	MALIGA LUPA*1	0	0	0	0	0	0	30	30	**30**
17	UMSA	MMIP II	SARAPANI PANICUPAN*1	0	0	0	0	0	0	60	60	**60**
18	UMSA	MMIP II	NALAPANI	0	0	0	0	60	0	30	90	**90**
21	UMSA	MMIP II	CHRISLAM*1	0	0	0	0	60	0	0	60	**60**
			Total No. of Beneficiaries	**262**	**180**	**442**	**300**	**330**	**300**	**300**	**1,230**	**1,672**
			Total No. of IAs	**4**	**3**	**7**	**5**	**7**	**8**	**6**	**18**	**21**

Source: ATI Regional Training Centre (XII)

Note: *1 Out of 21 IAs, 10 IAs will receive the government fund in the wet season of 2018.

5) Challenges of Agricultural Extension Service

It is generally recognized that agricultural extension services in the Philippine remains ineffective and receives modest support from the government despite the crucial role of the services in achieving sustainable development of agriculture. Relevant papers have pointed out the following issues and problems on an agricultural extension system in the Philippines.

- ✓ Lack of financial support: LGUs allocate budget preferentially to infrastructure projects in most cases. Funds allocated for agricultural development including extension services are minimal in general. Several papers noted that decentralization policy without financial decentralization is meaningless. Due to limited operational funds for travel, extension workers encounter difficulty in providing extension services to farmers. Shortage of funds also limits the production of information, education and communication materials necessary for the services.

- ✓ Less development of human resources: Extension workers are not well motivated for providing quality and efficient services due to lack of career development plan and opportunities. Low salaries and poor incentive systems also discourage them from concentrating on their duties. Many experiences noted that extension workers should be empowered through continuous capability building in order to facilitate community-based and participatory approaches and enhance their technical knowledge and skills.

- ✓ Strong political influences: Political interventions largely determine type and quality of the extension services to be provided. In some extent, political influences affect hiring of the extension staff.

- ✓ Weak function of DA for supporting LGUs: ATI is mandated to function as an apex agency for agricultural extension at national level under DA. However, DA has not established yet a firm institutional channel to work with LGUs while LGUs need to have a national institution to work with on matters concerning agricultural extension policy, coordination, supporting, etc.,

- ✓ Complexities of extension services: In cope with weak capability of LGUs in providing agricultural extension services, various agencies are directly involved in providing the services to farmers. There is, however, an apparent disharmony of programs. Overlapping and redundancy of functions and activities of the agencies are often observed. Empowerment of LGUs is necessary for enabling them to play an expected role in agricultural extension under strategic and gradual implementation of the decentralization policy by the national government.

2.4 Irrigation System in MMIP

2.4.1 Irrigable area of MMIP

The Malitubog-Maridagao Irrigation Project (MMIP) was set out with the technical assistance in the feasibility study conducted from 1985 to 1988, which was financed by ADB. Initially, it was proposed to establish two independent projects with two (2) diversion dams at the Malitubog River and the Maridagao River to irrigate a total of 19,601 ha. Therefore, the project was named as the Malitubog-Maridagao Irrigation Project (MMIP), and even after the original two projects were merged into one having the Maridagao River as the only water resource, the project name was maintained. On the other hand, the management of a part of the original project was handed over to the Cotabato Irrigation Management Office (CIMO) under the NIA Region office XII, and this transferred part was named as the Maridagao River Irrigation System (MRIS).

MMIP was, due to the intermittent armed conflicts since 1970's which have affected the project sites, divided into two phases: the Phase-I (MMIP I) to irrigate 10,840 ha; and the Phase-II (MMIP II) to irrigate 8,760 ha. MMIP I was commenced in October 1989 with the signing of the Loan Agreement between the Government of the Philippines (GOP) and the Japan Bank for International Cooperation (JBIC). The general objectives of this irrigation development project were: 1) to increase rice production, 2) to reduce poverty through job generation, and 3) to contribute to the food sufficiency and sustainability in the region.

Irrigated paddy fields near the Maridagao River in the Upper Malitubog Service Area during rainy season 2016

The scope of MMIP I to generate 10,840 ha of irrigated area at Maridagao Service Area (MSA) and the Upper Malitubog Service Area (UMSA) included the construction of diversion facilities, right wing dike, left wing dike, diversion canal, bridge and siphon across the Maridagao River, irrigation and drainage facilities, canal service roads, access roads, temporary facilities, pilot demonstration farms, water master quarters, office buildings, a farmers training center, farmers quarters, and on-farm facilities, in addition to the provision of agricultural inputs and extension services as well as institutional development activities.

The implementation of the construction works under MMIP I started in April 1993. However, the Project was often interrupted due to recurring armed conflicts. Therefore, the MMIP I could finally complete the MSA and a part of UMSA (upstream) and handed them over to the MRIS Management Office of the Cotabato Irrigation Management Office (CIMO) only on October 31, 2011. It took more than 17 years from the commencement till the completion of the MMIP I.

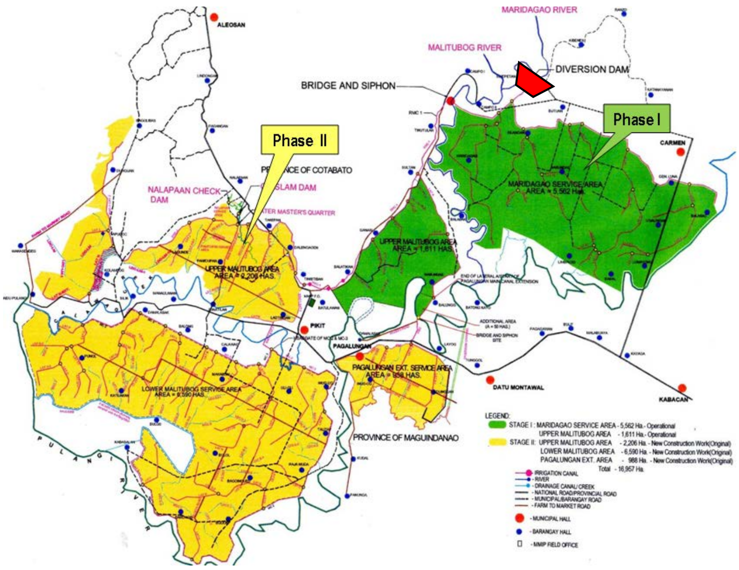


Figure 2.4.1 Project Map of MMIP I and MMIP II

Source: NIA- PMO

Originally the planned gross area of MSA was about 6,562 ha. However, according to the NIA Region XII and MMIP-PMO Joint Inventory Report submitted on October 7, 2003, in the course of project implementation, about 530 ha of water-logged area was identified. Of which, 306 ha was swampy through the year, and the remaining 224 ha was wet lands only in the rainy seasons and grassland during the dry seasons. Thus, the total area to be irrigated had to be reduced by 306 ha to 6,256 ha. In addition, another 695 ha was found not irrigable due to their higher elevations than the canal surface elevation. Thus, in the end the total area to be irrigated in MSA remained 5,561 ha.

According to the SAPROF report (May 2007)[1], a field inspection was carried out by walking through MSA to identify the actual conditions of the area in December 2006. As shown in the Figure 2.4.2, 4,715 ha of the cultivated area (green color) and 1,136 ha of submerged area, which could be divided into about 606 ha of water-logged area (light blue color) and 530 ha of swamp area (crisscrossed), were confirmed. In addition, the team identified 836 ha of flood prone area (light yellow color) adjacent to the Pulangi river, and other areas whose landowners opposed to irrigate their lands having coconut trees planted and houses established on them.

Figure 2.4.2 Land Use of Maridagao Service Area in Dec. 2006

Source: Final Report of SAPROF

According to the MRIS Management Office, as of April 2017, the net irrigable area for MMIP I is 7,173 ha, with the break-down of: 5,562 ha in MSA, and 1,611 ha in the MMIP I site of UMSA. On the other hand, the net irrigable area for MMIP II is 10,541 ha with the break-down of: 2,550 ha in the MMIP II site of UMSA, 6,849 ha in Lower Malitubog Service Area (LMSA), and 1,142 ha in Pagalungan Extension Service Area (PESA). Thus, the net irrigable area of the entire MMIP I and MMIP area comes to 17, 714 ha.

Table 2.4.1 Irrigable Areas of MMIP I and MMIP II

Service Area	Stage	Irrigable Area (ha)		Remark
		Original Plan	Current Plan	
Maridagao	Phase 1	6,562	5,562	5,562 ha is the net irrigable area
Upper Malitubog	Phase 1	4,278	1,611	1,611 ha is the net irrigable area
	(Phase 1) ↓ Phase 2	-	2,550	Originally the development of this area was to be undertaken under the Phase 1; however, was shifted to the Phase 2.
Lower Malitubog	Phase 2	7,618	6,849	
Pagalungan Extension	Phase 2	1,142	1,142	
Total	**Phase 1**	**1,0840**	**7,173**	
	Phase 2	**8,760**	**10,541**	
Grand Total		**19,600**	**17,714**	

Data Source: Project Completion Report, Malitubog Maridagao Irrigation Project, Stage 1 (Loan No. PH-P112) Year 2007
Malitubog Maridagao Irrigation Project II, Status of Construction as of May 15, 2017

2.4.2 Irrigation System of MMIP

1) Diversion Dam

All water volume required for the entire irrigation systems of MMIP I and MMIP II is taken from the

[1] Japan Bank for International Cooperation, 2007; Special Assistance for Project Formation (SAPROF) for Malitubog-Maridagao Irrigation Project (Phase-II)

Maridagao River through the diversion dam, which consists of 8 gates with concrete weir spillway structure. It is also equipped with 2 lanes of concrete bridge decks, 2 sluice ways with bascule type steel gates, 3 gate intakes with mechanically operated steel gates and trash rack, 650m-long right wing dike as well as 360m-long left wing. The elevation of the dike is set at EL35m (AMSL) to serve as reservoir at the same time, and the 65m-long fuse dike with the highest elevation of EL32.3m was designed to be collapsed by flood at EL34m level. In addition, the electro-mechanical apparatus are wired so that they can be operated from the operation house (for details, see Table 2.4.2).

Table 2.4.2 Specifications of the Diversion Dam

Description		Description	
I. Diversion Works		e) Sluice way	2 opening
a) Right Wing Dike (RWD)	Earth type	・ Gate Type	Double leaf wheel type
・ Length	650m	・ Upper Lift	4.1m x 4.2m
・ Height (maximum)	26.0m	・ Lower Lift	5.0m x 4.2m
・ Top Bank Elevation	El 35.0m AMSL	・ Top of Gate Elevation	El 31.0 AMSL
・ Width of Top bank	6.0m	f) Intake	3 openings
b) Left Wing Dike (LWD)	Earth type	・ Gate Type	Vertical Slide
・ Length	360m	・ Height	1.75m
・ Height (maximum)	11m	・ Width	4.2m
・ Top Bank Elevation	El 35.0m AMSL	・ Top of Gate Elevation	El 29.75m AMSL
・ Width of Top bank	6.0m	**II. Reservoir**	
c) Fuse Dike	Earth type	・ Catchments Area	1,460 sq.km
・ Length	65m	・ Reservoir area	1.99 sq.km (WL31.0)
・ Height (maximum)	1.8m	・ Reservoir area/ volume	500ha/12.2 million cu m
・ Top Bank Elevation	32.3m AMSL	・ Design Flow Level	El 32.50m AMSL
・ Width of Top bank	4.0m	・ Design Flood Discharge	1,600 cu m/s
d) Gated Spillway/Weir	8 openings	・ Normal Operation Water Level	El 31.00m AMSL
・ Gate Type	Radial Type	・ Upper Operation Level	El 30.90m AMSL
・ Height	3.9m	・ Lower Operation Level	El 30.70m AMSL
・ Width	8.7m	・ Intake Upper Water Level	El 31.00m AMSL
・ Top of Gate Elevation	El 31.3m AMSL	・ Intake Mean Water Level	El 30.80m AMSL
		・ Intake Maximum Discharge	35.9 cu m/s

Note: AMSL: above mean sea level
Data Source: Final Report (Volume II) of SAPROF for Malitubog-Maridagao Irrigation Project

2) Irrigation Canal Network

The entire MMIP beneficiary area is divided into 4 main Service Areas, namely MSA, UMSA, LMSA and PESA. UMSA can be further divided into 3 areas; Phase 1 area, Phase 2 area and an extension area. The irrigation canal network of these Service Areas consists of: 8 main canals with the total length of 117.7 km; 66 lateral canals with the total length of 165.8 km; and on-farm canal ditches with the total length of 748.9 km. The irrigation canal network is shown in Figure 2.4.3 and details of canals are also shown in Table 2.4.3 below.

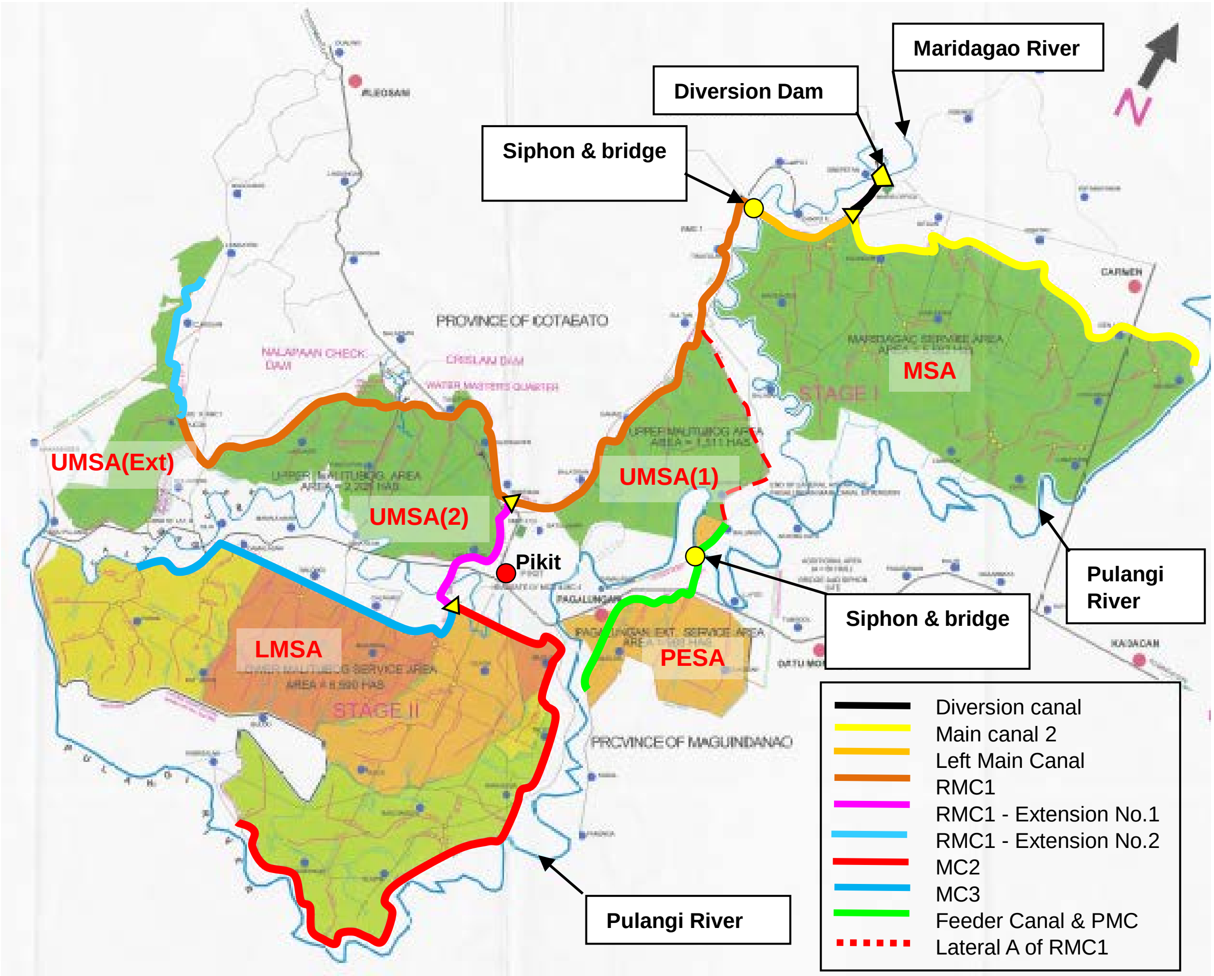


Figure 2.4.3 Irrigation Canal Network in MMIP

Source of Base Drawing: NIA- PMO

Table 2.4.3 Length of Main Canal & Lateral Canal and Number of Turnouts in MMIP

Particular	Unit	MSA	UMSA (1)	UMSA (2)	LMSA.	PESA	Total
Diversion canal	km.	3.4					3.4
Main canal 2	km.	29.2					29.2
Left Main Canal	km.	13.5					13.5
Right Main Canal 1 (RMC 1)	km.		11.5	17.4	0		28.9
RMC1 - Extension No.1	km.			4.4			4.4
RMC1 - Extension No.2	km.			4.7			4.7
MC2	km.				22.5		22.5
MC3	km.				11.1		11.1
PMC	km.					7.3	7.3
Lateral & sub-lateral canal	Nos	19	5	9	30	3	66
Lateral & sub-lateral canal	km.	38.5	13.6	22.0	82.9	8.8	165.8
Turnout	Unit	186	52	82	69	28	417
Farm Canal (MFD & SFD)	km.	341.9	238.1	82.00	69.0	17.9	748.9

Data Source: NIA- PMO

The irrigation water taken from the diversion dam is carried through the diversion canal. At the bifurcation located at 3.4 km downstream from the intake, the water is distributed to the Left Main Canal and the Main Canal 2. The irrigation canal system in MSA covering 5,562 ha consists of: 2 main canals, namely, the Main Canal 2 with the length of 29.2 km and the Left Main Canal with the length of 13.5 km; and 19 lateral canals with the total length of 38.5 km. The Left Main Canal goes across the Maridagao river at the location of Sta. 4+635, and the name of the same canal is altered to the Right Main Canal 1 (RMC) when it enters into UMSA, after passing through the siphon.

The irrigation canal system in the MMIP I site in UMSA covering 1,611 ha consists of: the main canal, RMC 1 with the total length of 11.5 km from Sta. 0 to Sta.11+500, and 5 lateral canals with the total length of 13.6 km. The irrigation canal system in the MMIP II site in UMSA with 2,550 ha including the Extension area of UMSA consists of: the main canals, RMC 1 with the length of 17.4 km from Sta. 11+500 to Sta.28+900, RMC1 - Extension No.1 canal (RMC 1 - EXT-1) with the length of 4.4 km, RMC 1 - Extension No.2 canal (RMC 1 - EXT-2) with the length of 4.4 km; and 9 lateral canals with the total length 22.0 km. RMC 1 - EXT-1 is the only canal to supply the irrigation water to the Main canal No.2 & No.3 in LMSA. RMC 1 - EXT-2 is the canal to irrigate the Extension area of UMSA.

The irrigation canal system in LMSA to cover 6,849 ha consists of: Main canal No.2 (MC-2) with the length of 22.5 km; Main canal No.3 (MC-3) with the length of 11.1 km, which is derived from RMC 1 - ECT-1; and 31 lateral canals with the total length of 82.9 km. MC-2 will serve 3,224 ha of the eastern part of the service area while MC-3 is planned to serve 4,336 ha of the remaining middle and western parts of LMSA.

The location where PMC goes crossing the Pulangi River through a siphon structure (box size: 1.3m x 1.3m, length: 141 m).

PESA originally formed a part of the Kabacan River Irrigation System. However, when the diversion canal running from the Pulangi river to the Liguasan Marsh was constructed, the area was left isolated from the Kabacan River Irrigation System. Therefore, the restoration of the irrigation canal system in PESA to cover 1,142 ha was planned to be carried out under MMIP II. The system consists of: the Pagalungan Main Canal (PMC) with the total length of 7.3 km, which is derived from the Lateral A of RMC 1; and 3 lateral canals with the total length of 8.8 km.

3) Drainage System

The drainage system in MSA consists of: 3 main drainage canals with the total length of 24.3 km and 40 lateral drainage canals with the total length of 59.5 km. The total length of drainage canals in MSA reaches 50.0 km and their details are shown in Table 2.4.4. The drainage system in UMSA consists of: 3 main drainage canals with the total length of 34.4 km and 30 lateral drainage canals with the total length of 39.3 km. The total length of drainage canals in UMSA reaches 73.7 km and their details are shown in Table 2.4.5.

Table 2.4.4 Drainage Canal in MSA

Drainage canal		Length (m)	Drainage canal		Length (m)	Drainage canal		Length (m)
MDC	I	10,330	LDC	IC-1	1,856	MDC	IA	4,662
LDC	IA	3,197	LDC	IC-2	2,080	MDC	II	9,320
LDC	IA-2	2,921	LDC	IC-2A	1,243	LDC	IIA	1,035
LDC	IA-3	2,220	LDC	ID	2,802	LDC	IIB	1,720
LDC	IA-3a	380	LDC	ID-1	2,691	LDC	IIC	5,260
LDC	IA-4	2,467	LDC	ID-1a	292	LDC	IIC-1	2,720
LDC	IA-4a	1,200	LDC	ID-1b	449	LDC	A	1,400
LDC	IA-4b	1,280	LDC	ID-2	980	LDC	B	4,779
LDC	IA-4c	957	LDC	ID-3	940	LDC	B1	1,706
LDC	IA-8a	304	LDC	IE	1,733	LDC	B2	1,492
LDC	IB	2,775	LDC	IE-1	2,525	LDC	EXTRA	1,996
LDC	IB-1	814	LDC	IE-2	713	LDC	EXTRA-1	580
LDC	IB-2	628	LDC	IE-3	1,299	LDC	EXTRA-2	1,100
LDC	IB-3	465	LDC	IE-4	932	**Total of MDC**		**24,312**
LDC	IC	2,724	LDC	IE-5	300	**Total of LDC**		**59,453**
						Total		**45,995**

Data Source: NIA PMO of MMIP II

Table 2.4.5 Drainage Canal in UMSA

Drainage canal	Length (m)	Drainage canal	Length (m)	Drainage canal	Length (m)
MDC KC	21,872	LDC KC-V	2,290	LDC PR-IVB-2	1,000
MDC LM	12,508	LDC KC-VI	1,616	LDC PR-IVC	1,200
LDC LM-I	3,728	LDC KC-EXTRA	2,200	LDC PR-IVD	697
LDC LM-II	7,168	LDC PR-I	1,948	LDC PR-IV-E	840
LDC LM-IIA	1,072	LDC PR-II	2,600	LDC PR-V	1,226
LDC KC-I	2,756	LDC PR-III	7,442	LDC PR-Va	470
LDC KC-II	3,180	LDC PR-IIIA	2,024	LDC PR-Vb	400
LDC KC-IIA	1,440	LDC PR-IIIB	1,565	LDC PR-Vc	763
LDC KC-III	3,040	LDC PR-IV	2,520		
LDC KC-IV	2,582	LDC PR-IVA	1,740	**Total of MDC**	**34,380**
LDC KC-IVA	2,752	LDC PR-IVB	1,040	**Total of LDC**	**39,340**
LDC KC-IVB	968	LDC PR-IVB-1	932	**Total**	**73,720**

Data Source: NIA PMO of MMIP II

The drainage system in LMSA consists of: 10 main drainage canals with the total length of 27.9 km and 20 lateral drainage canals with the total length of 24.7km. In addition, the construction of 14.7 km long Façade Drain, into which 8 of the main drainage canals flow, is planned as the last drainage canal pouring out to the Pulangi river under the framework of MMIP I & II. Construction of the 8.5 km long Kalawag Creek is also planned for the improvement on the drainage system in LMSA. The total length of drainage canals in LMSA reaches 75.8 km and their details are shown in Table 2.4.6. The drainage system in PESA consists of: only 4 main drainage canals with the total length of 14.5km, and their details are shown in Table 2.4.7:

Table 2.4.6 Drainage Canals in LMSA

Drainage canal	Length (m)	Drainage canal	Length (m)	Drainage canal	Length (m)
LDC A1	547	LDC D1	1,760	MDC E	2,562
LDC A2	1,079	LDC D2	1,220	MDC F	3,116
LDC A3	1,275	LDC D3	940	MDC G	2,871
LDC A4	882	LDC F	3,116	MDC H	2,296
LDC B1	2,746	LDC H1	1,824	MDC I	1,908
LDC B1	1,941	LDC H2	1,091	MDC J	1,066
LDC B3	651	LDC H3	883	**Total of MDC**	**27,936**
LDC B4	1,082	LDC H4	896	**Total of LDC**	**24,657**
LDC C1	874	MDC A	4,540	**Total of MDC & LDC**	**52,593**
LDC C2	1,161	MDC B	4,294	FAÇADE DRAIN	14,748
LDC C3	2,746	MDC C	2,871	KALAWAG CREEK	8,460
LDC C4	689	MDC D	2,412	**Total**	**75,801**

Data Source: NIA PMO of MMIP II

Table 2.4.7 Drainage Canal in PESA

Drainage canal	Length (m)	Drainage canal	Length (m)	Drainage canal	Length (m)
MDC LM I	3,714	MDC LM III	3,839		
MDC LM II	3,630	MDC LM IV	3,336	**Total of MDC**	**14,549**

Data Source: NIA PMO of MMIP II

4) Project Components of MMIP II

MMIP II started in January 2011 aiming at the generation of 9,784 ha of irrigable area in UMSA, LMSA and PESA and its target of the total irrigable area was later expanded to the 10,541 ha. As shown in Table 2.4.8, most of the target areas belong to Pikit Municipality and the total service area in Pikit reaches 9,208 ha, which corresponds to 87 % of the total target area under MMIP II. As of May 2018, the irrigable area which has been generated since the commencement of the project arrives at 5,513 ha, namely, about 53% of the project target. This consists of: 2,958 ha in UMSA, 1,567ha in LMSA and 988 ha in PESA and further details are shown in Table 2.4.9.

As of May 2018, the total area under operation is 1,478 ha, which is a part of UMSA. It includes the improvement area of 430 ha, where the water source was Chrislam dam in Panicupan before and was changed to Lateral canal H of RMC 1. While for the irrigation area of 1,048 ha, water source came from Laterals canal E, F, G, I & J of RMC 1. The remaining area of UMSA which is irrigated by Lateral canals K, K Extension, L & M along RMC1 EXT.1 and RMC1 EXT. 2 will be turned-over soon. The Nalapaan Stream Check area, which was developed under MMIP II, covers 100 ha under operation by CIMO of Cotabato Province since 2012.

Table 2.4.8 Service Areas of MMIP II (by Service Area & Municipalities)

Service Area	Province	Municipality	Service Area (ha)				Farmer Beneficiaries			
			Original		Revised		Original		Revised	
UMSA	Cotabato	Pikit	2,015	2,206	2,359	2,550	343	649	694	750
		Aleosan	191		191		306		56	
LMSA	Cotabato	Pikit		6,590		6,849		1,937		2,014
PESA	Maguindanao	Pagalungan	634	988	788	1,042	186	291	232	336
		Datu Montawal	354		354		104		104	
		Total		**9,784**		**10,541.**		**2,877**		**3,100**

UMSA: Upper Malitubog Service Area, LMSA: Lower Malitubog Service Area, PESA: Pagalungan Extension Service Area

Table 2.4.9 Progress in Generation of Irrigable Area in MMIP II (as of April 2017)

Service Area	Target	2011	2012	2013	2014	2015	2016	2017	2018	Total
UMSA	2,550	530	565	107	644	1,085	27	0		**2,958**
LMSA	6,849	-	-	-	-	10	599	341	**617**	**1,567**
PESA	1,142	-	-	-	-	988	0	0	**0**	**988**
Total	**10,541**	**530**	**565**	**107**	**644**	**2,083**	**626**	**197**		**5,513**
Cumulative		**530**	**1,095**	**1,202**	**1,846**	**3,929**	**4,555**	**4,896**	**5,513**	**-**

Data Source: Malitubog Maridagao Irrigation Project II, Status of Construction as of May 15, 2018
Note: UMSA: Upper Malitubog Service Area, LMSA: Lower Malitubog Service Area,
PESA: Pagalungan Extension Service Area

The project component of MMIP II is shown in Table 2.4.10; the total lengths of main canal and lateral canals are planned to be 66.8 km and 100.2 km totaling 167.0 km. The total numbers of the canal structures and the turnouts are planned at 207 and 412. For the on-farm development, construction of total 168.85 km of on-farm canals with 1,605 farm structure is planned. 323 steel gates for water management as well as the total length of 127 km of main and lateral drainage canals together with the total length of 94.18 km of farm drainage canals are also to be constructed in the project area.

Table 2.4.10 Project Components of MMIP II

Particular	Unit	UMSA	LMSA.	PESA	Total	Remarks
RMC1	km.	17.35	0		17.35	Main canal: 69.320 km. Revised to 66.772 km. Lateral canal: 113.660 km Revised to 100.263 km. Total Canal 178.02 km Revised to 167.035 km.
RMC1 – Extra	km.		4.41		4.41	
MC2	km.		22.54		22.54	
MC3	km.		11.06		11.06	
Feeder Canal	km.			1.70	1.70	
PMC	km.			7.30	7.30	
Lateral & Sub Laterals	km.	22.00	82.86	8.8	113.66	
Canal Structure	Unit	85	100	22	207	
Turnout	Unit	82	69	28	179	Revised to 412 units
Farm Canal (MFD)	km.	82.00	69.00	17.85	168.85	
Farm Structure	unit	1,230		375	1,605	
Steel Gates	unit	98	194	31	323	
Access /Intra-site Road	km.	20.00		5.4	25.40	
Canal Service Road	km.	39.00			39.00	
Farm Bridge	unit		1		1	
Bridge & Siphon	unit			2	2	
Main Drain & Lateral Drain	km.	62	53	12	127	Revised to 119.96 km
Farm Drain	km.	82.00		12.18	94.18	Dev. Cost.
Estimated cost (M PhP)	Original	[redacted]		[redacted]	[redacted]	628 K/Ha.
	Revised	[redacted]		[redacted]	[redacted]	**517 K/Ha**.

Data Source: Monthly Progress Report of MMIP II, (May, 2018)
Note: UMSA: Upper Malitubog Service Area, LMSA: Lower Malitubog Service Area,
PESA: Pagalungan Extension Service Area

The completion date of the project was originally planned in December 2015, but it had been changed to December 2019 as of May 2018. The current progress of the project implementation is shown in Table 2.4.11 and Table 2.4.12. As of May 2018, the progress rate of the Project is evaluated at 45.9% on the basis of value of accomplishment and at 40.7% on the basis of actual expenditure.

The Project (MMIP II) to date constructed; 31 km in the main canal (RMC1&Ext.1&2, MC2&MC3; 52.6% of the total length planed), 46 km of lateral canals (46.3% of the total length planned), 221 canal structures (28.7% of the total units planned), 2.1 km of the drainage canal and main drainage canals (4.1% of the total length planned), 12.5 km of the lateral drainage canals (18.1% of the total length planned) and 24.3 km of farm canals (MFD & SFD; 14.4% of the total length planned).

Table 2.4.11 Progress in the Implementation of MMIP II

No	Particular (major facilities)	Unit	Plan		Progress (as of May 2018)	
			Original	Revised		
1	**GENERATED AREA**					
	Upper Malitubog Service Area (UMSA)	ha.	2,206	2,550	2,958	(116.0%)
	Lower Malitubog Service Area (LMSA)	ha.	6,590	6,849	806	(11.8%)
	Pagalungan Extension Service Area (PESA)	ha.	988	1,142	988	(86.5%)
	Total	ha.	9,784	10,541	5,513	52.7%
2	**IRRIGATION FACILITIES**					
	Main Canal (RMC1&Ext.1&2, MC2&MC3) -Lined canal	km.	60.320	59.336	31.212	(52.6%)
	Feeder Canal & Pagalungan Main Canal -Lined canal	km.	9.000	7.436	6.952	(94.5%)
	Lateral Canal - Earth canal	km.	113.660	100.263	46.435	(46.3%)
	Canal Structure	Unit	386	768	221	(28.7%)
	Additional Structure for Nalapaan & Panicupan	Unit	14	32	32	(100.0%)
	Canal Lining for Nalapaan & Panicupan	km.	4.258		4.274	(100.4%)
3	**DRAINAGE FACILITIES**					
	Protection Dike (PESA)	km.		8.778	5.157	(58.7%)
	Main Drainage Canal	km.	57.670	50.630	2.100	(4.1%)
	Lateral Drainage Canal	km.	69.330		12.528	(18.1%)
	Drainage Structure	Unit	3		3	(100.0%)
4	**ON-FARM LEVEL FACILITIES**					
	Farm Canal (MFD & SFD)	km.	168.850		24.337	(14.4%)
	Farm Structure	Unit	1,605			
5	**ROAD NETWORK**					
	Access Road/Intrasite Road	km.	25.400		0.360	(25.2%)
	Canal Service Road	km.	39.000			
6	**OTHER MAJOR STRUCTURE**					
	Farm Bridge	Unit	1			
	Bridge & Siphon	Unit	2			
	Improvement of Office Building	Unit	13		10.0	(76.9%)
	Watermasters Quarter	Unit	2		1.0	(50.0%)
7	**FINANCE**					
	Budget allocation	M PhP	[redacted]	[redacted]	[redacted]	([redacted]%)
	Value of Accomplishment	M PhP			[redacted]	([redacted]%)
	Actual Expenditure	M PhP			[redacted]	([redacted]%)

Data Source: Monthly Progress Report of Malitubog Maridagao Irrigation Project II, (May, 2018)

Table 2.4.12 Progress in Civil Works (Contract Works and Direct Force Account) of MMIP II

Class/Item	Estimated Cost	Weight	Physical Accomplishment per Item	Expenditure/ Value of work	Remarks/ Actual Area Generated
	(MP)	(%)	(%)	(M PhP)	
CY2011					1,095 Ha.
a. Contract	[redacted]	57.21	100	[redacted]	*Completed 2012*
b. Force Account	[redacted]	42.79	100	[redacted]	*Completed 2012*
Total	[redacted]	100	100	[redacted]	
CY 2012 (Implemented 2013)					500 Ha.
a. Contract	[redacted]	94.26	100	[redacted]	*Completed 2014*
b. Force Account	[redacted]	5.74	100	[redacted]	*Completed 2014*
Total	[redacted]	100	100	[redacted]	
CY 2013					868 Ha.
a. Contract	[redacted]	77.33	100	[redacted]	*Comp. Physically June 2015*
b. Force Account	[redacted]	22.67	100	[redacted]	*Completed 2015*

Class/Item	Estimated Cost	Weight	Physical Accomplishm ent per Item	Expenditure/ Value of work	Remarks/ Actual Area Generated
	(MP)	(%)	(%)	(M PhP)	
Total	[redacted]	100	100	[redacted]	
CY 2014					495 Ha.
a. Contract	[redacted]	88.60	98.43	[redacted]	*Ongoing*
b. Force Account	[redacted]	11.40	100.00	[redacted]	*Completed*
Total	[redacted]	100	98.60	[redacted]	
CY 2015					1,825 Ha.
a. Contract	[redacted]	95.49	68.35	[redacted]	*Ongoing*
b. Force Account	[redacted]	4.51	92.45	[redacted]	*Ongoing*
Total	[redacted]	100	65.27	[redacted]	
CY 2016					570 Ha.
a. Contract	[redacted]	96.11	10.63	[redacted]	*Ongoing*
b. Force Account	[redacted]	3.89	5.93	[redacted]	*Ongoing*
Total	[redacted]	100	10.44	[redacted]	
CY 2017					152 Ha.
a. Contract	[redacted]	95.44	45.70	[redacted]	*Ongoing*
b. Force Account	[redacted]	4.56	100	[redacted]	*Ongoing*
Total	[redacted]	100	48.28	[redacted]	
CY 2018					8 Ha.
a. Contract	[redacted]	94.28	10	[redacted]	*Ongoing*
b. Force Account	[redacted]	5.72	20	[redacted]	*Ongoing*
Total	[redacted]	100	10.6	[redacted]	

Data Source: Monthly Progress Report of Malitubog Maridagao Irrigation Project II, (May, 2018)

2.4.3 Area Irrigated by Year and by Crop (MMIP I: MRIS)

Irrigation supply for Maridagao Service Area started in 2002, but was stalled in year 2003 due to deteriorated peace and order situation in the area. Actual operation and maintenance activities started in September 2004 with irrigated area of 3,832 ha (1,970 ha in the dry season and 1,861 ha in the wet season). Note that actual benefited area was 1,341 ha composed of 420 ha in the dry season and 921 ha in the wet season. Irrigated area and benefited area have been gradually increasing with completion of the remaining works for 1,611 ha in Upper Malitubog Service Area. From the dry season of 2013, the new additional service area of Crislam IA and Nalapani IA, which were generated under MMIP II, started supplying irrigation water.

On the current condition of the service area in the year 2016, as shown in Table 2.4.13, total service area of MRIS comes to 5,608 ha which is revised from the original service area of 7,173 ha, out of which 4,176 ha is in MSA which is also revised from original service area of 5,562 ha, and 1,431 ha is in UMSA revised from the original service area of 1,611 ha. The firmed-up service areas (FUSA) of MSA and UMSA are 4,126 ha and 1,400ha respectively. Total firmed-up service area (FUSA) reaches 5,527 ha.

Table 2.4.13 Current Condition of the Service Area in MRIS

Particular	Service area (ha)	Updated service area (ha)	FUSA (ha)	Operational area (ha)	Converted area (ha)	Remarks
MSA	5,562	4,176.49	4,126.14	3,165.08	50.35	Planted w/ permanent crops
UMSA	1,611	1,431.28	1,400.53	1,331.70	30.75	Planted w/ permanent crops
TOTAL	7,173	5,607.77	5,526.67	4,496.78	81.10	

Source: MRIS office (NIA Regional 12, Cotabato Irrigation Management Office)
Note: Updated service area is based on parcellary survey
FUSA is an abbreviation of "Firm-Up Service Area". It is the net service area of an irrigation system where converted areas and permanently non-restorable areas were deducted from the service area.
Operational area is the area within the FUSA where irrigation water can be served during the respective cropping seasons

As shown in Table 2.4.14, irrigated area/ planted area is 7,175 ha (4,115 ha in the dry season and 3,060 ha in the wet season), and therefore the annual crop intensity arrives at 130 % (74% in the dry season and 55% in the wet season). The benefited area comes to 5,941 ha (3,360 ha in the dry season and 2,580 ha in the wet season). Percentage of the benefited area to the irrigated area is estimated at 82 %

by the dry season, 84 % by wet season and 83% by annual. It means that over 80 % of irrigated farmland obtains the benefit, if the farmland can be irrigated.

Table 2.4.14 Actual Irrigated Area in Maridagao Service Area (MRIS)

Year	Service area (ha)	FUSA (ha) (Irrigable area)	Irrigated area/ Planted area (ha)			Crop intensity (%)			Benefited Area (ha)			Percentage of Benefited Area to irrigated area			Percentage of Benefited Area to FUSA		
			Dry	Wet	Annual	Dry	Wet	Annual	Dry	Wet	Annual	Dry	Wet	Annual	Dry	Wet	Annual
2004	5,562		1,970	1,861	3,832	35	33	69	420	921	1,341	21	49	35	8	17	24
2005	5,562		1,520	1,818	3,337	27	33	60	893	1,299	2,192	59	71	66	16	23	39
2006	5,562		2,110	2,247	4,357	38	40	78	1,324	1,980	3,304	63	88	76	24	36	59
2007	5,562		2,050	2,249	4,299	37	40	77	1,744	1,941	3,685	85	86	86	31	35	66
2008	5,562		2,745	2,508	5,252	49	45	94	1,815	2,115	3,930	66	84	75	33	38	71
2009	5,562		2,835	2,835	5,670	51	51	102	2,997	2,285	5,283	106	81	93	54	41	95
2010	5,562		3,069	3,415	6,484	55	61	117	2,646	3,088	5,734	86	90	88	48	56	103
2011	5,562	4,027	3,383	2,751	6,133	84	68	152	2,608	2,304	4,912	77	84	80	65	57	122
2012	5,562	4,027	2,896	1,087	3,983	72	27	99	2,454	908	3,362	85	84	84	61	23	83
2013	5,608	5,216	3,274	3,831	7,104	63	73	136	2,035	2,393	4,427	62	62	62	39	46	85
2014	5,608	5,608	3,868	4,369	8,237	69	78	147	2,935	3,684	6,618	76	84	80	52	66	118
2015	5,608	5,608	3,785	4,202	7,986	67	75	142	3,305	3,629	6,934	87	86	87	59	65	124
2016	5,608	5,527	4,115	3,060	7,175	74	55	130	3,360	2,580	5,941	82	84	83	61	47	107

Source: MRIS office (NIA Regional 12, Cotabato Irrigation Management Office)
Note: "Irrigated Area" is the area served irrigation water within the operational area of the FUSA during the respective cropping seasons (e.g. wet and dry seasons).
"Benefited/Planted Area" is the actual portion of the irrigated area that is planted with crops during the respective cropping seasons (e.g. wet and dry seasons).
"Cropping Intensity" is the ratio of the Irrigated area/ Planted area to the FUSA of an irrigation system.

2.4.4 Operation and Maintenance

In general, the operation and maintenance (O&M) of National Irrigation System is managed by the Irrigation Superintendent appointed under the Regional office of NIA. Maridagao River Irrigation System (MRIS) Management Office, which is in the Operation & Maintenance Section of Cotabato Irrigation Management Office (CIMO) under the NIA Region XII, has the responsibility of the operation of the irrigation system and maintenance of main structures such as diversion dam, siphon, main canal and lateral canal in service area of MRIS.

The MRIS Management Office is located near Pikit town. Table 2.4.15 shows the current staffing structure and appointment status of the MRIS management office. All the positions are filled with additional staff, e.g., three driver Mechanics, one utility worker. There are therefore not significant O&M constraints due to shortages in staff. MRIS management office has its own O&M manual which consists of Main System, Diversion Dam Operation and Maintenance, and Annexes. Based on the manuals, routine and monthly inspections are conducted.

Table 2.4.15 Staffing Structure of the MRIS Management Office

	Title	Major Responsibilities	Plan	Actual
1	Principal Engineer A	Direct supervision of the implementation and O&M	[redacted]	[redacted]
2	Senior Engineer A	Assistance in supervisory activities	[redacted]	[redacted]
3	Senior Irrigators Development Officer	Training/capacity building, strengthening of Irrigators' Associations	[redacted]	[redacted]
4	Senior Water Resources Facilities Technician	Maintenance of machinery and other mechanical equipment	[redacted]	[redacted]
5	Collection Representative A	Collection of irrigation service fees, developing plans and strategies to improve collection rates	[redacted]	[redacted]
6	Plant Electrician B	O&M of plant electrical system	[redacted]	[redacted]
7	Heavy Equipment Operator	Operation of heavy equipment	[redacted]	[redacted]
8	Accounting Processor A (Billing Check)	Accounting	[redacted]	[redacted]
9	Industrial Security Guard A	Safeguarding of properties, facilities and compounds	[redacted]	[redacted]
10	Data Encoder	Data input related to various acquired data and information	[redacted]	[redacted]
11	Driver Mechanic B	Mechanic maintenance and driving service	[redacted]	[redacted]
12	Water Resources Facilities Operator B	Operation of gates to regulate amount of water to store/needed	[redacted]	[redacted]
13	Utility Worker	Office maintenance	[redacted]	[redacted]
Total			[redacted]	[redacted]

Data Source: NIA-Region XII organizational structure and its authorized position (as of May 2017)

The O&M costs for the facilities and day-to-day operation activities are covered under the CIMO's and MRIS management office's budgets while the NIA Central Office has a budget framework to finance major maintenance and rehabilitation as needed. The financial status of MRIS is shown in Table 2.5.16. Approved corporate operating budget for MRIS is PhP [redacted] for personal service (PS) and [redacted] for maintenance and other operation expenses (MODE) for an average of past 5 years. However, as the operational area increases, the budget also increases; e.g., the budget allocated for 2016 reaches PhP [redacted] for PS and PhP [redacted] for MODE.

On the other hand, average expenditure for the past 5 years is PhP [redacted] for PS and PhP [redacted] for MODE, and thus the average total expenditure is PhP [redacted] per annum. Although the expenditure for MODE was over the budget in 2014 and 2015, it was within the total budget including the budget for personal service. The revenue-expenditure balance of the MRIS management office has been in deficit, which is average PhP [redacted] per year for the past 5 years. CIMO has supplemented MRIS' budgets for daily operation and maintenance activities while major rehabilitation was financed from NIA's maintenance and rehabilitation funds.

The irrigation area increases as the project progresses, and therefore the expenditure of MRIS for O&M of irrigation system will also increase in the future. As the Republic Act No.10969, Free Irrigation Service Act came to effect on February 2, 2018, it is necessary to secure new income sources such as government subsidies for sustainable and proper O&M of the irrigation systems in future.

Table 2.4.16 Approved Budget, Income and Expenditure of MRIS Management Office

Year	Approved corporate operating Budget		Income (PhP)				Expenditure (PhP)			Surplus (Deficit)
	Personal service	MODE	ISF	BA	Other Income	Total	Personal service	MODE	Total	
2012	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2013	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2014	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2015	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
2016	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Ave.	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Source: MRIS office (NIA Regional 12, Cotabato Irrigation Management Office)
ISF: Irrigation service Fee, BA: Back account of Irrigation service Fee. MODE: Maintenance and other operation expenses

2.4.5 Irrigators Association and IMT

With the development of irrigation system, the operation and maintenance (O&M) of the facilities could be another crucial sphere to enhance irrigation performance, as well as, to sustain the facilities and ensure the water supply up to the end beneficiaries. In order to make irrigation facilities function equally to the upstream, midstream, and downstream water users, a joint management by the NIA and the farmers organized, through irrigation management transfer (IMT), is to be one of the solutions. Accordingly, NIA has been conducting IMT activities step by step according to the condition of each of the NIA irrigation systems. Establishment of IAs is, in fact, the first step for the IMT.

At the last stage of the construction for MMIP I, the initial 6 IAs were officially and legally established in Maridagao Service Area (legal registration with SEC was made in the period of 1999-2002). Since the original service area managed by each IA was large and number of the members was also many, as shown in Table 2.5.17, all initial IAs were latter divided into 2 IAs from 2006 to 2015. Service area of MRIS IA Div 5 Inc. is 903.3ha, however, operational area without swamp area is 309.6ha, so that the size of IA is of appropriate size. As of April 2017, 12 IAs are established in MSA.

Table 2.4.17 Transition of IAs in MRIS

SA	Original (at beginning)			Present (as of April 2017)			
	Name of IA	Service area (ha)	Date of restoration	No	Name of IA	Service area (ha)	Date of restoration
MSA	MRIS IA DIV. 1 INC	1,045.5	Aug. 1, 2008	1	GAGDANEN BAYA	349.17	Sep. 22, 2010
				2	TAFIA	211.34	Sep. 25, 2010
	KIFABRE IA INC.	1,070.3	Apr.1,-2001	3	KATINGKONGAN	394.86	Sep. 22, 2010
				4	MORNING LIGHT	377.67	Sep. 7, 2008
	MRIS IA DIV. 3 INC	1,053.0	Jan. 8, 2002	5	BASBIA	437.12	Sep. 21, 2011
				6	MANSAPA	202.27	Sep. 21, 2011
	KIPAN IA INC	745.7	Apr. 21, 1999	7	KIPAN	376.89	Apr. 15, 1999
				8	NASGIA	214.69	Sep 7, 2008
	MRIS IA DIV. 5 INC.	1,594.8	Jan. 8, 2002	9	MRIS IA DIV 5 INC	903.88	August 1, 2002
				10	NASFIA	168.46	Sep. 21, 2006
	MRIS IA DIV. 6 INC	1,052.8	Jan. 8, 2002	11	MRISIA DIV 6	353.73	Jan. 8, 2002
				12	EDUFIA	186.41	Apr. 5, 2015
UMSA	DIV 7		N/A	13	BAGONABATI	543.2	May 5, 2009
				14	BALATIKAN	496.8	Mar. 26, 2013
	DAM NALAPAAN STREAM CHECK		N/A	15	CRISLAM	339.3	Nov. 21,2011
				16	NALAPANI	52.0	Dec. 19, 2011
	Total	**6,562.0**			**Total**	**5,275.4**	

Source: MRIS office (NIA Regional 12, Cotabato Irrigation Management Office)

Table 2.4.18 Irrigators Association in MRIS

No	Name of IA	Name of Service Area	Service Area (ha)	FUSA (ha)	Operational area (ha)	Number of FB's	Number of TSAG	Remarks
1	Gagdanen Baya	MSA	349.2	345.4	322.1	379	12	
2	Tafia		211.3	211.3	211.3	180	8	
3	Katingkongan		394.9	394.9	394.9	400	14	
4	Morning Light		377.7	377.7	249.0	240	13	
5	Basbia		437.1	432.9	288.0	330	11	
6	Mansapa		202.3	201.3	166.0	200	9	
7	Kipan		376.9	369.9	321.4	330	14	
8	Nasgia		211.1	211.1	211.1	185	10	
9	MRIS IA DIV. 5 Inc.		965.5	903.0	309.6	134	9	
10	Nasfia		135.0	165.6	165.6	165	9	
11	MRIS Div. 6		515.6	326.8	326.8	202	19	
12	Edufia		196.6	186.4	186.4	124	8	
13	Bagonabati	UMSA (P1)	543.2	641.0	641.0	680	33	
14	Balatikan		496.8	368.2	368.2	333	35	
15	Crislam, 1/	UMSA (P2)	339.3	339.3	283.7	316	11	Established under MMIP II
16	Nalapani, 1/		52.0	52.0	36.8	62	6	

No	Office Location	Barangay/S Covered	Date of registration	Number of farmer-member				
				Total	Christian		Muslim	
					Male	Female	Male	Female
1	Kilangan, Pagalungan	Kilangan	Sep. 22, 2010	274			272	2
2	Maridagao, Datu Montawal	Maridagao	Sep. 25, 2010	174			170	4
3	Kilangan Pagaungan	Kilangan	Sep. 22, 2010	254			250	4
4	Kilangan Pagaungan	Kilangan	Sep. 7, 2008	227			224	3
5	Nasapian. Carmen	Nabundas; Kibayao	Sep. 21, 2011	310			310	0
6	Nasapian. Carmen	Kibayao	Sep. 21, 2011	204			201	3
7	Kibayao, Carmen	Kibayao	Apr. 15, 1999	237			233	4
8	Kibayao, Carmen	Kibayao	Sep 7, 2008	192			190	2
9	Nasapian. Carmen	General Luna; Nasapian; Limbalod	August 1, 2002	124	68	22	30	4
10	Nasapian. Carmen	Nasapian	Sep. 21, 2006	127			124	3
11	Ugalingan, Carmen	General Luna; Nasapian	Jan. 8, 2002	217	107	15	91	4
12	Ugalingan, Carmen	Ugalingan	Apr. 5, 2015	63			56	7
13	Balabak, Pikit,	Bagonabati	May 5, 2009	581			576	5
14	Balatikan, Pikit	Balatikan	Mar. 26, 2013	336			333	3
15	Panicupan, Pikit	Crislam	Nov. 21,2011	261			255	6
16	Nalapaan, Pikit	Nalapani	Dec. 19, 2011	62			62	0

Source: MRIS office (NIA Regional 12, Cotabato Irrigation Management Office)

On Upper Malitubog Service Area, compared to MSA, the establishment of IA was delayed because the construction of the irrigation facilities was delayed. One IA was established under MMIP I and it was divided into 2 IAs in 2013. On the other hand, Crislam IA and Nalapani IA were established in

2011, which were the first service area generated under MMIP II. Total 4 IAs have been working within UMSA since 2013. As of May 2018, construction of the irrigation system in the MMIP II area of UMSA was almost completed and 5 IAs have been established and handed over to MRIS management office. The remaining 4 IAs will be handed over to MRIS management office in 2018. Accordingly, there are 13 IAs to be established in UMSA under MMIP I & II.

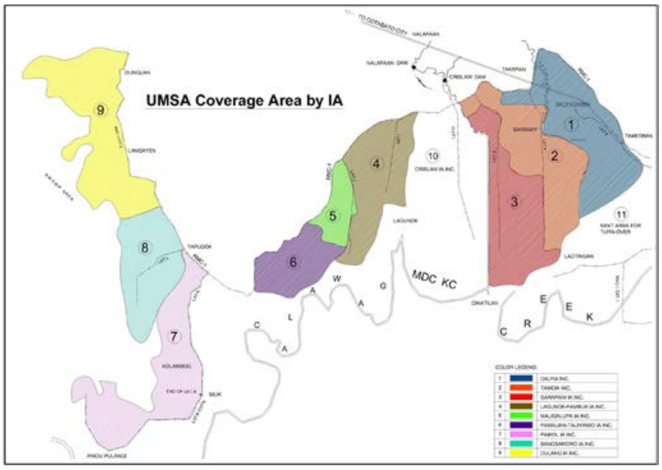


Figure 2.4.4 Location of the IAs in UMSA (Ph.2)
Source: NIA-PMO

On PESA, as of May 2018, 3 IAs have been established and already registered. On Lowe Malitubog Service Area (LMSA), as of May 2018, 13 IAs were established and have been registered and remaining 8 IAs will be established in the coming years of 2019 and onwards.

Table 2.4.19 Irrigators Association established under MMIP II

No	Name of IA	Name of Service Area	Location	Service Area (ha)	Number of FB's	Remarks
1	Dalfia		Dalingaoen, Pikit, Cotabato	255.7	195	Turned-over
2	Tamcia		Takepan, Pikit, Cotabato	251.9	82	Turned-over
3	Lagundi Pambua		Lagunde, Pikit, Cotabato	283.0	162	Turned-over
4	Maliga Lupa		Bualan, Pikit, Cotabato	118.0	64	Turned-over
5	Paikol		Paidu Pulangi/Kolambog, Pikit, Cotabato	410.1	120	To be turned-over
6	Pamalian Taliawid	UMSA	Pamalian, Pikit, Cotabato	116.9	78	To be turned over
7	Sarapani		Panicupan, Pikit, Cotabato	365.9	75	Turned-over
8	Chrislam		Panicupan, Pikit, Cotabato	339.3	316	Turned-over
9	Nalapani		Nalapaan, Pikit, Cotabato	52.0	72	Turned-over
10	Tapodoc Bangsamoro		Tapodoc, Aleosan, Cotabato	268.1	33	To be turned over
11	Dungguan-Langayen		Dungguan, Aleosan, Cotabato	191.0	28	To be turned over
12	Ubadala Farmers		Galakit, Pagalungan, Maguidanao	145.0	42	Registered
13	Layog Inug-Ug IA Inc	PESA	Layog, Pagalungan, Maguindanao	261.8	86	Registered
14	Pagalungan Taliawid		Pagalungan,, Maguindanao	N/A	40	Registered
15	Gli-Gli Lateral H & H2 Farmers		Gli-gli, Pikit, Cotabato	292.0	163	Registered
16	Bulod Bulol		Bulod, Pikit, Cotabato	238.7	90	Registered
17	Talitay Inug-Ug Gli-Gli Poblacion		Talitay, Pikit, Cotabato	225.7	130	Registered
18	Batolawan Ginatilan Ladtingan		Batulawan, Pikit, Cotabato	362.4	82	Registered
19	Makauyag Gli-Gli Lateral H3		Gli-gli, Pikit, Cotabato	217.0	150	Registered
20	Maglib		Gli-gli, Pikit, Cotabato	481.0	171	Registered
21	Macabual Kaltan Farmers		Macabual, Pikit, Cotabato	190.1	95	Registered
22	Kaltan Balong Farmers	LMSA	Balong, Pikit, Cotabato	268.5	95	Registered
23	Tambak Balong		Balong, Pikit, Cotabato	183.8	88	Registered
24	Manaulanan		Manaulanan, Pikit, Cotabato	172.7	70	Registered
25	Proper Macabual		Macabual, Pikit, Cotabato	122.7	78	Processing for registration
26	Sitio Galigayanen		Macabual, Pikit, Cotabato	245.0	89	Processing for registration
27	Nalkatan Manaulanan		Manaulanan, Pikit, Cotabato	371.3	N/A	Processing for registration

Source: MRIS office (NIA Regional 12, Cotabato Irrigation Management Office), NIA-PMO

As part of the IA-NIA relationship in the National Irrigation System (NIS), an IA is required to prepare a cropping calendar, a water distribution and delivery plan, and a maintenance and repair plan pursuant to the NIA irrigation system design guidelines. Among these requirements, a maintenance and repair plan is expected to show how the IA conducts maintenance works to the irrigation systems, such as canal clearing, desilting, road repairing and grading, debris removal and oiling of steel gates.

2.5 Distribution Infrastructure; Road and Bridges

On April 14, 2014, a memorandum was issued by the then Secretary of DPWH regarding the new road classification system as well as the route numbering to all primary roads, that has been extended to secondary roads at present. This new road classification and route numbering system was then implemented and incorporated in the Road and Bridge Information Application (RBIA) in compliance with the said memorandum. The classes of roads have included national roads, provincial roads, municipal and city roads, Barangay roads, and expressways. The table below provides the criteria for each of these classes of road:

Table 2.5.1 Criteria of Road Classification in the Philippines

Category	Contents
National Primary	✓ Directly connects major cities (at least around 100,000 people) (Cities within metropolitan areas are not covered by the criteria)
National Secondary	✓ Directly connects cities to National Primary Roads, except in metropolitan areas ✓ Directly connects major ports and ferry terminals to National Primary Roads ✓ Directly connects major airports to National Primary Roads ✓ Directly connects tourist service centers to National Primary Roads or other National Secondary Roads ✓ Directly connects cities (not included in the category of major cities) ✓ Directly connects provincial capitals within the same region ✓ Directly connects major National Government Infrastructure to National Primary Roads or other National Secondary Roads
National Tertiary	✓ Other existing roads under DPWH which perform a local function
Provincial Roads	✓ Connect cities and municipalities without traversing National Roads ✓ Connect to National Roads to barangays through rural areas ✓ Connect to major provincial government infrastructure
Municipal and City Roads	✓ Roads within Poblacion ✓ Roads that connect to Provincial and National Roads ✓ Roads that provide inter-barangay connections to major Municipal and City Infrastructure without traversing Provincial Roads
Barangay Roads	✓ Other Public Roads (officially turned over) within the barangay and not covered in the above definitions
Expressways	✓ Highways with limited access, normally with interchanges; may include facilities for levying tolls for passage in an open or closed system.

Source: Department of Public Works and Highway

2.5.1 Roads in and around the Project Area (Pikit Municipality)

As most of the MMIP II area falls in Pikit municipality jurisdiction, following discuss the road network in the municipality. In the Pikit municipality, there is one primary national road running between Cotabato city and Davao city via Pikit town. The MMIP II area extends in southern parts from the national road while MMIP I area is located in northern parts from the national road (see Figure 2.5.1).

Table 2.5.2 summarizes the roads within the Pikit municipality as of year 2018 or 2016 by type according to the afore-mentioned category, and also by pavement type.

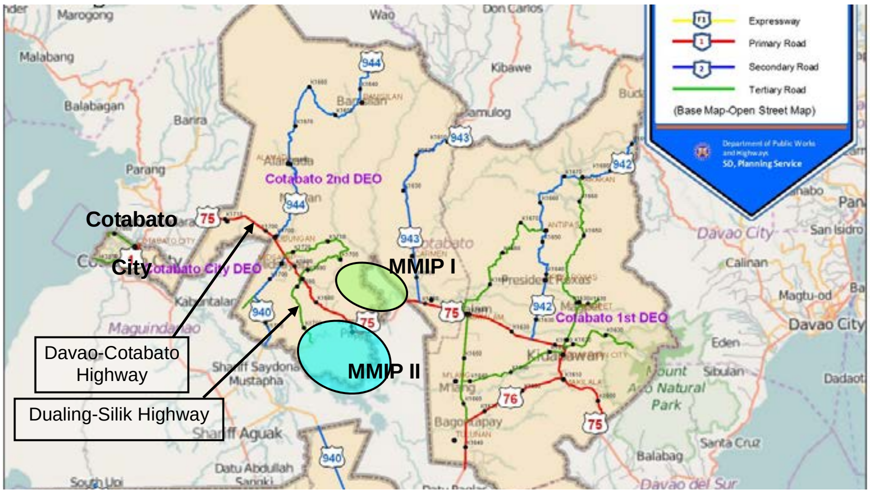


Figure 2.5.1 MMIP Area and National Road Network

Source: DPWH

Table 2.5.2 Status of Road Infrastructure in Pikit Municipality

Road Name	No.	Pavement Type and Road Length				
		Concrete (km)	Asphalt (km)	Gravel (km)	Earth (km)	**Total (km)**
National Road (as of 2018)	2	12.5	0.0	0.0	0.0	12.5
Provincial Road (as of 2016)	14	3.9	2.0	43.3	18.8	67.9
Municipal Street (as of 2018)	35	8.8	1.2	10.3	3.1	23.4
Barangay Road (as of 2018)	71	26.2	1.0	167.4	45.0	239.6
Total	**122**	**51.4 (15%)**	**4.2 (1%)**	**221.0 (64%)**	**66.9 (20%)**	**343.4 (100)**
(Total of 2015)	122	33.6 (10%)	4.2 (1%)	229.4 (67%)	74.4 (22%)	341.6 (100)

Source: Pikit Municipality

As in the above table, there are 2 national roads within the municipality; namely, Cotabato-Davao National Highway as afore-mentioned and Dualing-Silik Tertiary National Highway, total length of which comes to only 12.5 km. Provincial roads count at total 14 in number, and the total length arrives at 67.9 km composed of 3.9 km concrete road, 2.0 km asphalt road, 43.3 km gravel road and 18.8 km earth road. More than half length of the provincial roads is, in fact, of gravel (43.3 km) and earthen (18.8 km).

There are 35 municipal roads, total length of which is 23.4 km composed of 8.8 km concrete, 1.2 km asphalt, 10.3 km gravel and 3.1 km earthen. Barangay roads are extended over 71 routs with a total length of as much as 239.6 km. Though the barangay road is the longest one among the 4 categories roads, more than 200 km length (about 89%) is constructed with gravel and earthen.

By type of the roads, gravel road shares as much as 64% of the whole roads within the municipality, followed by earthen road with 20% share, and concrete with only 15%. Note that asphalt pavement roads consist of only 1% of whole roads within the municipality. With this status of the roads, especially, the earthen and gravel roads become hardly passable during rainy season (see photo as an example). With respect to the change from year 2015 to 2018, concrete pavement road was increased by 17.8 km (increased by 5%) from the gravel road and earthen road.

A typical Barangay Road in LMSA, becoming hardly passable during rainy season

2.5.2 Bridges in and around the Project Area (Pikit Municipality)

Following table indicates bridges within Pikit municipality as at year 2018. There are total of 10 bridges in the municipality, composed of 4 concrete bridges and 6 RC box culverts. In fact, concrete bridges are constructed on the national roads and provincial roads while barangay roads are equipped with only RC box culvert. The roads, extended in Pikit municipality, have a lot of small scaled crossing structures which cross the creeks and drainages etc. However, Table 2.5.3 doesn't include such a small structures due to the structural perspective, namely the small conduits (concrete pipe or corrugated steel pipe etc.) could not be categorized as the bridge.

Table 2.5.3 Status of Bridges in Pikit Municipality, as of 2018

Bridge Name or Name of Road Section (where bridge is located)	Bridge Type and Bridge Number & Average Length (as of 2018)				
	Concrete Bridge	Steel Bridge	Timber Bridge	RC Box Culvert	**Total**
Along the National Road	2 (L=8.0m)	0	0	0	**2**
Along the Provincial Road	2 (L=6.5m)	0	0	0	**2**
Along the Municipal Street	0	0	0	0	**0**
Along the Barangay Road	0	0	0	6 (L=4.0m)	**6**
Total	**4**	**0**	**0**	**6**	**10**

Source: Pikit Municipality

2.6 Related Projects and Programs

NIA has implemented in addition to own government funded projects, number of loan projects for irrigation development assisted by such donors as JICA, World Bank (WB), Asian Development Bank (ADB), among others. NIA has also received JICA Technical Assistance Programs (TA) for the irrigation improvement. The following table summarizes a list of major donor-assisted projects implemented by NIA:

Table 2.6.1 Major Donor-Assisted Projects by NIA

Donor	Period	Project Name	Type	Project Area
JICA	2012-2017	National Irrigation Sector Rehabilitation and Improvement Project (NISRIP)	Loan	Nationwide including Region XII
World bank	2009-2024	Participatory Irrigation Development Project (PIDP)	Loan	Nationwide including Region XII
ADB	2000-2011	Southern Philippines Irrigation Sector Project	Loan	ARMM, Caraga, Region-VI, VII
JICA	2005-2007	Irrigation Association Strengthen Project	TA	Nationwide
JICA	2007-2011	Irrigators Association Strengthening Support Technical Cooperation Project	TA	Nationwide
JICA	2013-2017	The Project for Improving Operations and Maintenance of NIS	TA	Nationwide

Source: NIA Headquarters

2.6.1 National Irrigation Sector Rehabilitation and Improvement Project (NISRIP)

NIA is currently implementing the NISRIP financed by JICA ODA loan for the rehabilitation of 11 National Irrigation Systems (NISs). In addition to the rehabilitation and improvement of existing facilities, the NISRIP covers IAs institutional development including promotion of Irrigation Management Transfer (IMT), agricultural support by PhilRice and O&M equipment procurement as the project components. Irrigable scale of each irrigation system and components of the NISRIP are similar to those of MMIP II.

While NISRIP is still under implementation as mentioned above, some delays in the civil works have been found from the original plan. Some issues have been identified for the reasons and these would be the lessons learned for the MMIP II project implementation. Issues and lessons learned from the NISRIP are abstracted as below, and these issues would be kept in mind for the implementation of the MMIP-II civil works:

1) Long period for the tendering and contracting process: There were cases it took several to 6 months from the bid opening to the contract conclusion due to the staff limitation of both NIA and local contactors. At least, NIA should allocate enough staff to evaluate the bidding or otherwise need to employ consultants in the areas of procurement.

2) Construction materials/machineries/manpower: Deployment of heavy machineries at necessary timing for effective construction works was very often difficult for small scale contractors. It was also found that there were difficulties for small scale contractors in securing necessary manpower due to low financial condition. To improve this issue, capably contractors should be selected, e.g. employing bigger scale of contractors rather than employing many small-scale contractors (also refer to the statement blow in terms of packaging).

3) Low capacity of local contactors: Since the package volume of civil works was divided into small scale, small or medium scale local contractors were mostly selected. These small or medium scale contractors are characterized with relatively lower capacity both in terms of technical and financial aspects. Financial limitation affected their construction performance in terms of both construction quality and also schedule. From this experience, it will be an option to increase the scale of one contract package, so that large scale contractors from Manila or other major cities could be

interested in the project implementation.

4) Pre-Qualification (PQ) setting for the selection of contractor: NISRIP set such term of contractors who can participate the bidding that the contractor shall have experiences of similar projects and shall be 3A rank in PQ. In order to prevent the selection of low capacity contractors, careful consideration should be necessary for the PQ setting in MMI II implementation, e.g. employing 3A rank contractors also with due reference to the similar experiences. It is noted that though large scale contractors are generally very much experienced in large scale civil works, those civil works may be associated with road/ bridge sector while less irrigation works implemented in very remote areas. Such similar experiences relative to irrigation sector and works in rural areas should be well taken into account.

2.6.2 Participatory Irrigation Development Project (PIDP)

NIA and World Bank (WB) are implementing PIDP since year 2009. APL (Adaptable Program Loan) was applied to the PIDP to support NIA's transformation with a long-term sector reform by three-phase implementation. PIDP APL Program components consist of; 1) irrigation sector restructuring and reform, 2) irrigation infrastructure development for 58 NISs, and 3) project management and coordination. Under component 1), NIA and the World Bank are implementing NIA Rationalization Plan (RAT Plan), NIA institutional strengthening and also irrigation management transfer (IMT) program.

NIA and WB have extended phase-1 period by two years because of the expansion of rehabilitation works for NISs which were damaged by typhoon Yolanda (November 2013). Although civil works have not been completed yet, RAT plan implementation and IMT program implementation have already accomplished their targets. IAs have been organized in all the 58 project-assisted NISs and 98%[1] IAs have successfully closed IMT program contacts for transferring of increased operation and maintenance (O&M) responsibilities under models 2-4[2] with institutional development training provision to IAs. For the designing and enhancement of IAs in MMIP II, example of the IMT application to IAs could be a reference, and their activities on RAP and IPP (Indigenous People Plan) would also be a reference to the MMIP II preparation.

2.6.3 Southern Philippines Irrigation Sector Project

NIA and Asian Development Bank (ADB) have implemented the project from 2000 to 2011. Project components consisted of infrastructure and institutional development. Infrastructure component covered development of NISs, CISs, SRISs (small reservoir irrigation systems) and construction of access and service roads. Institutional component was divided into two categories; one is participation for and irrigation transfer to IAs in the O&M and another one is the training for NIA and LGU staff. The project also undertook social activities including; 1) schistosomiasis control as a primary health measure, and 2) development of indigenous peoples development plan for Maranaos irrigation system in ARMM.

---

[1] Implementation Status & Results Report on 7th March 2017, WB

[2] NIA classified IMT models into 4 levels depending on the size of NIS and capacity of IAs;
Model 1: Maintenance of canals delegated to IAs; IA is compensated based on canal area maintained and existing labor rate,
Model 2: Turnover of management of lateral canals to IAs; IAs get a share of Irrigation Service Fee (ISF) collected (Typical ISF sharing: NIA 70%, IA 30%),
Moderl3: Turnover of management of main and lateral canal to IA Federation; IAs get a share of Irrigation Service Fee (ISF) collected (Typical ISF sharing: NIA 70%, IA 30%), and
Model 4: Complete turnover of Irrigation system to IAs; IAs pay NIA a rental fee at a rate of 75-100 kilograms of dry palay per hectare per year.

As the lessons learned from the said project, it was raised that the project erroneously estimated that the farmers in the project area could contribute 25% of the capital cost of the irrigation systems without conducting a thorough assessment of their paying capacity. The resulting resource limitations meant that fund would not be sufficient for routine and periodic maintenance of the project-funded infrastructure.

This lesson should be reflected in the O&M plan to be designed for MMIP II. In fact, it is estimated that MMIP beneficiaries are relatively poorer as compared to other areas of Philippines, and therefore financial burden, if required, for the beneficiaries should be set at minimal level at least during the construction phase as well as for several years after the project operation, i.e. until the time the project generates planned benefit.

Regarding other lessons, for example, importance of the participation of beneficiaries at an early stage was pointed out in preparing sub-projects under the Southern Philippines Irrigation Sector Project. In addition, coordinated provisions of technical supports to beneficiaries were also raised as one of important issues along with supplies such as firm credit. MMIP II should likewise inform the beneficiaries of the project implementation well in advance, and also coordination with agriculture extension organizations should be well established.

2.6.4 JICA Technical Cooperation Project

JICA has conducted series of TAs in the field of irrigation operation and management. Irrigation Association Strengthen Project (2005-2007) and Irrigators Association Strengthening Support Technical Cooperation Project (2007-2011) had been conducted focusing on capacity enhancement of IAs. As the lesson learned from Irrigators Association Strengthening Support Technical Cooperation Project, organized coordination was found very important among the stakeholders. Especially, functional SMC (System Management Committee) consisting of NIA officer, LGU, IDO (Institutional Development Officer), etc. is very important for decision making in terms of water distribution, cropping pattern setting, and effective O&M.

On the other hand, the Project for Improving Operations and Maintenance of NIS (2013-2017) focused on the promotion of efficiency and modernization of NIA’s O&M activities for irrigation systems in order to cope with the situation of curtailed O&M staff by Rationalization Plan (RAT Plan) enforced since year 2008. Project component was planned to utilize GIS for O&M activities, to introduce Asset Management (AM) concept and improve fair Water Distribution and Delivery (WDD) in the selected pilot sites. Project output could be a reference for future O&M of MMIP II.

2.6.5 Other Related Project in Neighboring Area of MMIP II

JICA is conducting various projects for peace building and rural development for ARMM area under umbrella of J-BIRD program. JICA has conducted the Technical Cooperation Project for Rice-Based Farming Systems Trainings and Support Program for ARRM with PhilRice during 2005-2010 and continues extension activities as of 2017-2018. Project succeeded in training farmers for farming techniques both rice and vegetable and achieved their income improvement by 96% from rice production and by 103 % from vegetable production according to the terminal evaluation report in 2009. As the reason for good result, it was referred to the provision of suitable techniques and efficient project management by the PhilRice. Possible linkage with PhilRice could be a good option for the improvement of rice production under MMIP II.

The Project for Community Development in Conflicted Areas (2015-2017), which is a grant project for improvement of farm to market roads, is under implementation with Department of Agriculture (DA). Barangay/municipal roads and related river crossing (bridges, box culvert) are being rehabilitated or constructed by local contractors as of 2017. Project information such as design condition, construction schedule, performance of local contractors, etc. could be a reference for the planning and construction of the farm-to-market roads under MMIP II. In addition, the project involves Bangsamoro Development Agency (BDA) as the cooperating agency for the linkage of municipality which is the implementer of future O&M of the constructed roads. Such implementation arrangement can be a reference for the MMIP II.

JICA is also currently conducting a Cooperation Project on Comprehensive Capacity Development Project for the Bangsamoro (2013-2019). The Project conducted Quick Impact projects (QIPs) cooperating with Bangsamoro Transition Commission (BTC) and BDA. QIPs have engaged great number of community people actively with the cooperation of BDA regional office.

CHAPTER 3 DELINEATION OF LMSA WITH FLOOD PROTECTION MEASURES

It is noted that non-disclose information for 3-year is included in this chapter as procurement by the Philippines government is scheduled.

3.1 Past Flood Occurrence and Its Magnitude on LMSA

3.1.1 Basin Area Covering the Project Area

Basin area covering the Project area (or Liguasan marsh) is as large as about 13,700 km^2. According to the historical record in and around the basin area, the mean rainfall on the catchment area of the basin is 2,016 mm/year during the past 66 years from 1951 to 2016. The total rainwater in the basin is thus estimated at 28 billion CUM per annum (13,700,000,000 x 2.016). Applying the runoff coefficient of 0.3 according to the analysis of Tinutulan gauging station (refer to sub-section 2.1.4), discharge volume becomes 8.3×10^9 m^3/year. Such copious amount of water concentrates on the Liguasan marsh which behaves as receptacle although it covers only 1 % of the basin area (156 km^2 / 13,700 km^2).

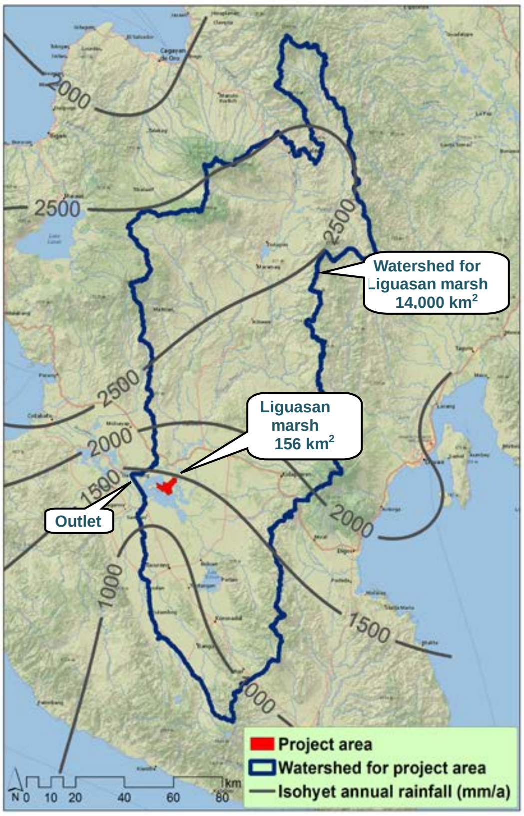


Figure 3.1.1 Watershed Area for the Project Area

The recent deforestation and the development of agricultural land have changed the flood condition of the basin, namely, flood event tends to occur more frequently and its damage becomes more serious. Moreover, because of the recent tendency of heavy rainfall, soil erosion occurs and heavy siltation has been taking place along the rivers within the basin. This siltation can also be seen in the main channel of the Pulangi river, where natural levees have been developed along the southern boundary of the Project area, the LMSA. Besides, grasses and debris conveyed by flood would be clogging the water course in particular at the outlet of the Liguasan marsh.

3.1.2 Channel Change in the Pulangi River

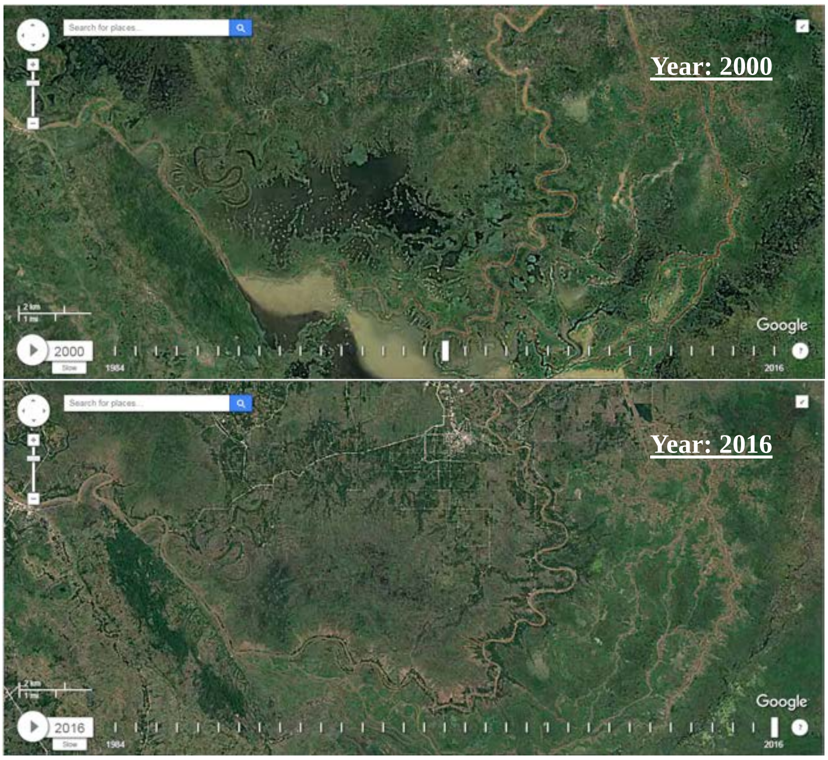
The long-term channel change in the Pulangi river can be observed on Google's "Earth Engine Timelapse"[1] which provides true color scenes over the whole earth covering 33 years between 1984 and 2016. The images of 1984, 2000, and 2016 in Figure 3.1.2 were captured on the browser and the URL is linked to Timelapse page

URL: https://earthengine.google.com/timelapse/#v=7.00335,124.64905,11.176,latLng&t=0.03
Source: Google Earth Engine Team, 2015. Google Earth Engine: A planetary-scale geospatial analysis platform. https://earthengine.google.com

Figure 3.1.2 River Channel Change in the Pulangi River (1/2)

[1] https://earthengine.google.com/timelapse/

zooming in LMSA. According to the images available on Timelapse, the Pulangi river channel bordering the LMSA has not radically changed between 1984 and 2016. It is assumed that, owing to the construction of the Diversion Channel in Tunggol in early 1980s, the flow volume into the lower stream of the Pulangi river in the south of Pikit municipality had decreased, which may have resulted in much less change in the course of the Pulangi river.



URL: https://earthengine.google.com/timelapse/#v=7.00335,124.64905,11.176,latLng&t=0.03
Source: Google Earth Engine Team, 2015. Google Earth Engine: A planetary-scale geospatial analysis platform. https://earthengine.google.com

Figure 3.1.2 River Channel Change in the Pulangi River (2/2)

3.1.3 Long Term Water Occurrence Change

Data of the surface water on the Liguasan marsh was obtained from the analytical result of 'Mapping long-term global surface water occurrence[2]' which utilized millions of LANDSAT images for a period of 32 years from 1984 to 2015. The spatial resolution is 30 m and it was recorded when water was presented, where the occurrence has changed, and how its location changed in terms of seasonality and continuity.

As for the adjacent area to the Project area, specifically in the LMSA, the water occurrence could be traced in both sides of the Pulangi river. The coverage of the water surface has been changing by season. In rainy season, the flood water spilling over natural levees and flowing into the hinterland on the right side of the Pulangi river as temporal waters. In dry season, on the other hand, permanent water remains only along the main channels in the left side of the Pulangi river as shown in Figure 3.1.3.

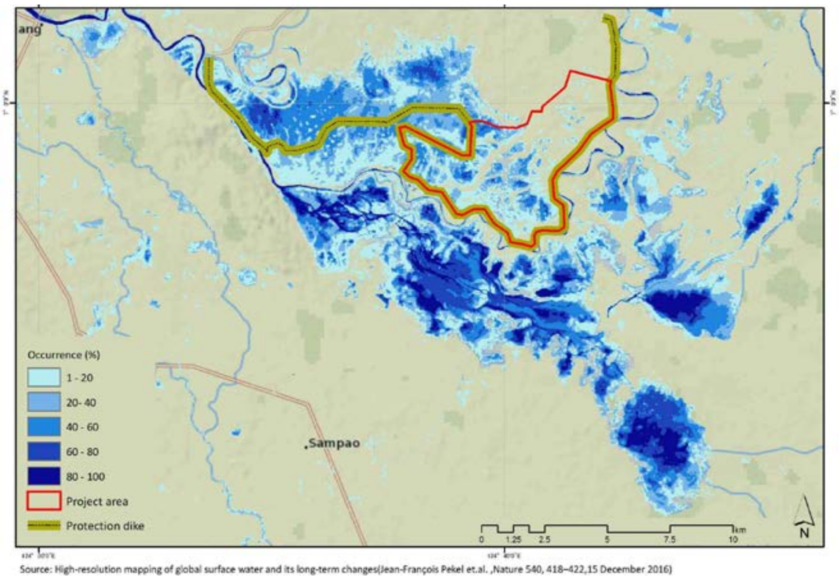


Figure 3.1.3 Long Term Water Occurrence Change (1984-2014)

Source: JICA Survey Team

[2] High-resolution mapping of global surface water and its long-term changes (Jean-François Pekel, Andrew Cottam, Noel Gorelick& Alan S. Belward, Nature 540, 418–422 ,15 December 2016)

3.1.4 Seasonal Change

Regarding the seasonal change, the prominent change was found as shown in Figure 3.1.4. In the climax of the rainy season, the most of areas are once covered by water at least for one month. However, in the dry season, only several separate ponds and channels remain on the area deeply depressed along the main tributaries. The area of permanent water is estimated at only 1,570 ha, which covers only 10% of the maximum water extent in the rainy season.

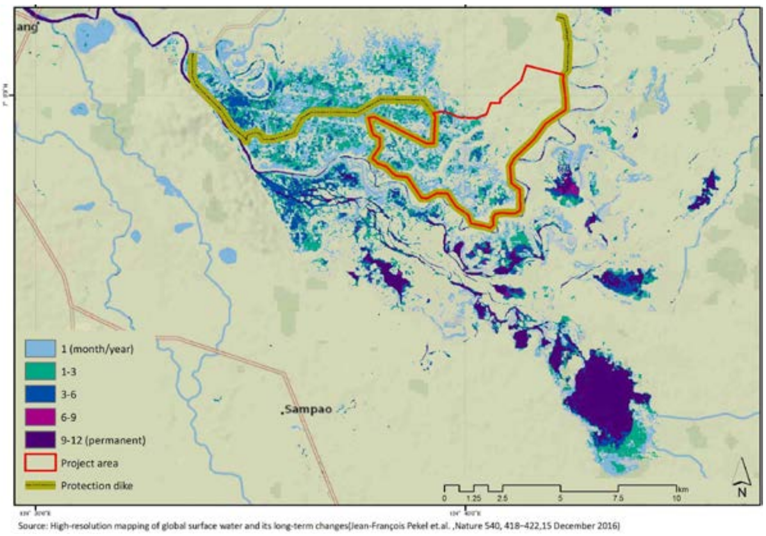


Figure 3.1.4 Seasonality of Water Surface (1984-2014)

Source: JICA Survey Team

In the history of water extent revealed by the satellite imageries of 32 years, the seasonal change on the right bank can be regarded as 'New seasonal area', which has turned to a wet-land from the dry land during the last 3 decades. On the other hand, the left bank area is characterized as 'Lost permanent area' which has interrupted or dried-up water in dry season.

3.1.5 Maximum Flood Water Extent and Inundation Ratio of LMSA

The maximum water extent image was made by a composite image which provides information of detected water on all locations ever over the 32 years from 1984 by 2015. The "light blue" parts in Figure 3.1.5 shows an area of the maximum surface water extent.

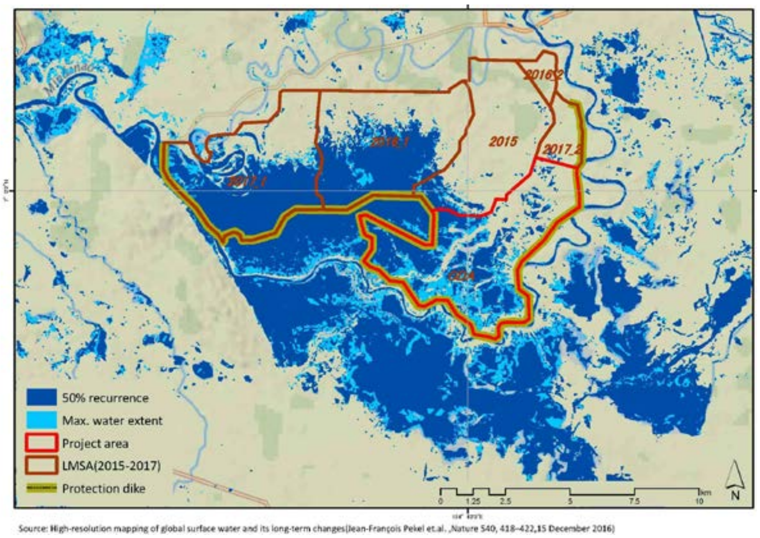


Figure 3.1.5 Flood Area and Recurrence of Annual Behavior of Water Surface (1984-2014)

Source: JICA Survey Team

The maximum water extent was not analyzed by a certain flood event but estimated based on multiple images in long period. The images applied were acquired from LANDSAT's archive data which provide as 16 days interval in line with sun-recurrent orbit. However, the acquisition follows periodic orbit and the number of images for the analysis reached to several hundreds at different timings. These acquired images could give sufficient information in pixels bases (10m x10m) during 32 years even to understand a time series changes of water condition whether it was being in dry or wet condition all over the Project area.

Although the flood area shown in Figure 3.1.5 was delineated as combined water pixels which had been experienced in wet condition at least one time during 32 years since 1984, its extent was concordant with the past inundation records of factual inundated area and depth in 2008's flooding (NIA, 2010). The flood area shown in Figure 3.1.5 broadly covers almost the half of the LMSA by the damming-up, which spreads from the narrow outlet channel at Paidu Pulangi. Note that a part of water inundating the southern parts of the LMSA comes back from Paidu Pulangi area, not only the direct flood water from the Pulangi river running along the southern side of the area due to elevation difference.

Dark blue color in Figure 3.1.5 shows the water extent in 50% of recurrence, i.e. return period 2-year, which can be regarded as normal hydrological year, while light blue color parts show the maximum water extent for the last 32 years based on the 16-day satellite image interval. As summarized in the following Table 3.1.1, 50% occurrence inundation area shares about 60 % to 90 % of the maximum water extent with the overall coverage of 78% (see the column of Rate (c)/(d)) for the whole LMSA.

On the other hand, the ratio between the 50% occurrence water extent and the total area comes to 0 – 55 % with the overall average of 34% (see the column of Rate (c)/(e)). It means that during the normal hydrological year, 34% of the LMSA had been inundated, leaving only 66% as surface land. Likewise, the ratio between the maximum occurrence of water extent and the total area comes to 0 – 63 % with the overall average of 44% (see the column of Rate (d)/(e)). It means that during the maximum water extent year, 44% of the LMSA had been inundated, leaving only 56% as surface land. Concerning the originally requested ODA target area located at most eastern part of the LMSA, the inundated areas reached 32% and 53% respectively for the 50% occurrence and maximum water extent occurrence.

Table 3.1.1 Water Area on LMSA in Normal Year (probability: 50%) and Maximum Water Extent

Flooding Area (ha)	Map Symbol	Remained Land area (a)	Water area on RP* (probability)			Rate (c)/(d)	Rate (c)/(e)	Rate (d)/(e)	Total Area (e)
			> 2 year (< 50%) (b)	< 2year (>50%) (c)	Max. water extent (d)				
LMSA construction area									
Construction from 2017	2017_1	800	186	1,191	1,378	86%	55%	63%	2,177
Construction from 2017	2017_2	321	1	5	6	83%	2%	2%	327
Construction from 2015	2015	1,573	43	131	174	75%	7%	10%	1,748
ODA requested area	ODA	1,222	540	841	1,381	61%	32%	53%	2,603
Construction from 2016	2016_1	1,069	122	991	1,114	89%	45%	51%	2,183
Construction from 2016	2016_2	164	0	0	0	-	0%	0%	164
Total		**5,149**	**892**	**3,160**	**4,052**	**78%**	**34%**	**44%**	**9,201**

Note: *RP: Return Period
Source: JICA Survey Team

3.1.6 Elevation Corresponding to the Maximum Flood Area

1) Elevation Corresponding to the Maximum Flood Area by Topographic Map

NIA-PMO has a topographic map of 1/4,000 scale covering whole LMSA which was made during the detail design. It is the significant material because it covers the most western part of the LMSA, which is very close to Paidu Pulangi mentioned above. The maximum flood area detected by satellite image analysis for the 32 years from 1984 to 2015 is now overlaid on this topographic map (show Figure 3.1.6). By reading the contour lines where the

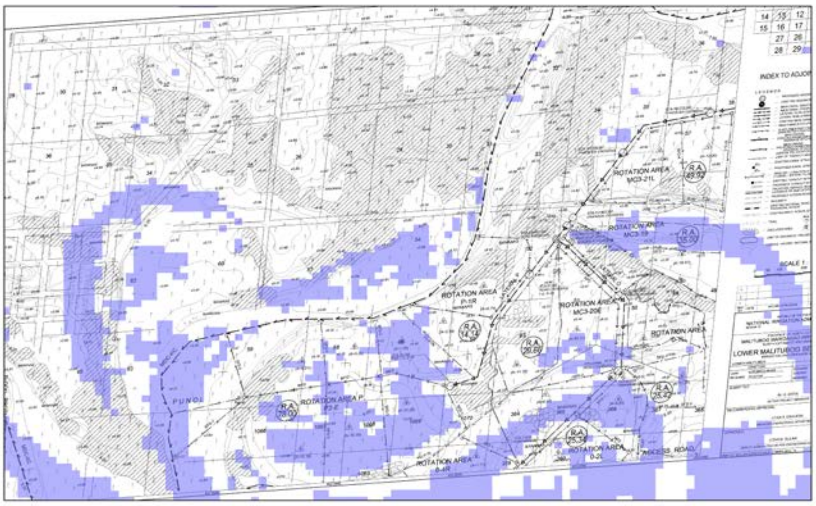


Figure 3.1.6 Overlaid Maximum Inundation Line with the Topo Map
Source: JICA Survey Team

peripheral of inundation has reached, it is known that the past highest water levels had come to around 6.4 m AMSL.

2) Elevation Corresponding to the Maximum Flood Area by DEM

There are digital elevation maps available with 1.0 m contours[3]. Of them, Shuttle Radar Topography C-band data are available to the public. The radar contains two types of antenna panels, C-band and X-band. The near-global topographic maps of Earth called Digital Elevation Models (DEMs) are made from the C-band radar data. These data were processed at the Jet Propulsion Laboratory and are being distributed through the United States Geological Survey's Earth Resources Observation and Science (EROS) Data Center.

Figure 3.1.7 was produced with the free DEM data, on which the maximum inundation area detected by the satellite in the past 32 years was overlaid (pink colored portions show the maximum inundation areas while the white ones indicate permanent water body). Also, H-V (height-volume) and H-A (height-area) relations were generated based on the DEM data. With reference to the DEM data and H-A relationship, the elevation to which the past maximum inundation reached was estimated. According to the interpolated estimation, the highest inundation level is around 6.60 m AMSL.

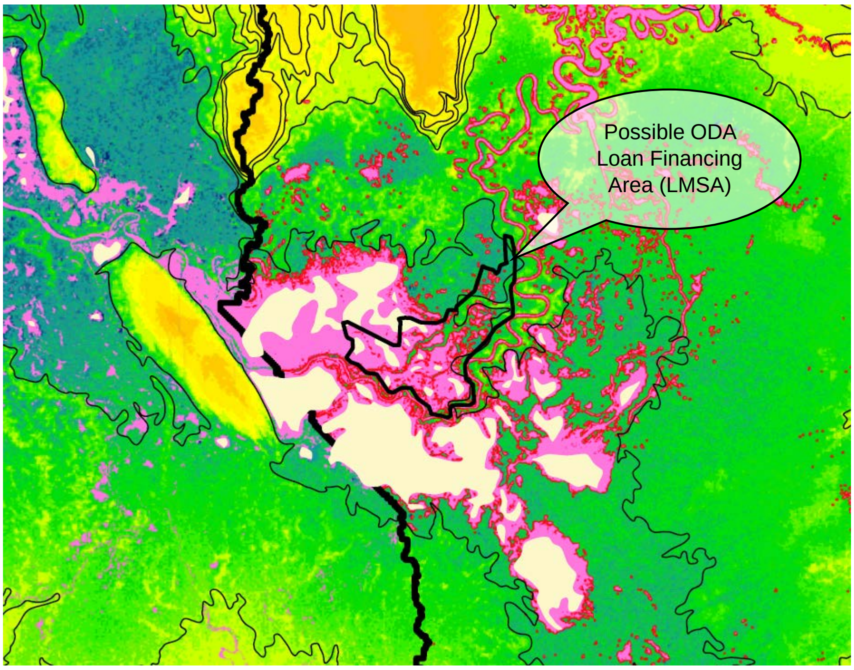


Figure 3.1.7 DEM and Max. Water Extent

Source: JICA Survey Team, Jet Propulsion Laboratory

Table 3.1.2 Estimation of Past Maximum Inundation Elevation with DEM Data

El.	Area (m2)	A (ha)	Cumulative Area (ha)	Volume (MCM)	Height (ELm)	Remarks
1	256,375	26	26	0	1	
2	22,790,746	2,279	2,305	23	2	
3	691,538	69	2,374	24	3	
4	3,645,171	365	2,738	27	4	
5	15,519,410	1,552	4,290	43	5	
6	70,948,932	7,095	11,385	114	6	
	Max Water Extent		15,609	156	6.595	
7	71,046,715	7,105	18,490	185	7	
8	64,836,613	6,484	24,974	250	8	
9	114,142,418	11,414	36,388	364	9	
10	150,383,190	15,038	51,426	514	10	
11	147,992,116	14,799	66,225	662	11	
12	127,524,574	12,752	78,978	790	12	

Source: JICA Survey Team, Jet Propulsion Laboratory, US

[3] https://www2.jpl.nasa.gov/srtm/dataprod.htm.

3.1.7 Past Design Flood Water Level

NIA-PMO has been carrying out the detail design for the LMSA. This detail design includes not only irrigation facilities but also Protection and Ring Dikes which are to protect the irrigable area of LMSA from flooding of the Pulangi river. The design water level for the dikes was once examined and decided during the detail design stage for MMIP II concluded in December 1992 by the loan consultants[4]. After that, the design water level was changed in a later year by NIA-PMO based on the interviews to the local residents.

1) Past Design Flood Water Level for Dikes (1992 Detail Design)

In the detail design which was concluded in December 1992, the frequency analysis was conducted based on the flood data recorded at the Pagalungan bridge (Inug-ug) from 1981 to 1988. Also, one rainy season flood observation data in 1987 at 3 locations of Paidu Pulangi, Kabasalan, and Barongis, which are all located at downstream, midstream and up-mid stream of the LMSA along the Pulangi river were utilized (see Figure 3.1.8 and Figure 3.1.9).

The 1992 detail design summarized the maximum flood records as indicated below, and the maximum flood level at the 3 locations in years other than 1987 were interpolated with reference to the flood water level observed at the Pagalungan bridge (see water levels in brackets in Table 3.1.3). Taking into account the effect of diversion channel[5] constructed in the early 1980s, the 1992 detail design concluded the 1987 flood water level (6.5 m AMSL at Paidu-Pulangi) should be applied for the design even though the flood water levels in years, for example, 1982, 1983, were higher than 1987.

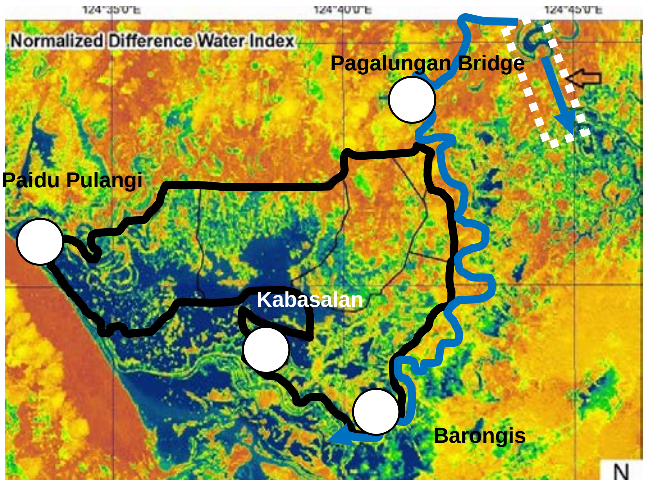


Figure 3.1.8 Flood Observation Stations (1987)
Source: 1992 Detail Design of MMIP

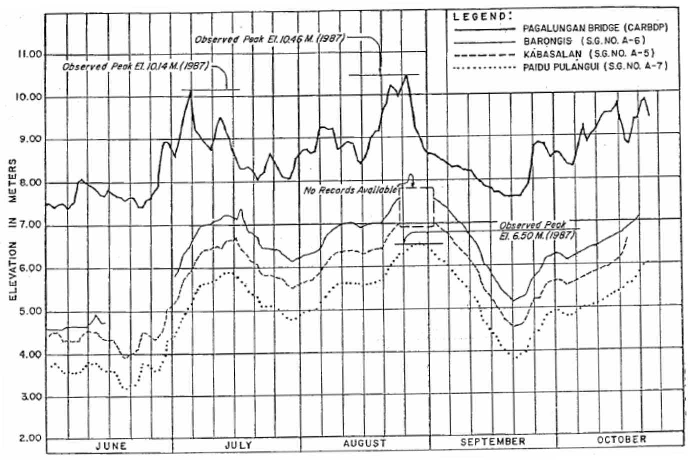


Figure 3.1.9 Flood Records at 4 Stations (1987)
Source: 1992 Detail Design of MMIP

Table 3.1.3 Flood Water Records and Design Flood Water by 1992 Detail Design

Location		Pagalungan Bdg	Barongis	Kabasalan	Paidu Pulangi
Distance from estuary, km		102.7	84.0	75.0	62.5
Flood water slope			1/6,850	1/14,490	1/18,180
Water level deference			-2.73	-0.62	-0.69
1981	July 3	10.38	(7.65)	(7.03)	(6.34)
1982	Feb 1	11.04	(8.31)	(7.69)	(7.00)
1983	July 27	10.67	(7.94)	(7.32)	(6.63)

[4] Refer to Malitubog-Maridagao Irrigation Project, Detailed Engineering Design from Stage II Areas, Final Design Report, December 2992, Associated Consultants Joint Venture, Sanyu, ECL-Electroconsult, Meralco, Engineering and Development Cooperation.

[5] Diversion channel, called Liguasan Diversion Channel, was constructed in early 1980s, and is said to have started functioning from mid 1980s, so that the 1987 flood water level was taken up as the design water level.

Location		Pagalungan Bdg	Barongis	Kabasalan	Paidu Pulangi
1984	June 15	10.59	(7.86)	(7.24)	(6.55)
1985	Oct 13	10.46	(7.73)	(7.11)	(6.42)
1986	June 21	10.00	(7.27)	(6.65)	(5.96)
1987	**Aug 26**	**10.46**	**7.80**	**7.30**	**6.50**
1988	Sep 27	10.06	(7.33)	(6.71)	(6.02)
Maximum flood level		11.0	8.3	7.7	7.0
Design flood level		**10.5**	**7.80**	**7.30**	**6.50**
Proposed dike top bank		11.0	8.30	7.80	7.00

Source: MMIP Detail Design, December 1992

2) Current Design Flood Water Level for Dikes (NIA-PMO DD)

The current design water level applied in the detail design by NIA-PMO is as follows:

Table 3.1.4 Design Flood Water Level by NIA-PMO

Item	Condition
Maximum flood level	**8.013 m (AMSL) at the design station 0.0** (outlet of the façade drain from the meeting point of Protection Dike and Ring dike)
Minimum flood level	7.812 m (AMSL)
Normal water level:	4.520 (AMSL)
River bed:	-3.48 m (AMSL)
Free board:	Min. 0.5m (therefore, the bank top elevation is set at MFL + 0.5m)
Elevation of starting point	8.77 m (AMSL)[6]
Elevation of ending point	9.90 m (AMSL), equivalent to the end of Lateral G of MC-2 Note that the ring dike has a longitudinal gradient of S = 0.00008, and therefore the ring dike, which starts with the elevation of 8.77 m AMSL, arrives at 9.90 m AMSL at the end point of Sta:14+748.432.

Source: NIA-PMO

During the survey of 'Vulnerability Assessment for Flooding in Malitubog-Maridagao Irrigation Project, June 2010', a series of interviews from local residents were organized. NIA-PMO had also confirmed high flood levels experienced with reference to the markings observed on trees, walls on residences/ buildings, etc. Based on the past high flood levels observed in the localities, the NIA-PMO has decided the above flood water levels as the design water level.

3) Difference of Flood Water Level by Studies

In the 1992 detail design, the design flood water level was decided at 6.50 m at the point of Paidu Pulangi. Recently NIA-PMO revised the design flood water level and they decided that water level at the outlet of façade drain which is located almost mid point of Paidu Pulangi station and Kabasalan station. Therefore, when adjusting the flood design water level of 6.5 m at the point of Paidu Pulangi with reference to the flood level of 7.3 m at Kabasalan in the 1992 detail design, the design flood level at the mid point between the two (2) points could be the average of the two levels, i.e., 6.90 m AMSL. Likewise, the NIA-PMO flood design level of 8.013 m AMSL at the outlet of façade drain can be interpolated at less 0.4 m level at the Paidu Pulangi point, namely, 7.61 m AMSL.

Table 3.1.5 summarizes the design flood water level by studies. From the comparison in the table, it is noted that the current NIA-PMO design flood water level is almost 1.0 m higher than those in the other studies. The following are considered as the causes of this difference; 1) the analysis in the 1992 detail design did not include recent heavy rain records, and 2) Satellite images may not show the actual maximum flood area because those images were captured every 16 days and therefore timing of image capturing and maximum flooding was not same.

[6] Though MFL 8.013 + 0.50 is 8.513m, the top elevation at the starting point of the Ring Dike (the end point of the Protection bank) is set at 8.77m. This was decided as the end elevation of the protection dike, which in turn the beginning point elevation of the ring dike.

Table 3.1.5 Design Flood Water Levels by Studies

Station	Paidu Pulangi	Outlet of façade drain	Kabasalan	Barongis
Satellite Image, 1/	6.40	(6.80)	(7.20)	(7.70)
DEM & Satellite, 1/	6.60 (inside the Lower Malitubog Service Area)			
1992 DD	6.50	(6.90)	7.30	7.80
NIA-PMO DD	(7.61)	8.013	(8.41)	(8.91)

Note: 1/ Max. water extent by Satellite image was generated by overlaying different times water extent, so that no specific year is given.
Source: JICA Survey Team

3.2 Flood Protection Measures

As described in "3.1 Past Flood Occurrence and Its Magnitude on LMSA", 32% of the originally requested ODA target area and 34% of the whole LMSA is submerged in normal hydrological year, which is equivalent to 2-year return period flood. Without any flood protection measures, this area remains as submerged area and cannot be converted to farmland during the rainy season even if irrigation facilities are constructed. Additionally, constructed structures would be damaged by flood. Therefore, any flood protection works are required to protect farmlands from the flood.

Two approaches are deemed as effective flood protection approaches; 1) Flood Protection Dike along the Pulangi river to prevent flood from flowing into the farmland, and 2) Dredging of the Pulangi river to increase flow capacity and to lower the flood water level.

3.2.1 Flood Protection Dike

1) Structure of the Dike

Generally, the structure of the flood protection dike is concrete or backfilled soil; however only backfilled soil type can be adopted because it is believed that the base is too soft for the foundation of concrete made dike.

2) Alignment of the Dike

Since the Project area is located on the right bank of the Pulangi river, it is enough to construct the dike only along the right side of the river. The following two options can be considered as the alignment of the dike (see Figure 3.2.1).

Option-1: Peripheral of the LMSA (a part of the Ring Dike)
Option-2: Along the Pulangi river (extension of the protection dike)

NIA-PMO originally proposed the Option-1 while Option-2 came later taking into account the long alignment, which will require a huge investment for the implementation of the Option-1 dike.

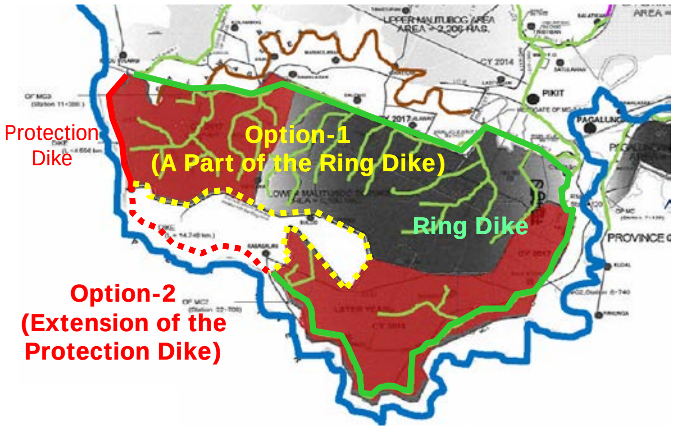


Figure 3.2.1 Dike Construction Options
Source: NIA & JICA Team

Table 3.2.1 summarizes the scale of the dike, construction cost with/without foundation treatment (required measure for foundation treatment is discussed later), and EIRR of the 2 options. Additionally Figure 3.2.2 comparatively shows the dike heights of the 2 options. From the table, followings are deduced:

- ✓ **Option-1 cannot be technically and financially feasible** because:

1) high dike reaching over 6 m height would require foundation treatment which causes a surge of the construction cost. Even with the most economical measure of foundation treatment, e.g. sand compaction pile method, additional PhP [redacted] is required for the treatment. Thus, the EIRR would fall in negative range (-0.2%).

✓ **Option-2, on the other hand, could be financially and technically feasible** from the view point of the scale, 11.7 km length with maximum 4-5 m height dike, and the EIRR of 12.3% (foundation treatment NOT considered). In case that foundation treatment should be required, the EIRR would go down to 8%; however, this scenario's risk may not be so high considering the necessary height of dike (not more than 4.5 m for most of the alignment).

Table 3.2.1 Flood Protection Dike Construction Options

Particulars	Option-1 (NIA-PMO Original: A Part of the Ring Dike)	Option-2 (Extension of the Protection Dike)
Dike Length	19.95 km	11.7 km
Max. Dike Height	6 – 7 m	4 – 5 m
Dike Volume	1,400,775 CUM	617,105 CUM
Construction Cost	PHP [redacted]	PHP [redacted]
(Foundation Treatment), 1/	PHP [redacted]	Possibly NOT required
EIRR (NO foundation treatment)	9.9% (for whole LMSA)	12.3% (for whole LMSA)
EIRR (with foundation treatment)	-0.2% (for whole LMSA)	8.0% (for whole LMSA)

Note: 1/ since geological condition of the foundation is not known, this treatment is an assumption based on Sand Compaction Pile Method discussed later. It is noted that taking into account the geological condition conducted at a bridge construction site upstream of the LMSA, the foundation condition is very soft so that with the scale of 6-7m height dike, there should be at least some foundation treatment required.
Source: JICA Survey Team

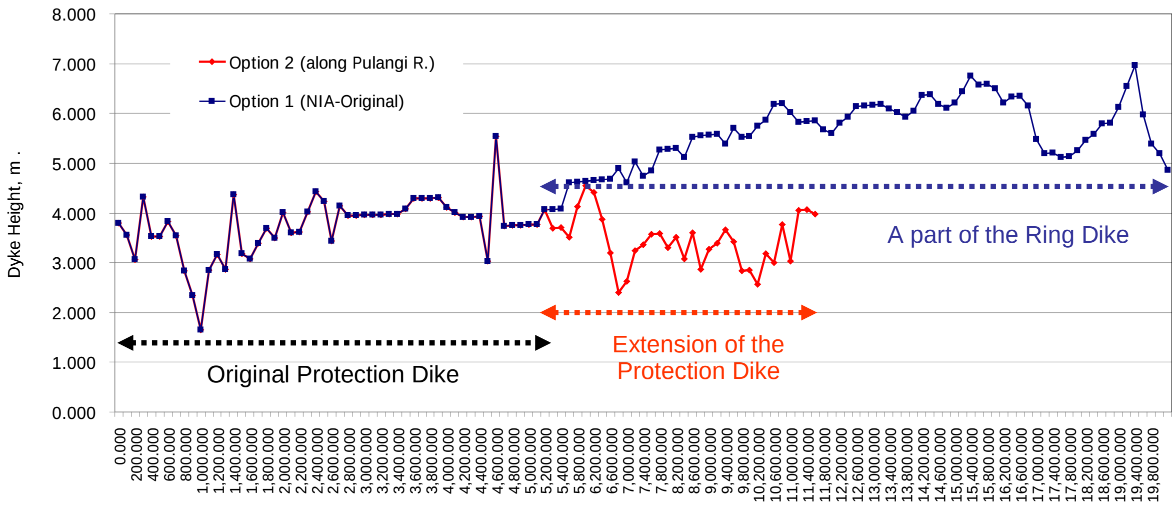


Figure 3.2.2 Dike Heights by Option

Note: According to the NIA-PMO original design, the Option-1 dike is composed of; 1) Protection Dike which runs along the Pulangi river natural bank and 2) Ring Dike running along the peripheral line of the LMSA.
Source: JICA Survey Team

3) Required Measure for Foundation Treatment

The flood protection dike is planned to be constructed along the Pulangi river starting at Paidu Pulangi, the most western location of the LMSA, and extended to the edge of the Ring Dike (see Figure 3.2.1). The protection dike is a kind of polder dike which prevents flood water from coming into the farm lands. However, the foundation of the dike is soft and therefore would require consolidation treatments.

The following examination was conducted under the conditions of the Option-1 but the same treatment may be required for the selected Option-2.

The maximum height of the Ring Dike is, according to the NIA-PMO detail design, expected to reach as high as 7 m above the foundation, while it reaches about 5 m height in Option-2. In both cases, the foundation of the dike may be soft and may consist of clay soils though geotechnical investigation has not been done along and around the alignment of the dike. When the foundation consists of clay soils, a long-term settlement, called consolidation settlement, and/or foundation circular sliding should be considered.

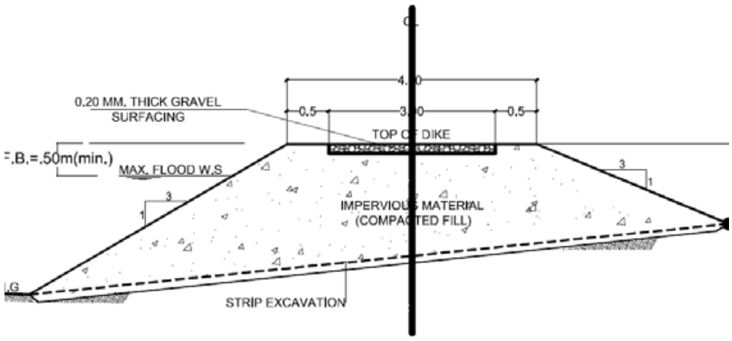


Figure 3.2.3 Typical Cross Section of Ring Dike

Source: NIA-PMO

Here, there is a geotechnical investigation result conducted at the construction sites of siphon and bridge connecting the PESA (MMIP II Geotechnical Investigation & Specification for Bridge & Siphon at Pagalungan Extension, December 2014). Though its location is far by about 30 km towards upstream from the midpoint of the LMSA along the Pulangi river, this test result is the only available geotechnical data in and around the Project area. Therefore, with this test result referred, a preliminary examination of the foundation for the dike construction is conducted below:

a) Extra-banking and foundation work method of dike

The sites for the protection and ring dikes are of soft-ground and the dikes need extra-banking and foundation treatment due to the settlement and insufficient of bearing capacity of the foundation. Extra-banking height should be given by the calculation of settlement volume (depth). The consolidation settlement will proceed by the load of dike embankment. In this case, “Cc method” is commonly applied to evaluate the settlement volume (depth):

[Cc method] $$S = \frac{C_c}{1+e_0} H \log_{10} \frac{\sigma'_0 + \Delta\sigma'}{\sigma'_0}$$

S: Settlement Volume (Depth)

Cc: Compression Index (supposed by Terzaghi’s theory) = 0.45

e_0: Void Ratio of Foundation Ground (before loading of dike embankment) = 1.36

H: Average Height of Dike Embankment

1) Ring Dike; 5.5m, 2) Protection Dike (along Pulangi River); 4.0m

σ'_0: Effective Stress of Foundation Ground (before loading of dike embankment) = 82 kN/m2

$\Delta\sigma'$: Effective Stress of Dike Embankment

1) Ring Dike; 99 kN/m2, 2) Protection Dike (along Pulangi River); 72 kN/m2

Value of the above-mentioned coefficient “Cc” and “e_0” are given by the laboratory test results which were conducted in the “MMIP II Geotechnical Investigation & Specification for Bridge & Siphon at Pagalungan Extension (NIA, December 2014)” survey as shown in the following table:

Table 3.2.2 Consolidation Parameters

Boring No.	Depth (m)	Symbols (USCS) *1)*	Void Ratio (e_0)	Compression Index (Cc)
BH-1	14.55~15.00	MH	1.592	0.660
BH-2	14.55~15.00	ML	0.961	0.245
BH-3	13.05~13.50	MH	1.501	0.505
BH-4	13.05~13.50	MH	1.457	0.490
BH-5	13.05~13.50	MH	1.370	0.460
BH-6	13.05~13.50	MH	1.811	0.600

Boring No.	Depth (m)	Symbols (USCS) *1)*	Void Ratio (e_0)	Compression Index (Cc)
BH-7	-	-	-	-
BH-8	14.55~15.00	MH	0.999	0.264
BH-9	-	-	-	-
BH-10	-	-	-	-
BH-11	14.55~15.00	MH	1.481	0.425
BH-12	-	-	-	-
BH-13	13.05~13.50	MH	1.203	0.360
BH-14	13.05~13.50	MH	1.207	-
Average			**1.36**	**0.45**

USCS: Unified Soil Classification System
Source: "MMIP II Geotechnical Investigation & Specification for Bridge & Siphon at Pagalungan Extension (NIA, December 2014)"

According to the above-mentioned survey report, stratum structure of the soft ground area along the siphon and bridge construction sites consists of SP (poorly graded sand), SM (silty fine sand), ML (silt with few sand, low liquid limit (50%<)) and MH (elastic silt, high liquid limit (50%>)) etc. Further, the depth of these soft layers reaches maximum 25 m and 20 m in average depth.

The "Effective Stress of Foundation Ground (σ'_0)" and the "Effective Stress of Dike Embankment ($\Delta\sigma'$)" are calculated by the following formulas;

[Effective Stress of Foundation Ground (σ'_0)]

$\sigma'_0 = (\gamma s - \gamma w)*h/2 = (18.0 - 9.8)*20.0/2 = 82$ kN/m^2 (average stress)

- γs: Unit Weight of Soil (soft ground) = 18.0 kN/m^3
- γw: Unit weight of Water = 9.8 kN/m^3
- h: Thickness of Soft Ground Layer = 20m (average)

[Effective Stress of Dike Embankment ($\Delta\sigma'$)]

Ring Dike

$\sigma'_0 = \gamma s*H = 18.0*5.5 = 99$ kN/m^2

- γs: Unit Weight of Soil (soft ground) = 18.0 kN/m^3
- H: Average Height of Dike Embankment

Protection Dike (along the Pulangi river)

$\sigma'_0 = \gamma s*H = 18.0*4.0 = 72$ kN/m^2

- γs: Unit Weight of Soil (soft ground) = 18.0 kN/m^3
- H: Average Height of Dike Embankment

Therefore, the settlement volume (depth) of the ring dike and protection dike along the Pulangi river is calculated as follows, namely, around 1.5 m consolidation settlement and 1.0 m settlement would be expected for the ring dike and the protection dike respectively.

- **Settlement Volume (Depth) of the Ring Dike: S = 1.31 m, say 1.5 m**
- **Settlement Volume (Depth) of the Protection Dike (along the Pulangi river): S = 1.04 m, say 1.0 m**

In addition, time to settle is estimated with assumed consolidation indexes by applying the following formula. Unfortunately, consolidation indexes are not available in the afore-mentioned test, therefore the following range of the index is assumed, e.g., from 2 x 10^{-3} m^2/day (clay dominant soil) to 15 x 10^{-3} m^2/day (clay including sand and gravel):

[Time to settle the foundation (t)]

$T = (HD^2/Cv) \times T$

Where ;

t : Time (day, in the following table, the time was converted in year)

Hd: Maximum drain length (assumed to be 10 m, half of the assumed layer thickness)

Cv: Consolidation index (m^2/day)

T: Time factor

Table 3.2.3 Estimated Years to Settle for the Dike Foundation

Consolidation Ratio U	Time Factor T	Consolidation Index (CV), m^2/day					
		Clay Soil (MH)			Gravel/ sand included (SP)		
		$2x10^{-3}$	$3x10^{-3}$	$4x10^{-3}$	$5x10^{-3}$	$10x10^{-3}$	$15x10^{-3}$
		Years to Settle (Years)					
90	0.848	116	77	58	46	23	15
80	0.567	78	52	39	31	16	10
70	0.403	55	37	28	22	11	7
60	0.287	39	26	20	16	8	5
50	0.197	27	18	13	11	5	4

Source: JICA Survey Team

According to the estimation above, taking into account such conditions as foundation soils being clay with the thickness of 20 m, the time for the foundation to settle 60% would be 20–26 years and the time to settle as much as 80% could be 39–52 years. Of course, should there be sand and gravel layers in the foundation, which can facilitate consolidation, the time to settle could be considerably reduced. For example, the calculation results show that it takes only 5 years and 10 years for 60% and 80% consolidation respectively with the consolidation index of 15×10^{-3} m^2/day.

b) Comparison of foundation works

Foundation of dikes should have resistances against the circular slip (sliding), shear failure, differential settlement and liquefaction, etc. The foundation works (foundation treatment methods) should strengthen the bearing capacity and stability of foundation. General foundation works which can be adopted for the ring dike and the protection dike along the Pulangi river are shown in the following table;

Table 3.2.4 Summary of Foundation Works (Foundation Treatment Methods)

Foundation Treatment Methods	Construction Method and Characteristics
Replacement Method	Excavation of soft ground layer and backfilling (replace) by the fine soil. This method is generally known as most certain method. However huge amount of disposal soil will occur and disposal area and borrow-pit will be required.
Sand Compaction Pile Method	Placing the sand pile in the soft ground and quicken the consolidation and thus strengthen the ground. This method prevents especially the liquefaction failure.
Sand Drain Method	Sand is used as drain material and soft ground will be consolidated by the load of dike embankment. This method needs relatively long time to achieve the strength of foundation.
Deep Layer Mixing-type Stabilization Method	Soft ground is solidified by cement-base or lime-base coagulant (Mechanical Stirring Method). This method can achieve the strength of foundation in a quicker time.

Source: Latest Works and Points of selecting Foundation Treatment, Japanese Civil Society, Feb, 2011

Table 3.2.5 shows the purposes of different foundation works, the effects of each method and comparison of construction costs. With the comparison of these factors, it is considered that the “Sand Compaction Pile Method” should be the most economical method for the foundation treatment work for the ring dike and the protection dike as well:

Table 3.2.5 Comparison of Foundation Works (Foundation Treatment Methods)

Objectives \ Name of Method			Replacement Method	**Sand Compaction Pile Method**	Sand Drain Method	Deep Layer Mixing-type Stabilization Method
Stability of Ground	Circular Slip (Sliding)		A	**B**	C	A
	Shear Failure		A	**B**	B	A
	Stability of Surface Ground		A	**B**	C	A
Control of Settlement	Consolidation Settlement		A	**B**	C	A
	Differential Settlement		A	**B**	C	A
Quickening the Consolidation			Non applicable	**A**	A	Non applicable
Prevention of Liquefaction			A	**A**	C	A
Cost of Foundation Work	Ring Dike *1)*	(million PHP)	[redacted]	[redacted]	[redacted]	[redacted]
		(million JPY)	[redacted]	[redacted]	[redacted]	[redacted]
		Cost Ratio	([redacted])	([redacted])	([redacted])	([redacted])
	Protection Dike *2)*	(million PHP)	[redacted]	[redacted]	[redacted]	[redacted]
		(million JPY)	[redacted]	[redacted]	[redacted]	[redacted]
		Cost Ratio	([redacted])	([redacted])	([redacted])	([redacted])
Evaluation			**Not adopted**	**Adopted**	**Not adopted**	**Not adopted**

1) Length of Ring Dike = 14.75 km, average embankment height = 5.5 m
2) Length of Protection Dike = 5.20 km, average embankment height = 4.0 m
3) A: Effective, B: Slightly effective, C: Not effective
Source: JICA Survey Team

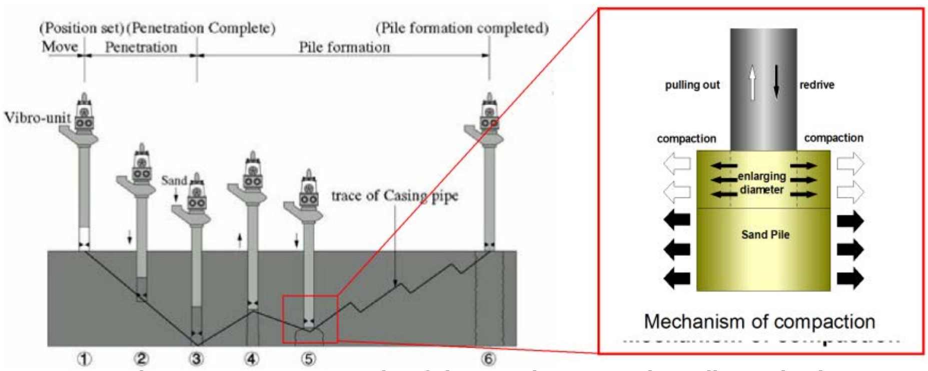


Figure 3.2.4 An Example of the Sand Compaction Pile Method
Source: ISSMGE - TC 211 International Symposium on Ground Improvement IS-GI Brussels 31 May & 1 June 2012

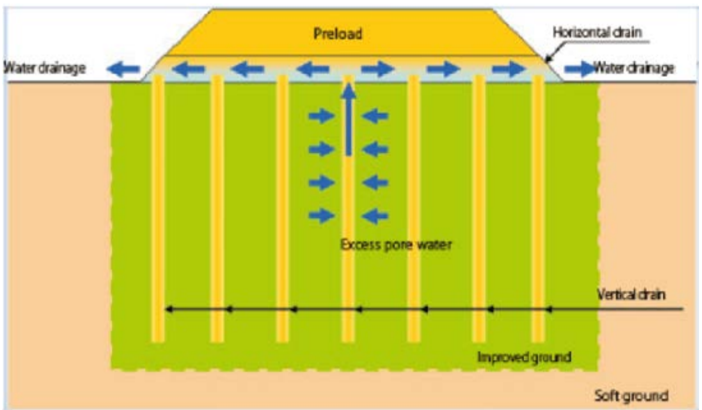


Figure 3.2.5 An Example of the Sand Drain Method
Source: WAKACHIKU CONSTRUCTION Co., Ltd.

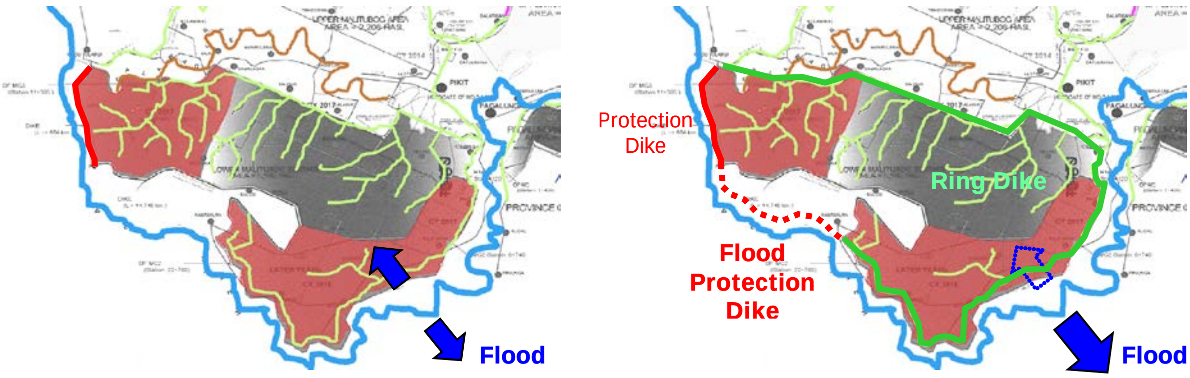
4) Negative Impact by the Construction of the Flood Protection Dike

The flood protection dike can function well to protect the beneficial irrigable area from the floods.

However, it would cause the following adverse effects:

a) Dike construction amplifies the flood impact to the left side of the Pulangi river.

The flood protection dike limits the course of the flood because the right side of the Pulangi river is closed by this dike and the ring dike. Under this condition, flood discharge volume flowing out to the left side of the Pulangi river, namely the Liguasan marsh, will increase, which causes submerged depth to be deeper and inundation area to be wider than the present condition.



Present Condition After Construction of the Dike

Figure 3.2.6 Image of Flood Situation under Present Condition and After Construction of the Dike
Source JICA Survey Team

b) Dike construction may incur inundation by rainfall originating from inside of the Dike.

Under the present condition, surface water in the LMSA flows out to the Pulangi river when its water level becomes lower than that within the LMSA. However, by the construction of the dike, the LMSA will be closed by dike, thus rainfall would accumulate therein and stagnate in the LMSA at certain extent. Therefore, drainage structures would be required to drain the stagnated water out to the Pulangi river.

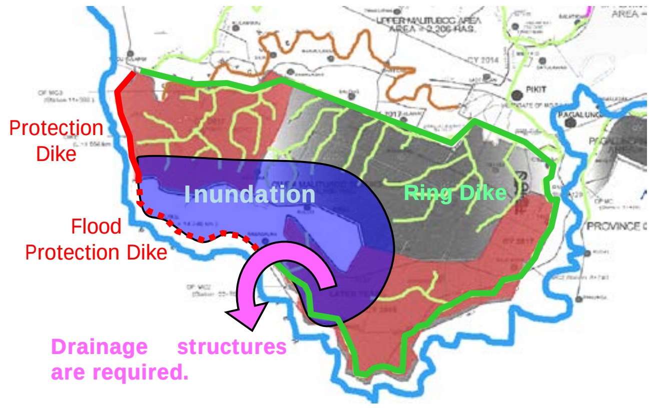


Figure 3.2.7 Image of Inundation Situation within LMSA
Source: NIA & JICA Survey Team

c) Dike would act as the physical border dividing the vicinity area socially and environmentally.

There are communities belonging to the same Magindanaon ethnic group (Moro ethnic people) around the planned dike alignment. Those communities would be separated physically, and whereby socially, by the construction of the dike.

The height of the dike ranges mostly 4 – 5 m. Left photo in Figure 3.2.8 shows a dike which height is around 3 – 3.5 m only, while the right photo in the same figure is an example of very high dike reaching over 5 m to 6 m (compare with the tree in the photo). The size of the dike proposed for the LMSA may provide the people with somewhat psychological impact, namely, the local area would be divided by the wall-like dike.

An example of dike constructed in a polder area, height ranges from 3 to 3.5 m.

An example of dike constructed in MMIP II (MC-2 Main Canal), height goes up more than 5.0 m.

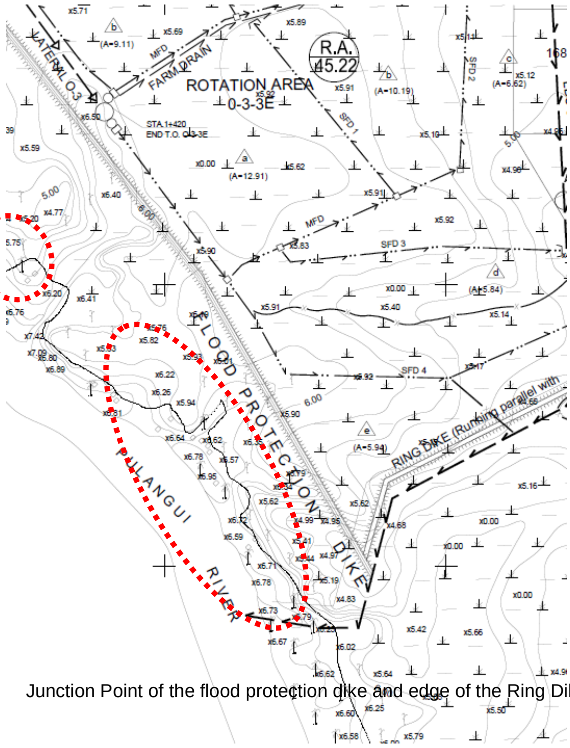
Figure 3.2.8 Examples of the Constructed Dike

Source: JICA Survey Team

d) Land acquisition and resettlement are required for dike construction.

There are residents living along the right side of the Pulangi river and their resettlement will be required to construct the dike. Since any field survey for the resettlement has not been conducted, the number of households to be relocated due to the dike construction is unknown at this moment.

There are, however, 1/4,000 topographic maps produced in early 1990s, and these maps show not only contour lines but also ground objectives, e.g. trees and houses. For example, a certain number of houses exist on the natural bank where direct effects by the construction of the dike will be concerned (see Figure 3.2.9). This indicates that the dike alignment, if constructed, should be put back toward inside of the LMSA in order to reduce the resettlement as much as possible.



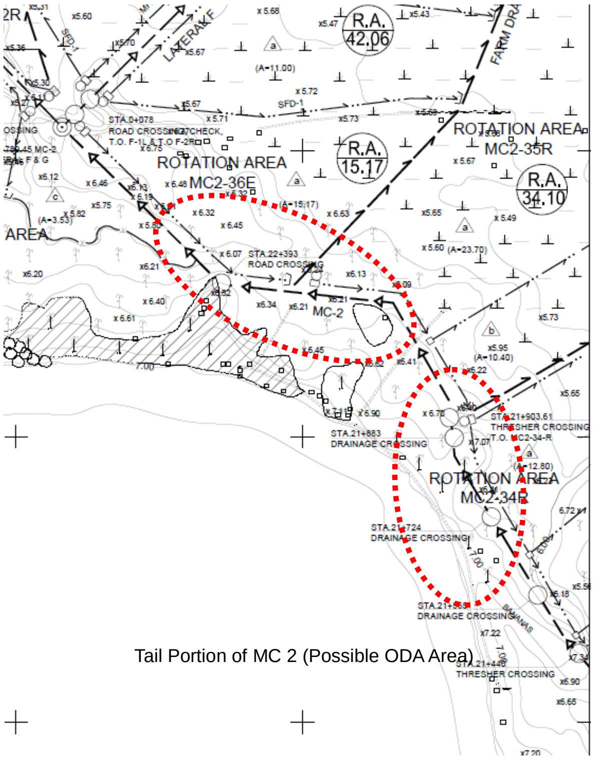


Figure 3.2.9 Topographic Map (1/4,000) showing Houses Near the Pulangi river

Note: Since most of the houses are erected just near the Pulangi river, dike should be aligned somewhat inside in order to avoid or reduce the number of resettlements.

Source: JICA Survey Team

Land acquisition can be estimated with reference to the topographic maps. The following table summarizes the area of the land acquisition comparing with/without the dike construction. As indicated below, the case with the dike construction along the Pulangi river requires about 30ha land to construct the flood protection dike, and the total land acquisition area is estimated at around 160ha.

Table 3.2.6 Land Acquisition for Dike Construction

Works	Area to be Required, ha		Remarks
	With Dike* Construction	Without Dike Construction	
1. RMC 2 (ODA Area)	**34.4**	11.3	
2. Laterals (ODA Area)	**26.1**	19.8	
3. Drains (ODA Area)	**24.3**	24.3	
4. Access Road (LMSA)	**14.8**	14.8	
5. Borrow Area 1	**20.9**	7.6	
6. Borrow Area 2	**8.8**	No Dike Considered	
7. Façade Drain	**-**		
8. Protection Dike	**29.79**		
9. Ring Dike	**-**		
Total, ha	**159.1**	77.9	

Note:* The Dike is planned along the Pulangi river, not the ring dike running within the LMSA originally planned by NIA-PMO

Source: JICA Survey Team based on Topographic map (1/4,000)

3.2.2 Dredging of the Pulangi River

1) Target Area for Dredging

DPWH has a plan for dredging of some rivers. According to DPWH, the Rio Grande de Mindanao river, Tamontaka river and Tunggol flood way are included in the target of the dredging, however the Pulangi river is not included. The dredging of the Rio Grande de Mindanao river and Tamontaka river aims to mitigate flood damage on Cotabato city. Dredging length from the river mouth is 6.15km for Rio Grande de Mindanao river and 7.15km for the Tamontaka river. Since the Project area is located about 80 km away from the river mouth, the impact by dredging may be very limited or almost nothing from the aspect of increase in flow capacity of the Pulangi river.

As for the dredging of Tunggol flood way constructed in 1980s in an upstream of LMSA in order to relieve flooding to Pikit City, it contributes to disperse the flood water and decrease the peak volume of the Pulangi river, however does not contribute to increasing the flow capacity of the Pulangi river.

Thus, it is not expected to increase the flow capacity of the Pulangi river for the Project by the DPWH plan. Additionally, according to the interview with DPWH officers, the budget for the dredging plan has not been arranged and they are still seeking donors to implement it as of mid 2017.

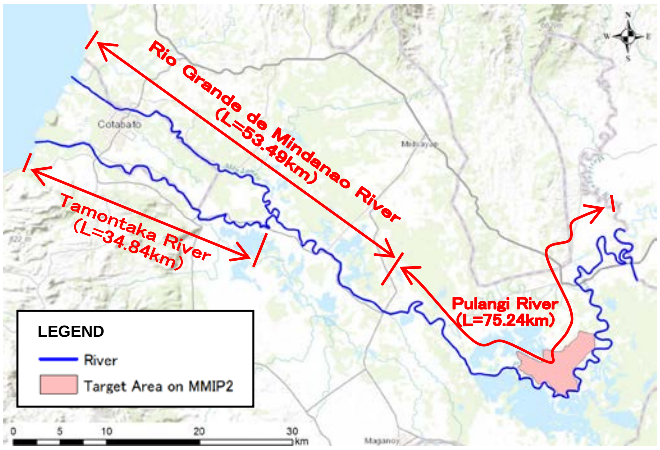


Figure 3.2.10 Target Area for Dredging

Source: JICA Survey Team

Therefore, on this study, dredging plan is examined from zero base (= without any other dredging projects), and as the first-step preliminary examination, whole length of the Pulangi river, Rio Grande de Mindanao river and Tamontaka river is selected as the target for dredging.

2) Dredging Formation

The dredging should be made both by expanding the river section and making the river bottom deeper (only making the river deeper seems to be insufficient since the river bed elevation beside the LMSA is already almost zero implying much deeper dredging would incur sea water intrusion). Additionally, since right side of the Pulangi river is the beneficiary area of the LMSA, horizontal expansion should be toward the left bank side only for the reach of LMSA.

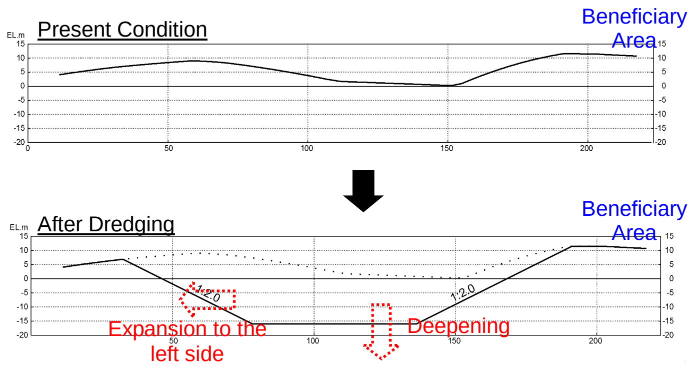


Figure 3.2.11 Image of the Dredging Formation
Source: JICA Survey Team

3) Negative Impact by the Dredging

The dredging work increases the flow capacity of the Pulangi river and lower the flood water level. However, it would cause the following concerns:

a) The edge of the Liguasan marsh might be dried up.

Flood from the Pulangi river to the Liguasan marsh works as natural supply of water to keep the marsh area wet. By the dredging work, this natural supply of water to the Liguasan marsh decreases, which instead may cause the dry out of the marsh to some extent.

b) Ecosystem of the Pulangi river may change.

By the dredging work, flow condition such as river depth and flow velocity will change. This may affect to the ecosystem around the Project area by changing the variety of the aquatic organisms and those residential areas.

c) Fishing industry may be affected by the change of the ecosystem.

Due to the change of the variety of the aquatic organism and those residential areas, fishing industry may be affected adversely.

d) Land acquisition and resettlement is required for dredging and for treating dredged mud.

There are residents living on the left bank of the Pulangi river, so dredging toward horizontal expansion will require the resettlement for those residents. Additionally, huge areas are required to dry up the dredged mud and to dispose the dried mud.

3.3 Preliminary Examination on Flood and its Mitigation Measures

3.3.1 Examination Cases

The following three simplified examinations are conducted aiming to 1) assess the feasibility of the dike construction and the river dredging, 2) evaluate positive/negative impact by the construction of the dike, and 3) examine the necessity of any additional measures to mitigate damage by flood as a rough estimate.

Table 3.3.1 Examination Case of the Preliminary Examination

Case	Purpose
1. Flood Simulation by Simplified Storage Model	- To assess maximum flood discharge, maximum flood water level and maximum inundation area
2. Inland Inundation Simulation by Simple Rainfall-Evaporation Model	- To assess the inundation area in the LMSA - To assess the necessity of any drainage facilities
3. Dredging Simulation by the Uniform Flow Calculation	-To assess required dredging volume

Source: JICA Survey Team

3.3.2 Flood Simulation by Simplified Storage Model

1) Purpose

According to the topographic map, the Pulangi river passes a narrow point located between the 2 residual hills at both sides of the river (hereinafter referred to as "bottle neck point", see Figure 3.3.1). Since the flow capacity of the Pulangi river at the bottle neck point must be low, huge flood volume may not be able to pass this point and this may cause the flood.

The purposes of this simulation are therefore to assess: 1) maximum flood discharge, 2) maximum flood water level and 3) maximum inundation area under present condition and after construction of the dike. This simulation also aims to assess the impact by the construction of the dike.

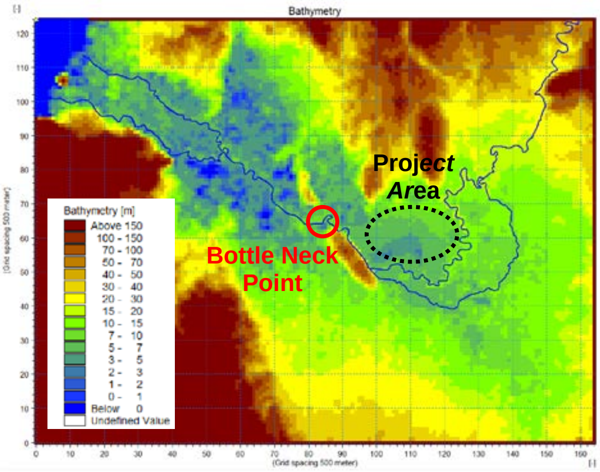


Figure 3.3.1 Location of the Bottle Neck Point
Source: JICA Survey Team

2) Methodology

Flood simulation at the bottle neck point by the rational formula, which is well known as a simplified storage model simulation, is selected.

3) Conditions for the Simulation

Catchment area at the bottle neck point is taken as a simplified storage reservoir and simulation is conducted under the conditions shown in Table 3.3.2:

Table 3.3.2 Conditions of the Simulation

Items		Condition
Rainfall	Probable Rainfall	Average rainfall within the catchment area of the bottle neck point calculated by Thiessen method
	Distribution	The method complied with the Flood Plan*
Base Flow Q_0		Specific runoff x Catchment Area at the bottle neck point
Inflow (flood discharge) Qin		Calculated by Rational Formula
Outflow Qout		Calculated utilizing H-Q relation at the bottle neck point
Cross section of the bottleneck point		Created by DEM data
H-Q relation curve at the bottle neck point		Created by Manning formula utilizing cross section of the bottle neck point
H-A and H-V relation curve of the catchment area		Created by DEM data

*Flood Plan: Nationwide Flood Control Plan and River Dredging Program, 1982
Source: JICA Survey Team

Detail explanation for each condition is described as below:

a) Probable rainfall

The historical rainfall records at the meteorological observation stations located within/near the catchment area are collected. The daily rainfall amount within the catchment area is determined according to the area of Thiessen division, and then 4-day consecutive rainfall data in the catchment area is calculated. Finally, annual maximum 4-day rainfalls are selected and probable 4-day rainfall is calculated as shown in the following Table 3.3.3:

Table 3.3.3 Probable 4-Day Rainfall (Mean Rainfall within the Catchment Area) by Return Period

Return Period	2years	5years	10years	20years	30years	50years	100years
4-day probable rainfall (mm/4days)	104	133	152	171	183	197	217

Source: JICA Survey Team

b) Rainfall distribution

Rainfall distribution of the Mindanao River Basin is generated according to the Mindanao River Basin Integrated Management and Development Master Plan (2014) as in the Figure 3.3.2. Since the distribution comprises of the ratio of each hourly rainfall as the design rainfall distribution, 4-day rainfall distribution by each return period is created by multiplying probable 4-day rainfall in Table 3.3.3 and this distribution.

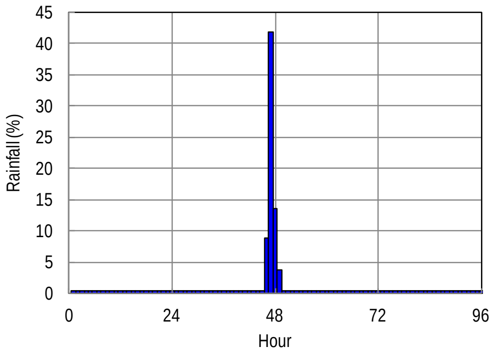


Figure 3.3.2 Rainfall Distribution

Source: JICA Survey Team

c) Base flow: Q_0

0.027 $m^3/s/km^2$ is applied as the base flow, which was determined as a specific base flow of the Mindanao River Basin in the above Master Plan. Since the catchment area at the bottle neck point is 13,700 km^2, the base flow volume is therefore calculated at 370 m^3/s.

Base flow volume = (specific base flow) x (catchment area) = 0.027 $m^3/s/km^2$ x 13,700km^2 = 370 m^3/s

d) Inflow (flood discharge): Qin

Inflow volume at the bottleneck point is calculated by the rational formula below, and the conditions for the rational formula are shown in Table 3.3.4.

Q=1/3.6 x f x r x A

Where:

- Q: Peak flood discharge (m^3/s)
- f: Runoff coefficient
- r: Average hourly rainfall during flood approach time (mm/hr)
- A: Catchment area (km^2)

Table 3.3.4 Conditions for Rational Formula

Item	F*1	Flood Approach Time*2 T (days)	r (=probable 4-day rainfall / 5.4days) (mm/hr)							A (km^2)
			2 years	5 years	10 Years	20 years	30 years	50 years	100 years	
Contents	0.383	5.4	0.80	1.01	1.16	1.31	1.40	1.51	1.66	13,700

Source: JICA Survey Team

*1: Average value within the Mindanao River Basin calculated in the Master Plan.

*2: T= Tin + Tdn

Where:

Tin: Time gap from rainfall starting time within the catchment area to flood starting time at the outlet of the catchment area (=30min)

Tdn: Flood flow time from the upstream end of the river to the bottle neck point

Tdn = Σ(L/ W)

Where:

L: Length of the main river

L1=100 km (flat slope area)

L2=229 km (moderate slope area)

W: Flood flow velocity (=20 x (h/L)^0.6)

h: Elevation gap from the upstream end of river to the bottle neck point

h1=100m (flat slope area)

h2=871m (moderate slope area)

As a result, peak flood discharge of each return period is calculated as shown in Table 3.3.5.

Table 3.3.5 Peak Flood Discharge by Return Period

Return Period	2 years	5 years	10 Years	20 years	30 years	50 years	100 years
Peak Flood Discharge Q (m^3/s)	1,160	1,476	1,694	1,907	2,033	2,192	2,412

Source: JICA Survey Team

Regarding the time series inflow, the triangle-shape hydrograph shown in Figure 3.3.3 is adopted.

e) Outflow: Qout

Qout is calculated by the Manning formula with cross section at the bottle neck point and stored water depth within the catchment area (Ht). Calculated H-Qout relation is shown in Figure 3.3.4.

f) H-A and H-V relation curve of the catchment area

With the DEM data, H-A and H-V relationships are estimated under the condition with/without dike. The results are shown in Table 3.3.6 and Figure 3.3.5.

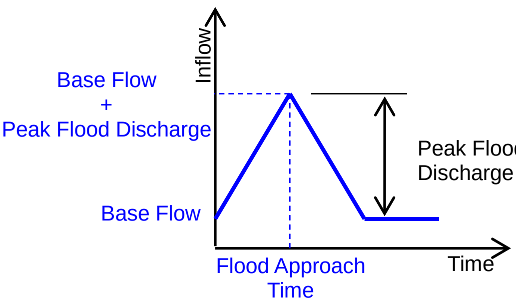


Figure 3.3.3 Triangle-shape Hydrograph

Source: JICA Survey Team

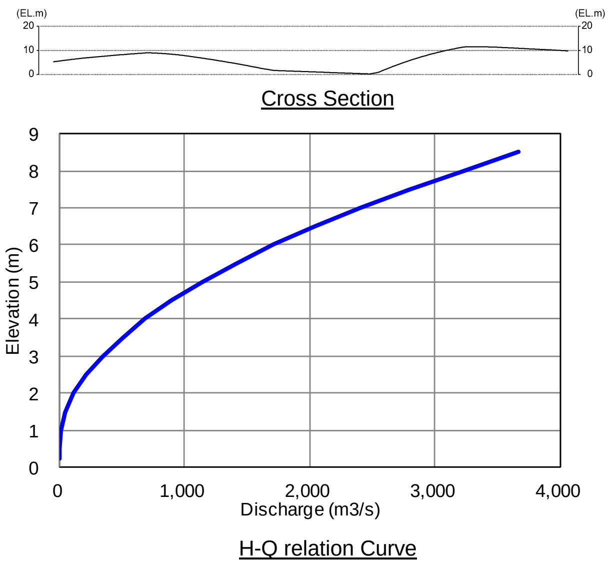


Figure 3.3.4 Cross Section and H (Elevation) - Qout Relation at the Bottle Neck Point

Source: JICA Survey Team

Table 3.3.6 Water Surface and Volume with/without Dike

Present Condition (Without Dike)				After Construction of Dike			Area Reduced	V reduced
A (ha)	cumulative A (ha)	V (MCM)	H (ELm)	A (ha)	cumulative A (ha)	V (MCM)	%	%
26	26	0	1	13	13	0	50.00	
2,279	2,305	23	2	689	702	7	30.46	30.46
69	2,374	24	3	33	735	7	30.98	30.98
365	2,738	27	4	96	831	8	30.36	30.36
1,552	4,290	43	5	1,310	2,141	21	49.90	49.90
7,095	11,385	114	6	6,516	8,657	87	76.04	76.04
7,105	18,490	185	7	6,126	14,783	148	79.95	79.95
6,484	24,974	250	8	4,816	19,599	196	78.48	78.48
11,414	36,388	364	9	10,045	29,644	296	81.47	81.47
15,038	51,426	514	10	14,269	43,913	439	85.39	85.39
14,799	66,225	662	11	14,323	58,237	582	87.94	87.94
12,752	78,978	790	12	12,410	70,647	706	89.45	89.45
9,889	88,867	889	13	9,654	80,300	803	90.36	90.36
8,318	97,185	972	14	8,122	88,422	884	90.98	90.98
7,589	104,774	1,048	15	7,469	95,892	959	91.52	91.52

Source: JICA Survey Team

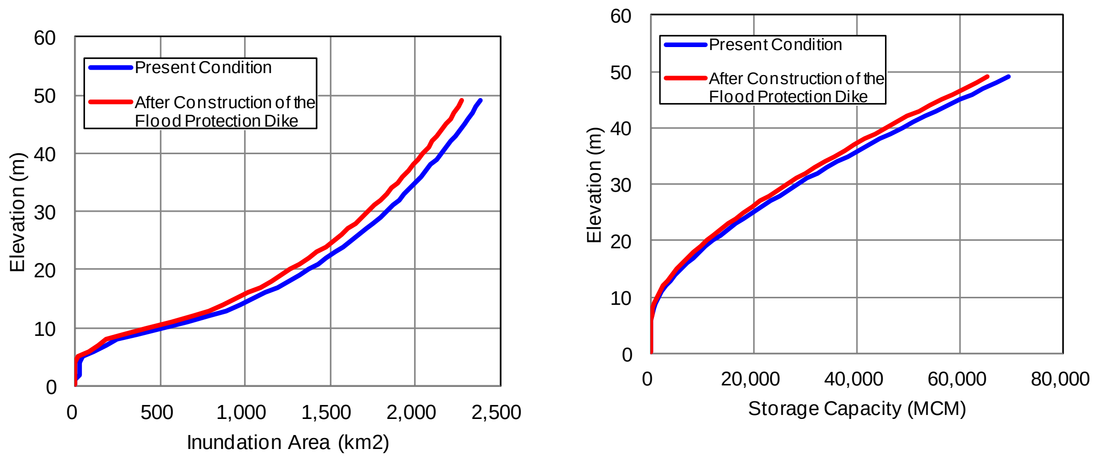


Figure 3.3.5 H-A and H-V Relation of the Catchment Area at the Bottle Neck Point

Source: JICA Survey Team

g) Formula

Flood volume, inundation area and flood water depth are calculated by the formula below. This formula shows that the difference between inflow and outflow is stored within the catchment area and inundation area is converted by stored water depth and H-A relation curve.

ΔQt = Qoutt - Qint
ΔVt = ΔQt x Δt
Vt = Vt-1+ΔVt → Converted to Ht

Where;

Qoutt: Outflow
*Calculated utilizing H-Qout relation curve at the bottle neck point and Ht-1

Qint: Inflow
*Calculated by the rational formula

Vt: Stored water volume

Δt : Time step in Analysis

Ht: Stored water depth (elevation)
*Calculated utilizing H-V relation curve of the catchment area and Vt

4) Results of the Simulation

Table 3.3.7, Table 3.3.8 and Figure 3.3.6 show the results of the simulation including the flood water level and inundation area under different probability with present condition (without dike) and after construction of the dike. In general, as the return period becomes bigger, the water level rises. The water level would, for example, rise up by 25cm and 31cm under 30-year and 100-year return periods, respectively.

Table 3.3.8 shows the inundation area on the left side of the Pulangi river by each return period. The result indicates that the inundation area would be enlarged by around 10% between with and without dike, e.g. 12.8% in case of 10-year return period and 7.9% under 30-year return period. These results may imply that the dike construction would magnify the flood impact to the left side of the Pulangi river, namely, Liguasan marsh.

Table 3.3.7 Maximum Flood Water Level with and without Dike

Return Period	(1) Present Condition (Without Dike)	(2) After Construction of Flood Protection Dike	(3) Ratio (=(2) / (1))
2 year	6.08 m	6.25 m (+17cm)	102.8 %
5 year	6.45 m	6.67 m (+12cm)	103.4 %
10 year	6.70 m	6.96 m (+26cm)	103.9 %
20 year	6.95 m	7.19 m (+24cm)	103.5 %
30 year	7.08 m	7.33 m (+25cm)	103.5 %
50 year	7.22 m	7.50 m (+28cm)	103.9 %
100 year	7.43 m	7.74 m (+31cm)	104.2 %

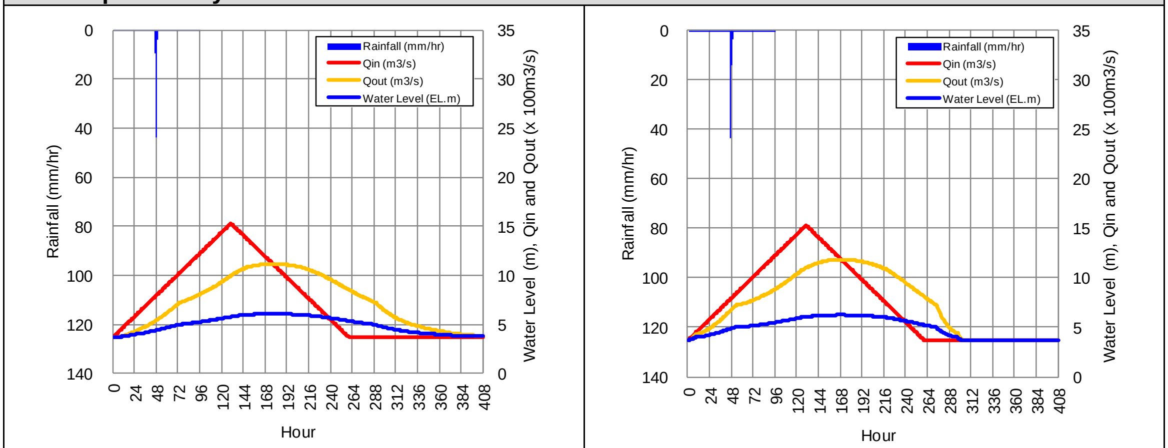
Source: JICA Survey Team

Table 3.3.8 Maximum Inundation Area with and without Dike (only Left Side of the Pulangi River)

Return Period	(1) Present Condition (Without Dike)	(2) After Construction of Flood Protection Dike	(3) Ratio (=(2) / (1))
2 year	83.4 km^2	93.6 km^2	112.2 %
5 year	105.6 km^2	118.6 km^2	112.3 %
10 year	120.6 km^2	136.0 km^2	112.8 %
20 year	135.6 km^2	147.3 km^2	108.6 %
30 year	142.2 km^2	153.5 km^2	107.9 %
50 year	148.6 km^2	161.4 km^2	108.6 %
100 year	158.2 km^2	172.4 km^2	109.0 %

Source: JICA Survey Team

Return period: 2-year



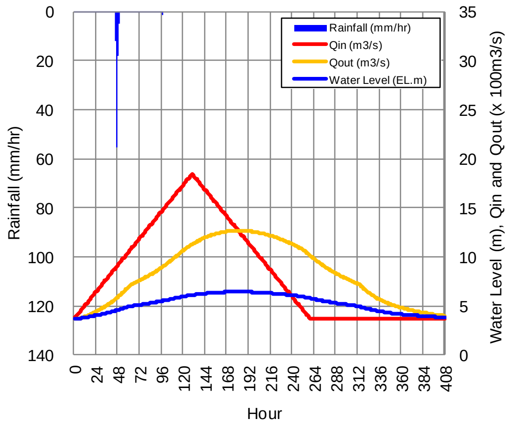
Maximum Water Level: **6.08 m**
Maximum Inundation Area: **119.8 km^2**
Present Condition

Maximum Water Level: **6.25 m**
Maximum Inundation Area: **93.6 km^2**
After Construction of the Flood Protection Dike

Figure 3.3.6 Results of the Flood Simulation by Simplified Storage Model (1/3)

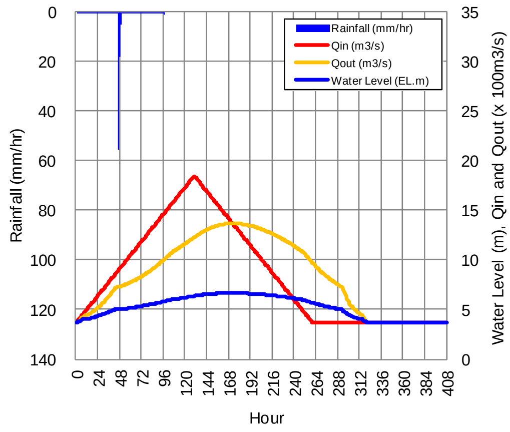
Source: JICA Survey Team

Return period: 5-year



Maximum Water Level: 6.45 m
Maximum Inundation Area: 145.7 km^2

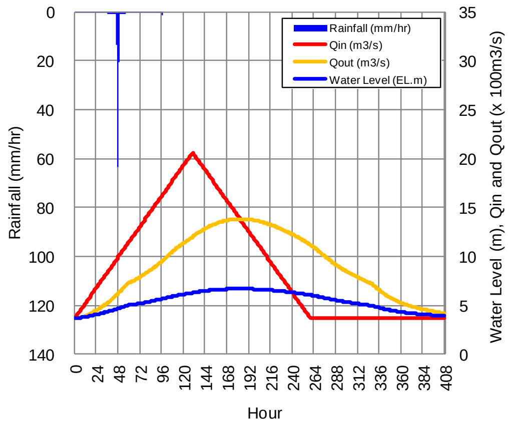
Present Condition



Maximum Water Level: 6.67 m
Maximum Inundation Area: 118.6 km^2

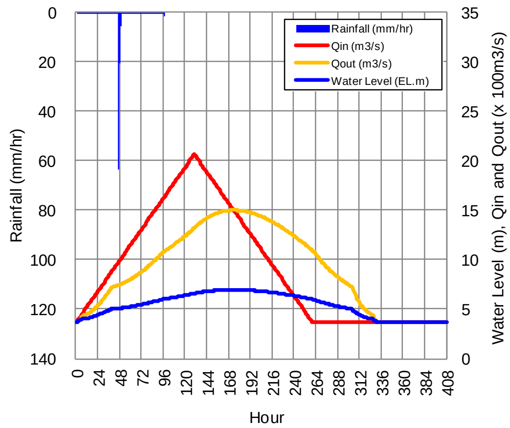
After Construction of the Flood Protection Dike

Return period: 10-year



Maximum Water Level: 6.70 m
Maximum Inundation Area: 163.8 km^2

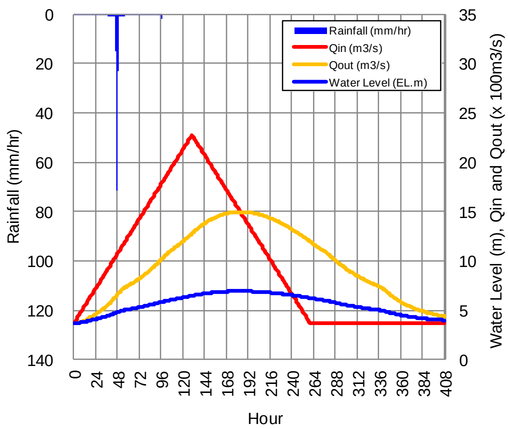
Present Condition



Maximum Water Level: 6.96 m
Maximum Inundation Area: 136.0 km^2

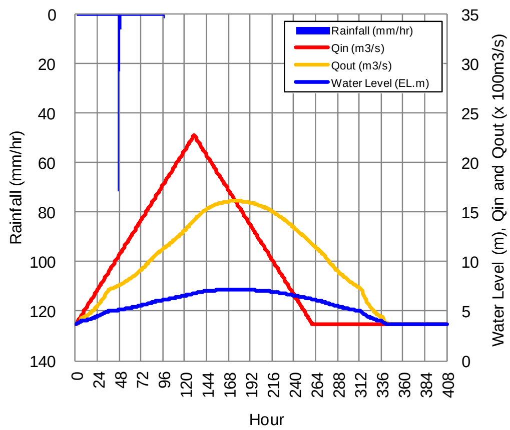
After Construction of the Flood Protection Dike

Return period: 20-year



Maximum Water Level: 6.95 m
Maximum Inundation Area: 181.7 km^2

Present Condition



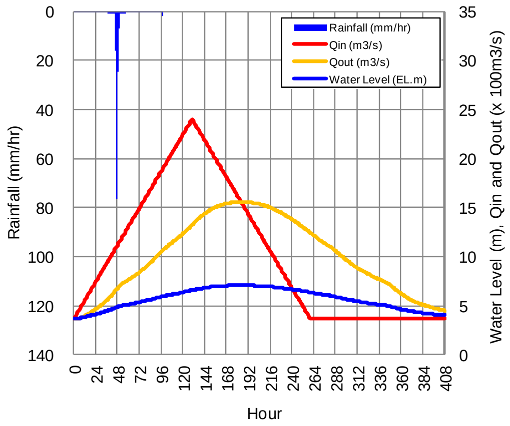
Maximum Water Level: 7.19 m
Maximum Inundation Area: 147.3 km^2

After Construction of the Flood Protection Dike

Figure 3.3.6 Results of the Flood Simulation by Simplified Storage Model (2/3)

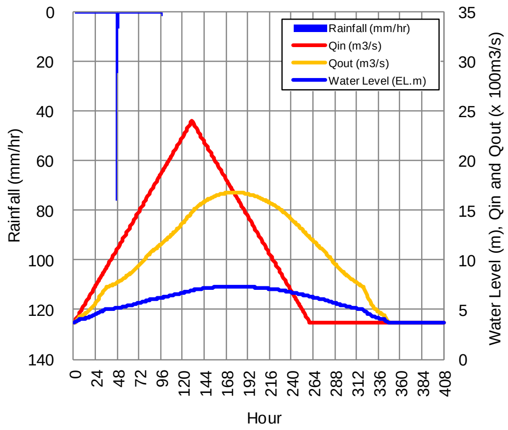
Source: JICA Survey Team

Return period: 30-year



Maximum Water Level: 7.08 m
Maximum Inundation Area: 190.0 km^2

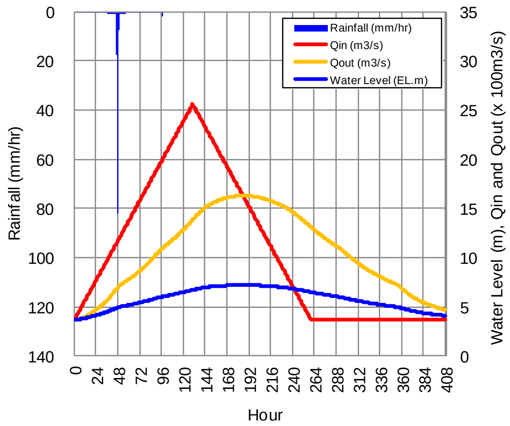
Present Condition



Maximum Water Level: 7.33 m
Maximum Inundation Area: 153.5 km^2

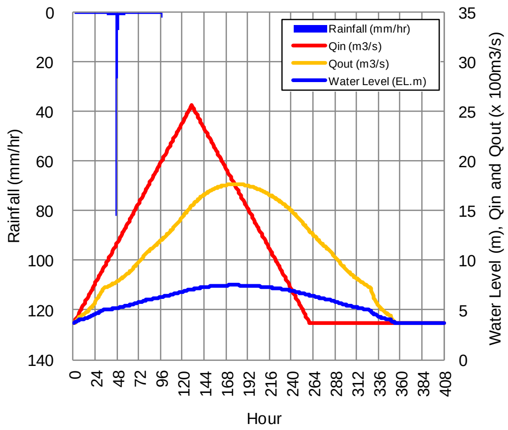
After Construction of the Flood Protection Dike

Return period: 50-year



Maximum Water Level: 7.22 m
Maximum Inundation Area: 199.4 km^2

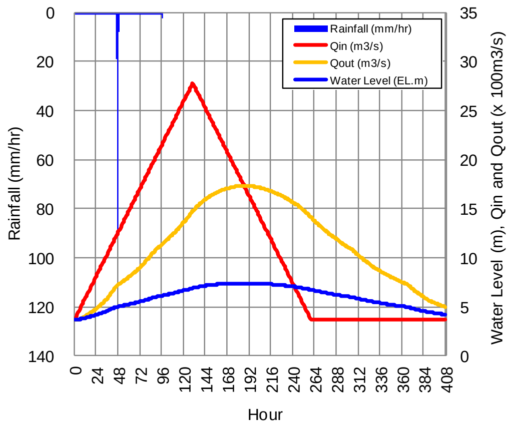
Present Condition



Maximum Water Level: 7.50 m
Maximum Inundation Area: 161.4 km^2

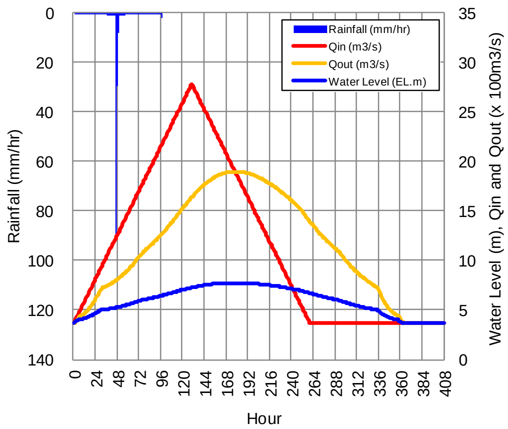
After Construction of the Flood Protection Dike

Return period: 100-year



Maximum Water Level: 7.43 m
Maximum Inundation Area: 212.8 km^2

Present Condition



Maximum Water Level: 7.74 m
Maximum Inundation Area: 172.4 km^2

After Construction of the Flood Protection Dike

Figure 3.3.6 Results of the Flood Simulation by Simplified Storage Model (3/3)

Source: JICA Survey Team

3.3.3 Inland Inundation Simulation by Simple Rainfall-Evaporation Model

1) Purpose

When the LMSA is enclosed by a dike, inland flood which is caused by the rainfall originating inside of the LMSA will occur within the LMSA. The purposes of this simulation are therefore to assess the following at a rough scale; 1) maximum inundation area, 2) maximum inland flood water level within the LMSA, and 3) damage on the designed irrigable area by inundation under the condition that the LMSA is enclosed by the dike.

2) Methodology

The balance of rainfall and evaporation within the LMSA is calculated and stored within the LMSA. The stored water volume is calculated by the formula below, and inundation area and inland flood water level are calculated with the stored water volume and H-V/H-A relation curves.

$$\Delta Vt = Rt - Et \longrightarrow Vt = Vt\text{-}1 + \Delta Vt$$

Where;

Rt: Rainfall

Et: Evaporation

Vt: Stored water volume within the LMSA

Water depth Ht:	Calculated with H-V relation curve of the catchment area and Vt
Inundation area At:	Calculated with H-A relation curve of the catchment area and Ht

3) Conditions for the Simulation

a) Simulation period

The period of this simulation is 1 year, since the impact by the evaporation, to reduce stored water volume, would not clearly appear within a short period of simulation time.

b) Rainfall applied

The historical data of the Datu Piang rainfall gauge station which is the nearest station to the LMSA (see Figure 3.3.7) is selected. Also probable annual rainfall patterns by each return period are generated based on the procedures below.

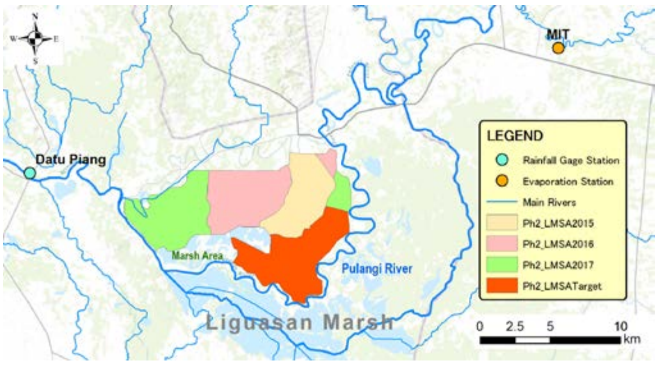


Figure 3.3.7 Location of the Rainfall Gauge Station and Evaporation Stations

Source: JICA Survey Team

i) Annual rainfall of each year at Datu Piang observation station is calculated,

ii) Probable annual rainfalls are calculated,

iii) Years which have the nearest rainfall amount to each target probable rainfall are selected, and

iv) The rainfall pattern which is selected in procedure iii) is extended according to the extension ratio which is determined by the annual rainfall of the selected year and the probable annual rainfall.

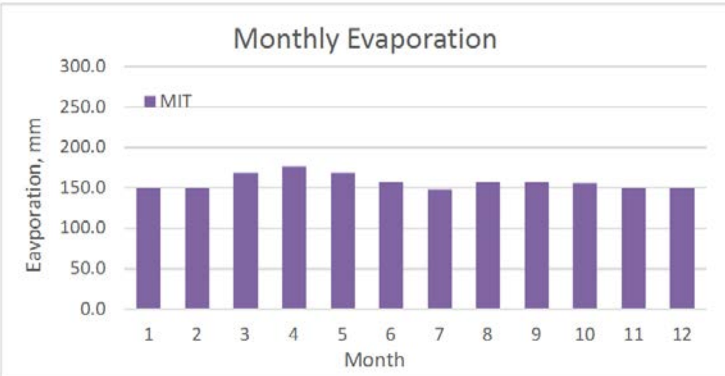
Table 3.3.9 Probable Annual Rainfall at Datu Piang Observation Station and Selected Years

Return Period (years)	Probable Annual Rainfall (mm)	Selected Year (Annual Rainfall)	Extension Ratio
2	1,415	1978 (1,385mm)	1.021
5	1,734	1994 (1,628mm)	1.065
10	1,931	1974 (1,965mm)	0.983
30	2,208	1975 (2,060mm)	1.072
50	2,328	1975 (2,060mm)	1.130
100	2,482	1975 (2,060mm)	1.205

Source: JICA Survey Team

c) Evaporation

The historical data of the MIT Evaporation station which is the nearest station to the LMSA (see Figure 3.3.8) is selected. Since the only monthly evaporation data are available, daily evaporation is calculated by dividing average monthly evaporation by the days of each month.



Month	Evaporation (mm)	
	Monthly	Daily
Jan	149.6	4.8
Feb	150.2	5.4
Mar	169.0	5.5
Apr	176.9	5.9
May	168.7	5.4
Jun	156.7	5.2
Jul	147.6	4.8
Aug	157.3	5.1
Sep	156.9	5.2
Oct	156.4	5.0
Nov	150.2	5.0
Dec	150.4	4.9

Figure 3.3.8 Evaporation at the MIT Station

Source: JICA Survey Team

d) H-V and H-A relation curve of the LMSA

1/4,000 scale plan map of the LMSA provided by NIA-PMO is selected as topographic condition within the LMSA. Also, H-V and H-A relation curves of the LMSA are generated based on this map.

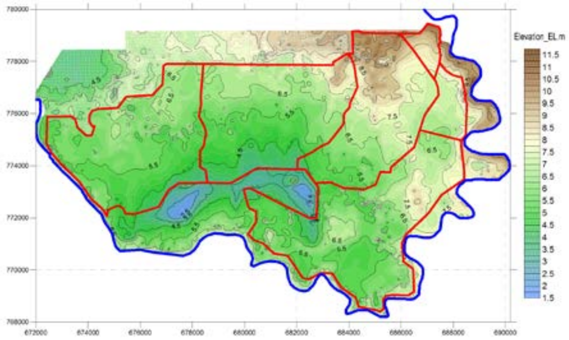
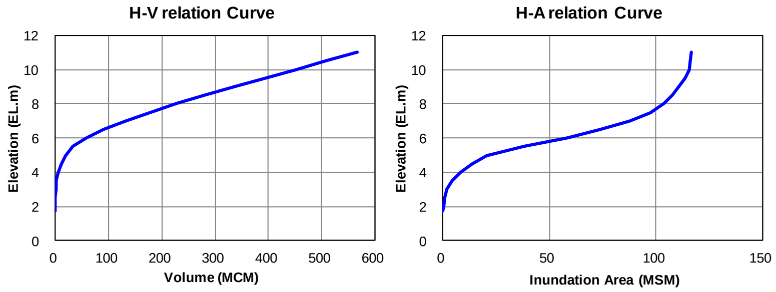


Figure 3.3.9 Topographic Condition of the LMSA

Source: JICA Survey Team



Elevation (EL.m)	Volume (MCM)	Area (MSM)
1.72	0	0
2.00	0	0
2.50	0	1
3.00	1	2
3.50	2	4
4.00	5	8
4.50	11	14
5.00	19	20
5.50	33	38
6.00	58	58
6.50	91	74
7.00	132	87
7.50	178	97
8.00	228	104
8.50	282	108
9.00	337	111
9.50	393	114
10.00	451	116
10.50	509	116
11.00	567	116

Figure 3.3.10 Topographic Condition, H-V Relation Curve and H-A Relation Curve of the LMSA

Source: JICA Survey Team

4) Results of the Simulation

Table 3.3.10 and Figure 3.3.11 indicate the computation results. Even in case of 2-year return period, there would be a certain inundation (inland flood water level within the LMSA is more than 4.5m, lowest elevation of the LMSA) which could occupy 28.9 % of the designed irrigable area of the LMSA, and as much as about half the area in case of 10-year return period. To drain out inland flood water in the LMSA, drainage pumping station(s) should be considered; otherwise the dike embankment cannot maintain the designed irrigable area of the LMSA.

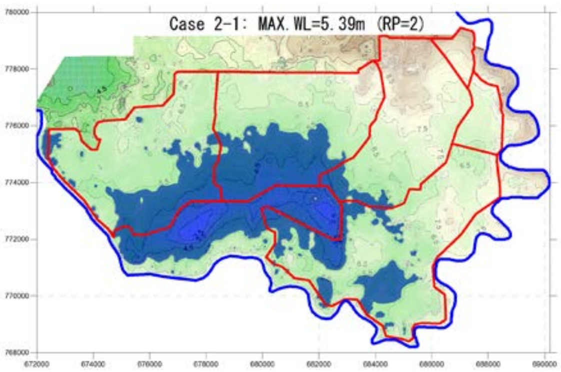
It is noted that, even during the rainy season, water level of the Pulangi river may become lower than the water levels within the LMSA, which means there might be a possibility of releasing the inland flood water to the Pulangi river by gravity. Such release is, however, NOT considered in this preliminary examination to consider the safer case.

Table 3.3.10 Inundation Magnitude Caused by Rainfall less Evaporation

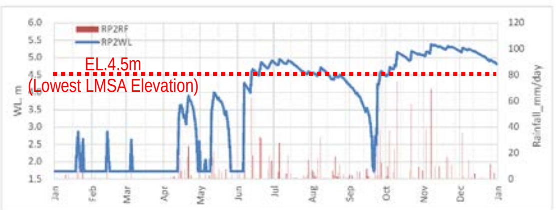
Retune Period, Year	Max Inland Flood Water Leve (EL.m)	Inundation Area within the LMSA *Elevation >4.5m	Inundated Ratio for LMSA, %
2	5.39	33.6	28.9
5	5.66	45.1	38.7
10	5.98	58.0	49.8
30	6.30	67.2	57.8
50	6.47	72.6	62.3
100	6.66	78.4	67.3
Lowest Elevation of the LMSA	**4.50**		

Source: JICA Survey Team

Return period: 2-year

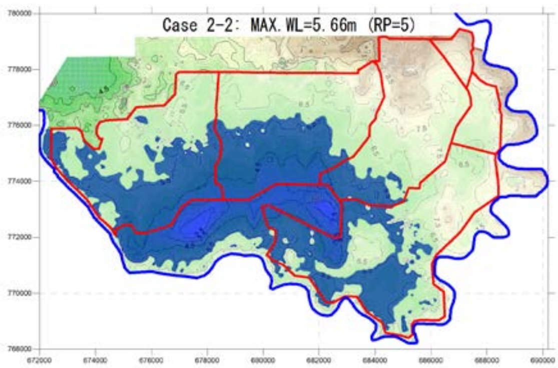


Maximum Inunation Area



Rainfall and Water level within the LMSA

Return period: 5-year



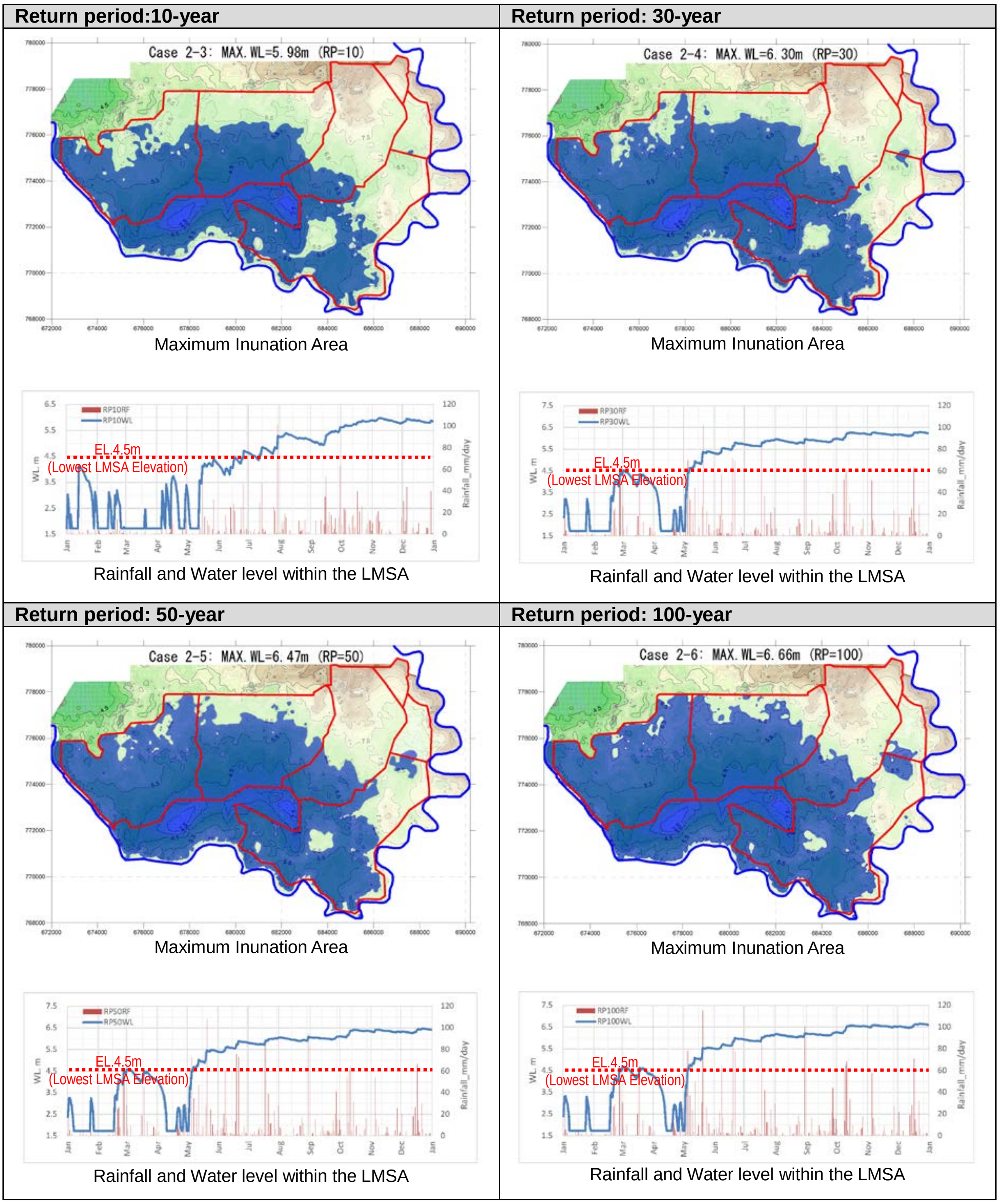
Maximum Inunation Area

Rainfall and Water level within the LMSA

*Dark green area and blue colored area are inundation area

Figure 3.3.11 Results of Inland Inundation Simulation by Simple Rainfall-Evaporation Model (1/2)

Source: JICA Survey Team



*Dark green area and blue colored area are inundation area

Figure 3.3.11 Results of Inland Inundation Simulation by Simple Rainfall-Evaporation Model (2/2)

Source: JICA Survey Team

5) Necessary Measure to Drain Inland Flood Water from the LMSA

Based on the results of the simulation, the necessity and the scale of drainage pumping station(s) should be examined to drain the inland flood water. Conditions for the examination are as follows:

a) Rainfalls applied are such three (3) cases as 10-year, 20-year and 30-year return periods based on the record of Datu Piang rainfall gauge station.

b) Only the water over 4.5m elevation is to be drained in 2 days (48 hours)[7]. The elevation of 4.5m is almost equivalent to the lowest point of the beneficiary area of the LMSA.

Table 3.3.11 indicates necessary specifications of the required drainage pumps with preliminary cost estimation including pump houses. As a result, it would not be financially feasible taking the followings into account:

a) If 1,200mm diameter pumps are to be procured, there should be 21, 23, and 24 numbers of pumps in order to drain the inland flood water in 10-year, 20-year and 30-year return period respectively. Even in the case of 1,800mm diameter pumps, 9, 10, and 10 numbers of pumps should be procured for the same cases respectively.

b) Above scope of the pumps would require huge investment, e.g. nearly around [redacted]. In addition, power arrangement including stand-by generator should be included, which further increases the investment cost in addition to the difficulty of O&M for the huge pump stations.

Table 3.3.11 Scope of Drainage Pumping Stations including Preliminary Cost

Rainfall Probability	Drainage Amount (m3/48hr)	Drainage Discharge (m3/s)	Pump Diameter (mm)	Pump Capacity (m3/s)	Number of pump	Motor Capacity (KW)	Construction cost (Million PHP)		
							Pump facility	Civil & building	Total
10-year probability	11,442,177	66.2	1200	3.2	21	400	[redacted]	[redacted]	[redacted]
		66.2	1350	4.2	16	600	[redacted]	[redacted]	[redacted]
		66.2	1500	5.4	13	630	[redacted]	[redacted]	[redacted]
		66.2	1800	8.0	9	1000	[redacted]	[redacted]	[redacted]
20-year probability	12,478,143	72.2	1200	3.2	23	400	[redacted]	[redacted]	[redacted]
		72.2	1350	4.2	18	600	[redacted]	[redacted]	[redacted]
		72.2	1500	5.4	14	630	[redacted]	[redacted]	[redacted]
		72.2	1800	8.0	10	1000	[redacted]	[redacted]	[redacted]
30-year probability	13,060,145	75.6	1200	3.2	24	400	[redacted]	[redacted]	[redacted]
		75.6	1350	4.2	19	600	[redacted]	[redacted]	[redacted]
		75.6	1500	5.4	14	630	[redacted]	[redacted]	[redacted]
		75.6	1800	8.0	10	1000	[redacted]	[redacted]	[redacted]

Source: JICA Survey Team

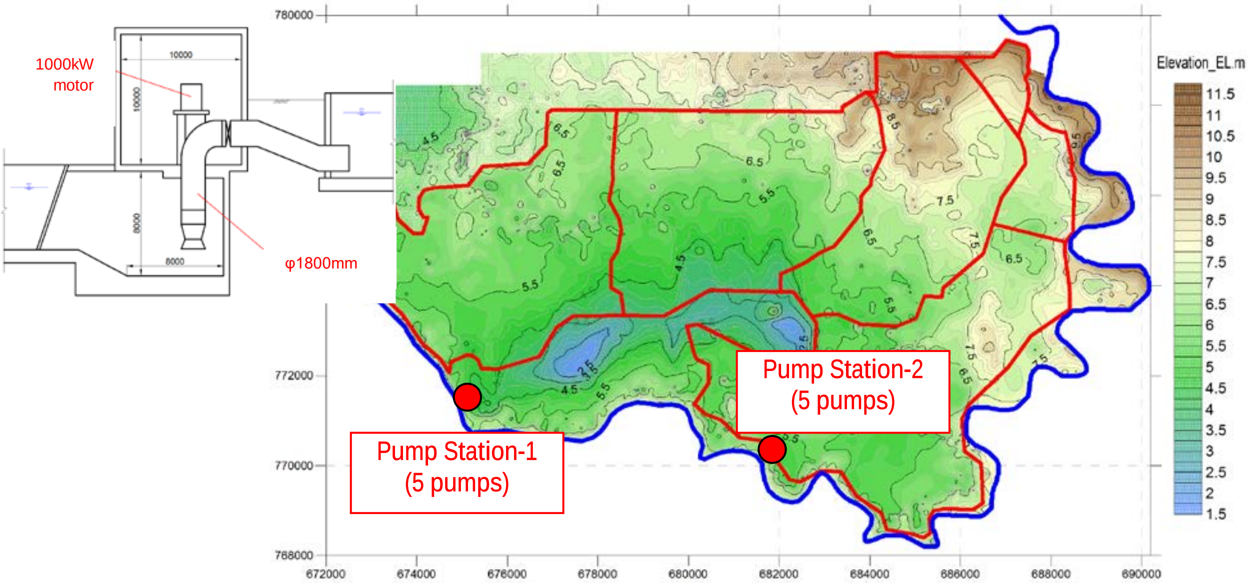


Figure 3.3.12 A Preliminary Example of Drainage Pump Stations and Typical Cross Section

Note: As an example, there should be total 10 drainage pumps with 1,800mm diameter at 2 stations. The stations would be placed at points where inland flood water could be discharged according to the topographic condition. Moreover, open trench should be excavated to the pumping stations.
Source: JICA Survey Team

7 In a Japanese standard, 24 hours are indicated as allowable (without any damages) inundation period in paddy field. In this survey, 48 hours is set as allowable period under a condition that some damages are acceptable.

3.3.4 Dredging Simulation by the Uniform Flow Calculation

1) Purpose

Dike construction would act as a physical border dividing the vicinity area socially and environmentally. From this aspect, however, social/environmental impact by dredging would be less than that of dike construction. The purpose of this calculation is to assess the possibility of mitigating damage on the LMSA by the dredging of the Pulangi river.

2) Methodology

As already discussed, flood would occur due to low flow capacity of the Pulangi river at the bottle neck point. Therefore, design cross section which has enough flow capacity at the bottle neck point is examined. The design cross section shall have enough flow capacity which can discharge the target flood volume with water level less than EL.4.5m (lowest elevation of the LMSA).

This formation is examined by the uniform flow calculation with the Manning formula below.

$Q = A \text{ x } V = A \text{ x } 1/n \text{ x } R(2/3) \text{ x } \sqrt{I}$

Where;

- Q: Discharge (m^3/s)
- A: Cross-section area of flow (m^2)
- V: Flow velocity (m/s)
- n: Manning roughness coefficient ($s/m^{1/3}$)
- R: Wetted perimeter (m)
- I: Slope

3) Conditions for the Calculation

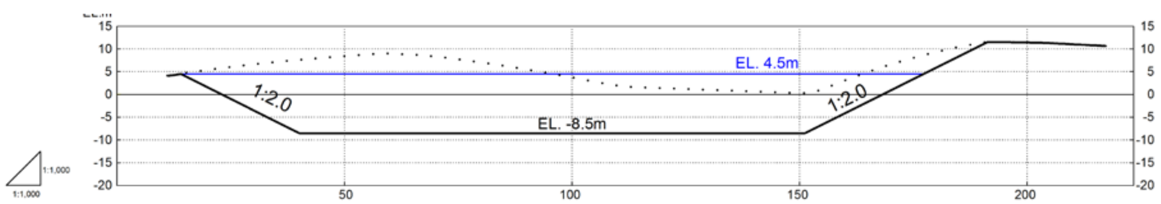
Table 3.3.12 Conditions of the Calculation

Present Cross Section	Target Flood Discharge Q	n	I
Created by DEM data	2,782m^3/s Base flow: 370 m^3/s 100-year RP Flood: 2,412 m^3/s	0.030	1/10,000 * Calculated by DEM data

Source: JICA Survey Team

4) Results of the Calculation

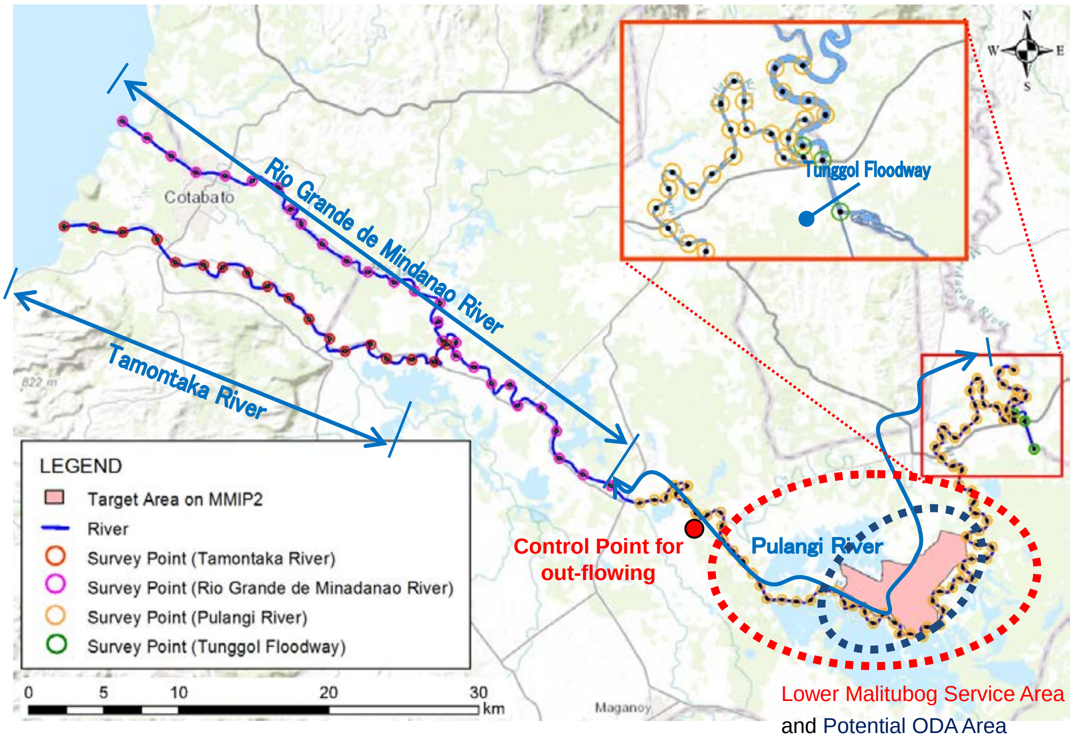
The design cross section is shown in Figure 3.3.13. At the bottle neck point, 1,868 m^3/m of the average unit dredging volume is required and this volume is required for all along the river, 163.6km in total to lower the flood water level. In this case, total dredging volume becomes 1,868 (m^3/m) x 163.6 x 103 (m) = 306 MCM.



…………… : Present Cross Section

Figure 3.3.13 Design Cross Section Formation

Source: JICA Survey Team



River	Average Unit Dredging Volume (m^2)	Rio Grande de Mindanao	Tamonotaka	Pulangi	Total
Length (km)	-	53.49	34.84	75.24	163.57
Dredging volume (MCM)	1,868	99.91	65.08	140.54	**305.53**

Figure 3.3.14 Dredging Plan: Total 163.57 km Length
Source: JICA Survey Team

Examination results indicate that the river dredging cannot be feasible because:

a) It is estimated that the necessary dredging volume is very huge, saying approximately 300 MCM, equivalent to 10m height x a square of 6 km x 5 km. The expected dredging cost would amount to 20 billion PH P[8]even not considering transportation cost to disposal area.

b) The dredging should be made both by expanding the river section and making the river bottom deeper (only making the river deeper seems to be insufficient since the river bed elevation beside the LMSA is already almost zero implying much deeper dredging would incur sea water intrusion). Due to this reason, the result requires at least 80m horizontal expansion is required, and therefore a number of houses have to be relocated.

3.4 Numerical Model for Computer Simulations

To assess the detail impact of the dike and its countermeasures, unsteady non-uniform flow simulations are executed with the software MIKE series. The feature of this detail simulation is to simulate both behaviors of the water flow on rivers and flood plains, integrating the one and two-dimensional models. In this section, the conditions of the simulations for each analysis case are described.

3.4.1 Simulation Cases

Table 3.4.1 shows the simulation cases, which are 1) Flood Simulation with/without the dike, 2) Inland

[8] Unit price for dreading is set at 64 PHP per CUM volume based on a cost estimation by DPWH applied for dreading works in the Rio Grand Mindanao river.

Inundation Simulation with/without the drainage structures, and 3) Flood Simulation with/without dredging, which are basically same cases as the afore-mentioned preliminary examinations.

Table 3.4.1 Simulation Cases for Detail Hydraulic Simulations

	Simulation Cases	Purpose
1	Flood Simulation with/without Dike	- Determination of the inundation area and flood water level - Assessment of the impact by the construction of the dike, especially impacts on the Liguasan marsh
2	Inland Inundation Simulation with/without Drainage Structures	- Assessment of inland inundation within the LMSA after the dike construction - Examination of the necessary structures to mitigate the inland inundation
3	Flood Simulation with/without Dredging	- Assessment of the necessary dredging volume of the Pulangi river to protect the LMSA from the flood. Note that the dredging considers 2 cases; 1) dreading along almost whole stretches of the Pulangi river and 2) dredging or widening of the bottle neck point.
4	Flood Simulation with the Ambal-Simuay River and Rio Grande de Mindanao Flood Control Projects	- Assessment of the flood water level after construction of the Ambal-Simuay River and Rio Grande de Mindanao flood control projects planned by DPWH

Source: JICA Survey Team

3.4.2 General Conditions of the Simulation

1) Topography

The Digital Elevation Model (DEM) from Shuttle Radar Topography Mission (SRTM) provided by National Aeronautics and Space Administration (NASA) are utilized. The spatial resolution of the original DEM is one (1) arc (approximately 30m), and the vertical resolution is one (1) meter.

2) River Alignments and Basin Boundaries

River alignments within the Mindanao River Basin are created through the spatial analysis of the SRTM DEM. Although the river alignments and the basin boundaries can be created automatically by tracing the depression and ridge line, determination of the basin boundaries should be created carefully especially on the marshy areas where the change in elevation is very small. Therefore, the determination of the basin boundaries are finalized by collating the past study, namely, "Mindanao River Basin Integrated Management and Development Master Plan", and also by the visual confirmation with the satellite images such as Google Earth.

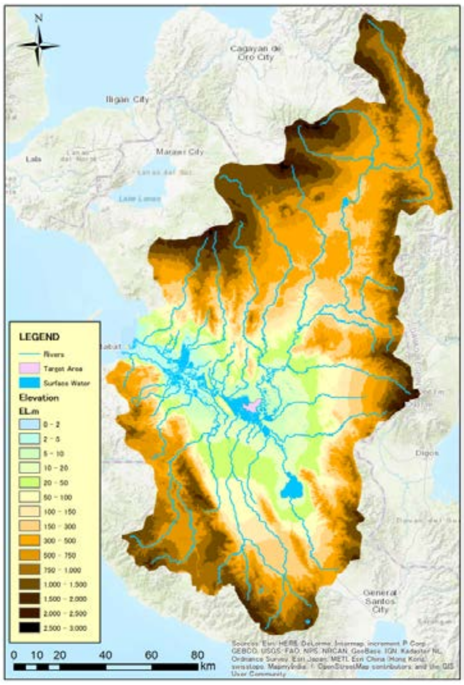


Figure 3.4.1 Elevation Distribution within the MRB

Source: JICA Survey Team

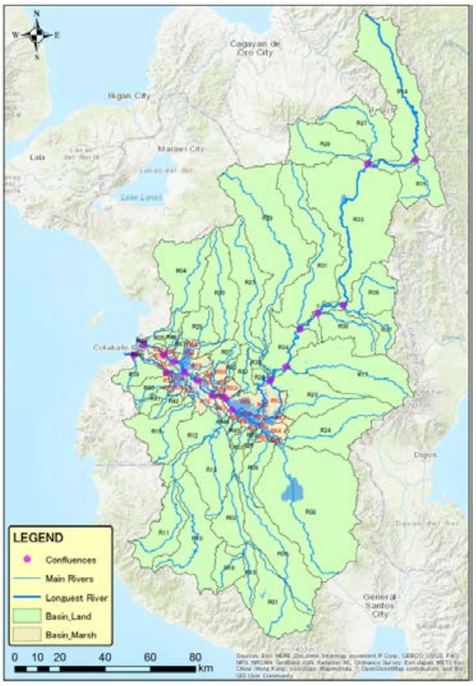


Figure 3.4.2 River Alignments and Basin Boundaries

Source: JICA Survey Team

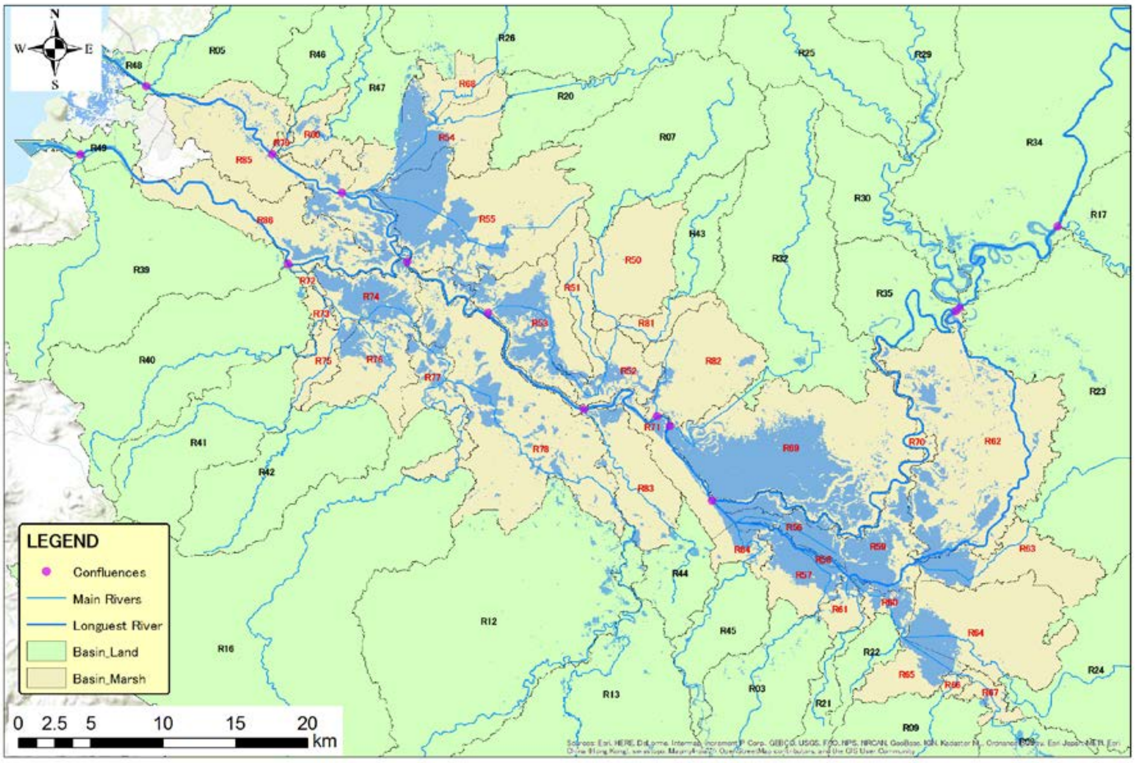


Figure 3.4.3 River Alignments and Basin Boundaries (focusing on the area from LMSA to the River Mouths)

Source: JICA Survey Team

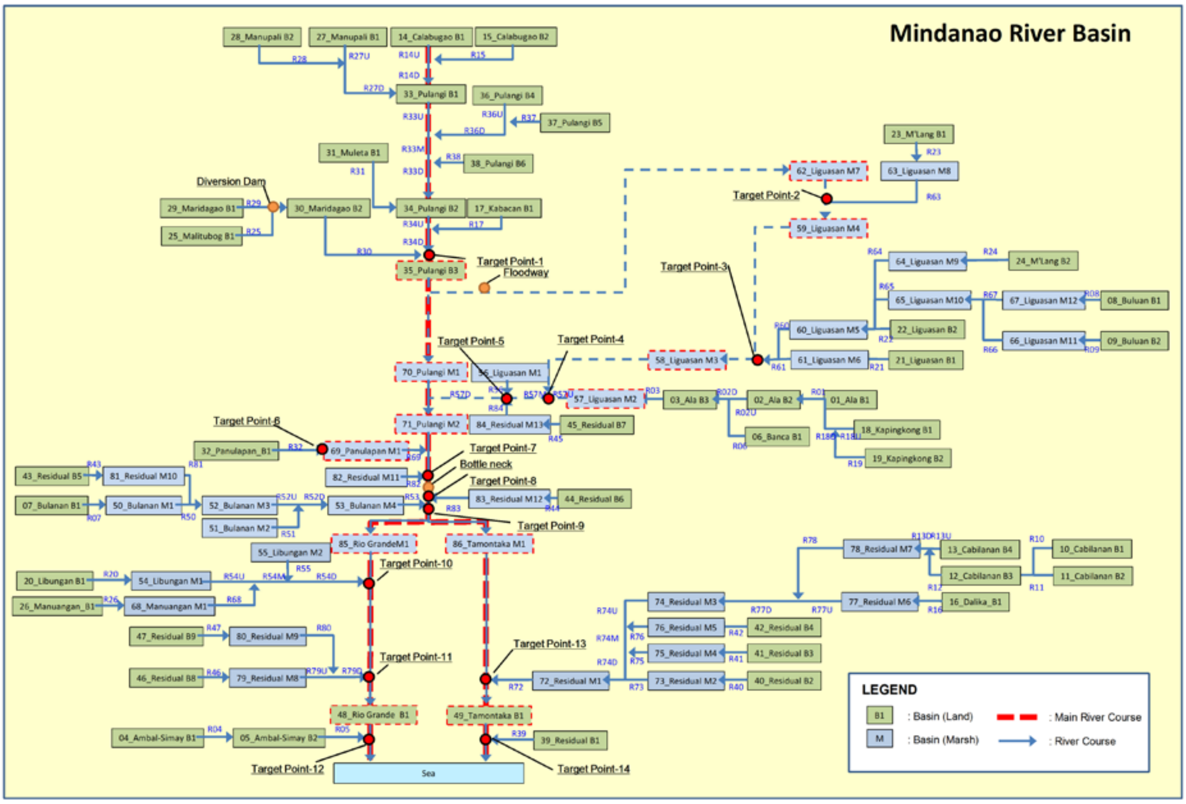


Figure 3.4.4 River Network Diagram in the Mindanao River Basin (MRB)

Source: JICA Survey Team

3) River Alignments and Basin Boundaries

Roughness coefficient on each mesh is determined based on the land use. As the Filipino standard, DPWH has their own standard about the relation between land use and roughness coefficient for the purpose of studies for flood control, and describes those roughness coefficients in "Design Guidelines, Criteria & Standards, Volume 3 Water Engineering Project 2015, DPWH" (hereinafter referred to as "DPWH standard").

In the simulation model, the average values of the DPWH standard are basically applied (see Table 3.4.2). In addition to the DPWH standard, Japanese standard is also supplementary applied in case of the land use types which are not described in the DPWH standard. Regarding the land use map, the data in 2007 provided by the Department of Agrarian Reform (DAR) is applied, which is presented in Figure 3.4.5. Figure 3.4.5 shows the catchment area is composed of cultivated annual and perennial crops, open forest, shrubs and woodlands, and inland water body, etc.

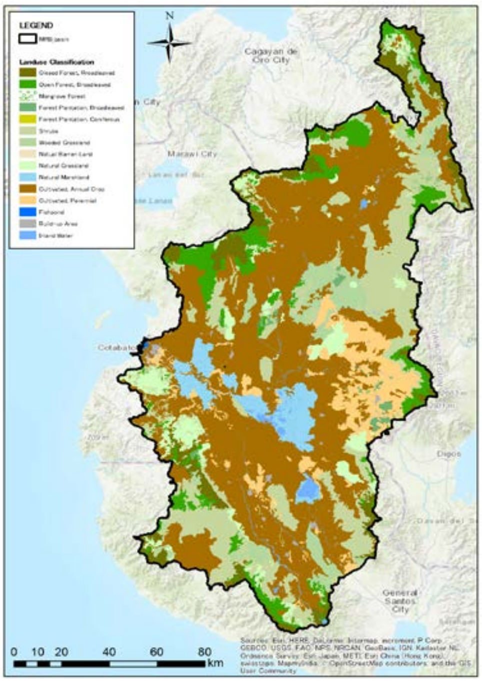


Figure 3.4.5 Land Use Map
Source: JICA Survey Team

Table 3.4.2 Roughness Coefficients by Land Uses

Land Use	Roughness Coefficient	Standard		Applied Land Use in the Standards
		Filipino	Japanese	
Closed, forest, broadleaved	0.140	✓		Wooded
Forest plantation, broadleaved	0.140	✓		Wooded
Forest plantation, coniferous	0.140	✓		Wooded
Forest plantation, mangrove	0.060	✓		Scrub& Scattered Brush
Inland water	0.025		✓	Water body
Mangrove forest	0.060	✓		Scrub& Scattered Brush, Flood Plain
Open forest, broadleaved	0.060	✓		Scrub& Scattered Brush, Flood Plain
Other land, built-up area	0.031		✓	Road
Other land, cultivated. Annual crop	0.050	✓		Cultivated Land, Nature field crops
Other land, cultivated. Perennial	0.060	✓		Scrub& Scattered Brush
Other land, cultivated, perennial crop	0.060	✓		Scrub& Scattered Brush
Other land, fishpond	0.025		✓	Water body
Other land, natural, barren land	0.035	✓		Cultivated Land (No Crop)
Other land, natural, grassland	0.038	✓		Average value of [Pasture, Short Grass, No Brush: 0.033] and [Pasture, Tall Grass, No Brush: 0.043]
Other land, natural, marshland	0.030	✓	✓	Average value of [Cultivated Land (No Crop): 0.035] in the Philippine's standard and [Water Body: 0.025] in Japanese Standard
Other land, wooded land, fallow	0.060	✓		Scrub& Scattered Brush
Other land, wooded land, shrubs	0.060	✓		Scrub& Scattered Brush
Other land, wooded land, wooded grassland	0.060	✓		Scrub& Scattered Brush
Other land, wooded lands, shrubs	0.060	✓		Scrub& Scattered Brush

Source: JICA Survey Team

4) Rainfall

All the past rainfall records (1951-2016, Maximum 66 years) at the rainfall gauge stations in the Mindanao Island were collected from Philippines Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) and National Irrigation Administration (NIA). As the result, 23 rainfall gauge stations are available for the analysis purpose.

The scarcity of the rainfall data within the immediate Project area is fatal for the analysis, so all the data of the rainfall stations which are located in and around the Mindanao River Basin (MRB) should be utilized for the analysis. In this context, the stations which have more than 15-year availability of full (365-day) data are also selected, and 12 of all the 23 stations are finally selected as target stations considering their location (neighbor of the MRB) and total record period (more than 15 years full data availability).

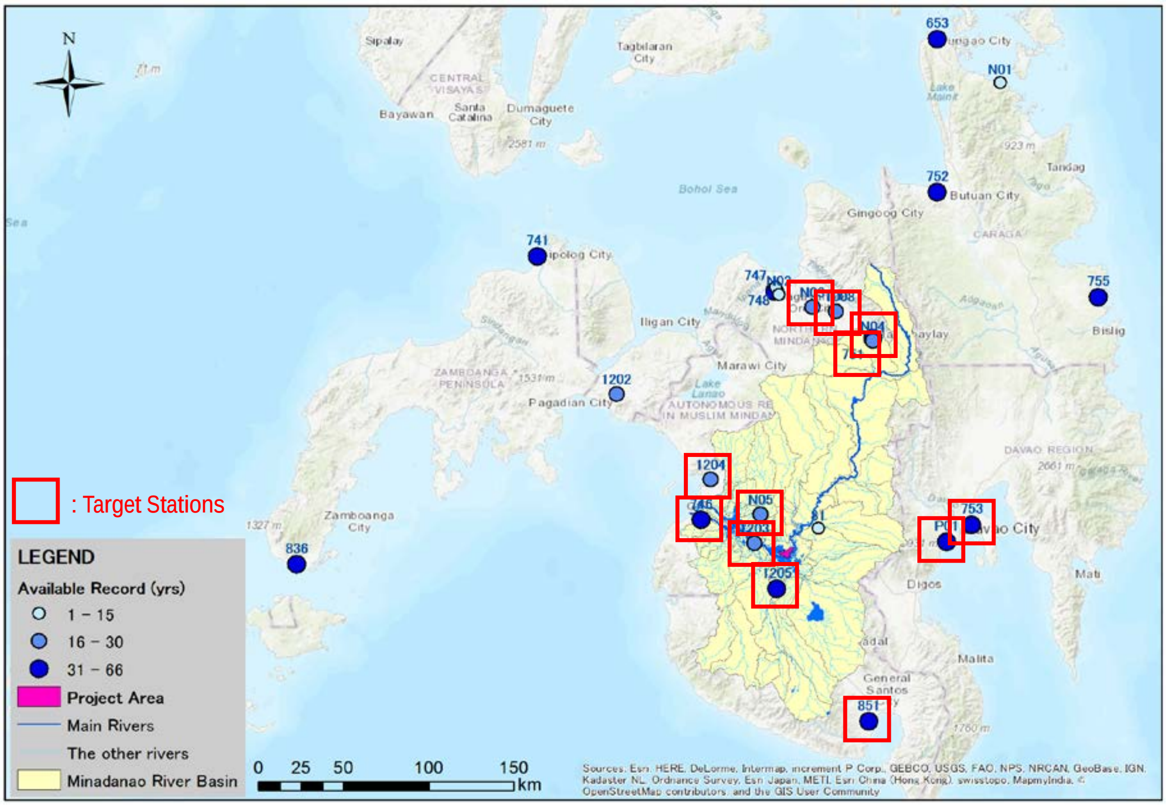


Figure 3.4.6 Rainfall Gauge Stations

Source: JICA Survey Team

Table 3.4.3 Information of the Rainfall Gauge Stations

Station ID	Name of Locatoin		Gauge Type*	Long. (°)	Lati. (°)	Elevation (EL.m)	Record Period	Source
81	USM	Kabacan	GR	124.839	7.114	20	1969-1985	PAGASA
653	Surigao	Surigao del norte	SYN	125.489	9.783	39	1951-1979 1984-2016	PAGASA
741	Diplog	Zamboanga del norte	SYN	123.345	8.603	4	1981-2016	PAGASA
746	Cotabato city	Maguindanao	SYN	124.215	7.162	50	1951-1960 1986-2016	PAGASA
747	Lumbia airport	Misamis oriental	SYN	124.612	8.409	182	1977-2013	PAGASA
748	El Salvador city	Misamis Oriental	SYN	124.617	8.433	9	2013-2016	PAGASA
751	Malaybalay	Bukidnon	SYN	125.134	8.151	627	1961-2016	PAGASA
752	Butuan city	Agusan del norte	SYN	125.482	8.947	18	1981-2016	PAGASA
753	Davao city	Davao del sur	SYN	125.655	7.128	17	1951-2016	PAGASA
755	Hinatuan	Surigao del sur	SYN	126.338	8.367	3	1951-2016	PAGASA
836	Zamboanga city	Zamboanga del norte	SYN	122.063	6.920	7	1951-2016	PAGASA
851	General Santos	South cotabato	SYN	125.103	6.057	132	1951-2016	PAGASA
1008	Kisolon, Sumilao	Bukidnon	CR	124.938	8.298	680	1980-2000	PAGASA
1202	Kapatagan	Lanao del Norte	-	123.767	7.850	90	1971-2000	PAGASA
1203	Datu Piang	Maguindanao	OR	124.500	7.033	9	1972-1987 1994-1998	PAGASA
1204	Parang	Maguindanao	OR	124.267	7.383	85	1972-2000	PAGASA
1205	Carmen, Tauron	Sultan Kudarat	OR	124.617	6.783	29	1960-2000	PAGASA
P01	PCA, Bago Oshiro	Davao del sur	-	125.522	7.037	-	1981-2016	PAGASA
N01	Claver	Surigao Del Norte	-	125.824	9.543	-	1980-1982	NIA
N02	Bubunawan	Bukidnon	-	124.634	8.393	-	1988-1990	NIA
N03	Camp Phillips	Bukidnon	-	124.813	8.323	-	1962-1987	NIA
N04	Malaybalay	Bukidnon	-	125.134	8.136	-	1957-1965 1968-1975	NIA
N05	Midsayap	North Cotabato	-	124.531	7.191	-	1956-1975	NIA

: Target Stations

* SYN Synoptic Station
GR Agrometeorological Station
OR Official Rain Station
CR Cooperative Rain Station

Source: JICA Survey Team

Table 3.4.4 Data Availability of each Rainfall Gauge Station (○: 365-day data available)

ID	Name	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
81	USM																						
653	Surigao	○	○	○	○	○	○	○	○	○	○	○		○		○		○		○	○	○	○
741	Diplog																						
746	Cotabato city	○		○	○	○	○	○	○	○	○												
747	Lumbia airport																						
748	El Salvador city																						
751	Malaybalay											○		○		○		○		○		○	○
752	Butuan city																						
753	Davao city	○	○	○	○	○	○	○	○	○	○			○	○	○	○	○	○	○	○	○	○
755	Hinatuan				○	○	○	○	○	○		○	○	○		○	○		○	○	○	○	○
836	Zamboanga city																						
851	General Santos	○	○	○		○	○			○			○	○	○	○	○	○	○	○	○	○	○
1008	Kisolon																						
1202	Kapatagan																						○
1203	Datu Piang																						
1204	Parang																						
1205	Carmen											○	○	○	○	○			○			○	○
P01	PCA																						
N01	Claver																						
N02	Bubunawan																						
N03	Camp Philips												○	○	○	○	○	○	○	○	○	○	○
N04	Malaybalay							○	○	○	○	○	○	○	○	○			○	○	○	○	○
N05	Midsayap						○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

ID	Name	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
81	USM			○	○			○	○														
653	Surigao	○	○	○	○		○							○	○	○	○	○	○	○	○	○	○
741	Diplog									○	○	○	○	○	○	○	○	○	○	○	○	○	○
746	Cotabato city															○	○	○		○	○	○	
747	Lumbia airport						○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○
748	El Salvador city																						
751	Malaybalay	○	○	○					○			○			○	○	○	○	○	○	○	○	○
752	Butuan city									○	○	○	○	○	○	○	○	○	○	○	○	○	○
753	Davao city		○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
755	Hinatuan	○	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○
836	Zamboanga city			○	○																		
851	General Santos	○	○	○	○	○		○	○	○	○		○	○	○	○	○	○	○	○	○	○	○
1008	Kisolon												○	○	○		○	○	○	○	○	○	○
1202	Kapatagan	○	○	○				○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
1203	Datu Piang	○	○	○	○	○	○	○	○	○	○	○	○	○	○								○
1204	Parang	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○
1205	Carmen	○	○		○	○	○	○	○	○	○	○	○	○				○	○	○	○		○
P01	PCA																	○					○
N01	Claver									○													
N02	Bubunawan																○						
N03	Camp Philips	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○							
N04	Malaybalay	○	○																				
N05	Midsayap	○	○	○																			

ID	Name	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
81	USM																						
653	Surigao	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
741	Diplog	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
746	Cotabato city	○	○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○	○
747	Lumbia airport	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○				
748	El Salvador city																				○	○	○
751	Malaybalay	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○
752	Butuan city	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
753	Davao city	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
755	Hinatuan	○	○	○	○	○	○	○	○	○	○	○	○	○	○		○	○	○	○	○		○
836	Zamboanga city																						
851	General Santos	○		○	○	○	○	○	○		○	○	○	○	○	○	○	○	○	○	○	○	○
1008	Kisolon	○	○	○	○		○																
1202	Kapatagan	○	○	○	○																		
1203	Datu Piang	○																					
1204	Parang	○	○	○	○		○																
1205	Carmen	○																					
P01	PCA		○	○			○		○	○	○		○	○	○		○	○	○	○	○	○	○
N01	Claver																						
N02	Bubunawan																						
N03	Camp Philips																						
N04	Malaybalay																						
N05	Midsayap																						

Source: JICA Survey Team

After the selection of the rainfall gauge stations, the basin mean rainfall data of the MRB is calculated with the Thiessen method. Based on the organized data shown in Table 3.4.3, 18 Thiessen division patterns for 52 years are finally created[9]. Figure 3.4.7 shows all the Thiessen division patterns applied in the analysis.

According to the Master Plan, the recommended rainfall duration for the flood analysis in the MRB is 4 days in due consideration of the lag time of runoff. Therefore, the four-day basin mean rainfall amount is calculated for all the 52 years (see Table 3.4.5), and the maximum probable rainfall amount is then calculated based on the four-day basin mean rainfall. The result of the probability calculation is shown in Table 3.4.6.

Table 3.4.5 Maximum 4-day Basin Mean Rainfall Amount in MRB

Thiessen Pattern	First Day	Final Day	RF. Amount (mm)	Thiessen Pattern	First Day	Final Day	RF. Amount (mm)
Pattern 01	1957/7/30	1957/8/2	87.0	Pattern 13	1987/7/2	1987/7/5	95.6
Pattern 01	1959/5/29	1959/6/1	90.1	Pattern 14	1988/3/30	1988/4/2	91.0
Pattern 02	1961/2/28	1961/3/3	55.4	Pattern 14	1989/4/13	1989/4/16	92.8
Pattern 03	1963/3/16	1963/3/19	96.3	Pattern 15	1990/8/2	1990/8/5	75.2
Pattern 04	1964/4/11	1964/4/14	131.2	Pattern 14	1991/5/13	1991/5/16	75.8
Pattern 03	1965/5/31	1965/6/3	83.7	Pattern 14	1992/10/23	1992/10/26	82.2
Pattern 05	1966/12/17	1966/12/20	179.5	Pattern 13	1993/7/2	1993/7/5	71.7
Pattern 05	1967/10/13	1967/10/16	97.8	Pattern 16	1994/6/5	1994/6/8	65.2
Pattern 03	1968/6/19	1968/6/22	73.4	Pattern 17	1995/8/30	1995/9/2	81.9
Pattern 05	1969/8/16	1969/8/19	90.2	Pattern 13	1997/7/9	1997/7/12	87.3
Pattern 05	1970/10/16	1970/10/19	106.5	Pattern 13	1998/11/7	1998/11/10	71.4
Pattern 03	1971/10/1	1971/10/4	104.2	Pattern 18	1999/8/31	1999/9/3	126.0
Pattern 03	1972/4/6	1972/4/9	78.4	Pattern 13	2000/8/15	2000/8/18	112.5
Pattern 06	1973/11/18	1973/11/21	85.5	Pattern 18	2001/11/2	2001/11/5	96.3
Pattern 06	1974/10/27	1974/10/30	77.1	Pattern 18	2004/5/29	2004/6/1	127.8
Pattern 07	1975/6/19	1975/6/22	101.6	Pattern 18	2005/9/7	2005/9/10	95.6
Pattern 08	1976/7/14	1976/7/17	78.7	Pattern 18	2006/3/6	2006/3/9	101.0
Pattern 08	1977/11/26	1977/11/29	112.9	Pattern 18	2007/7/10	2007/7/13	112.2
Pattern 09	1978/6/6	1978/6/9	160.1	Pattern 18	2008/5/8	2008/5/11	150.9
Pattern 08	1979/6/21	1979/6/24	79.7	Pattern 18	2009/7/24	2009/7/27	264.8
Pattern 08	1981/5/14	1981/5/17	69.1	Pattern 18	2010/9/29	2010/10/2	93.0
Pattern 08	1982/1/27	1982/1/30	78.8	Pattern 18	2011/10/7	2011/10/10	118.4
Pattern 10	1983/7/20	1983/7/23	95.2	Pattern 18	2012/9/21	2012/9/24	108.7
Pattern 11	1984/6/12	1984/6/15	70.1	Pattern 18	2013/10/4	2013/10/7	97.0
Pattern 11	1985/10/8	1985/10/11	76.2	Pattern 18	2014/1/11	2014/1/14	99.1
Pattern 12	1986/6/16	1986/6/19	92.7	Pattern 18	2016/7/27	2016/7/30	97.9

Source: JICA Survey Team

Table 3.4.6 Maximum 4-day Basin Mean Rainfall Amount in MRB[10]

Return Period	Gumbel	Iwai	Gev	SqrtEt
2	94.2	92.3	**90.3**	93.5
10	135.8	134.9	**133.8**	137.6
20	151.7	152.8	**156.7**	156.5
30	160.8	163.4	**171.9**	167.9
50	172.3	177.1	**193.4**	182.6
100	187.7	196.3	**227.1**	203.4
SLSC	0.186	0.094	**0.048 (Applied)**	0.115

Source: JICA Survey Team

9 In order to secure the accuracy of the basin mean rainfall amount of each Thiessen division pattern, at least 4 stations need to surround the MRB. Therefore, 14-year record of the 66-year was not applied.

10 The 52-year record was applied to each probability distribution model, namely, Gumbel distribution, Iwai method, Generalized extreme value distribution (Gev), and Square-root exponential type maximum distribution (SqrtEt), and Generalized extreme value distribution was selected as the most appropriate model based on the Standard Least Squares Criterion (SLSC).

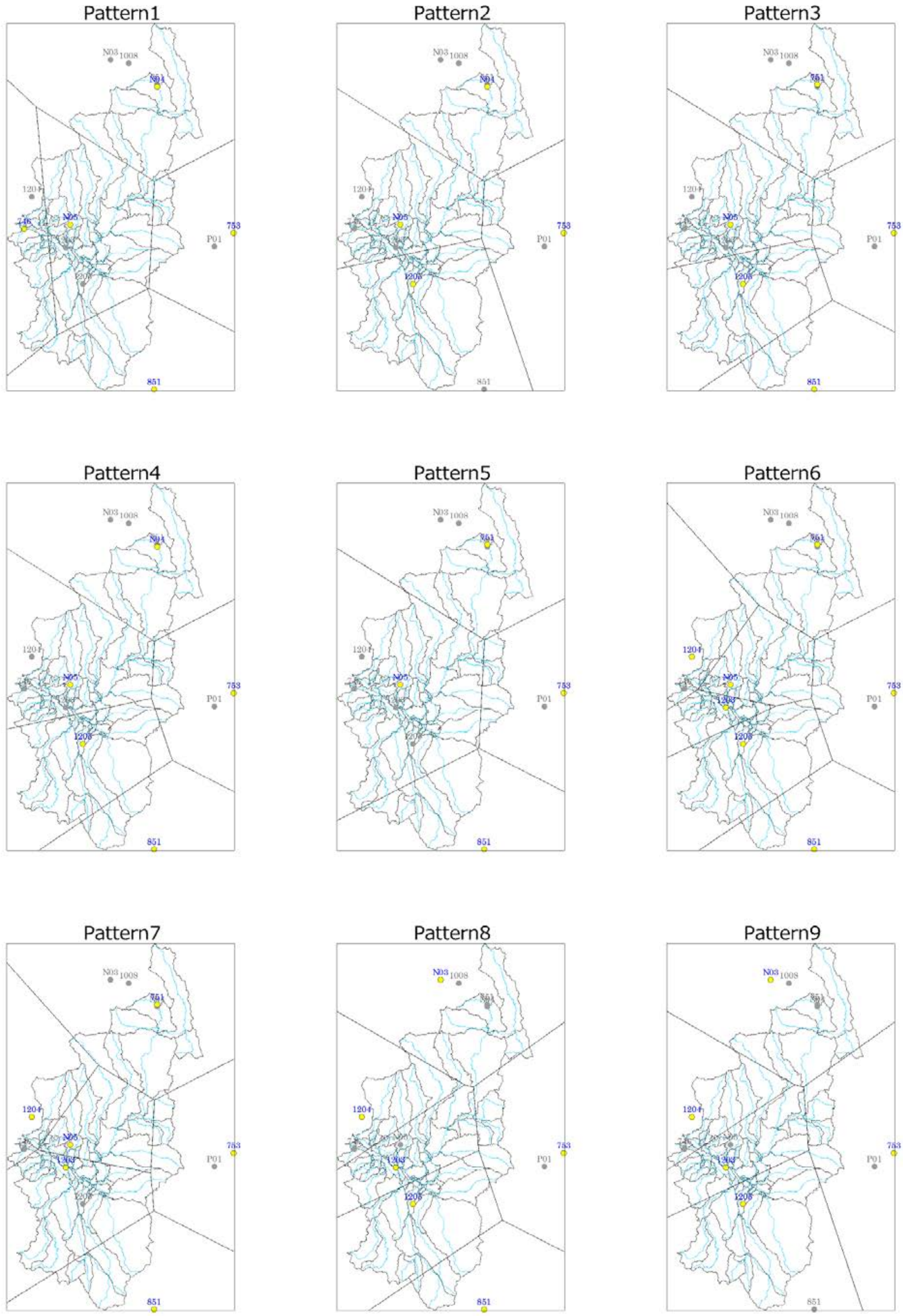


Figure 3.4.7 Area Division Patterns for Thiessen Method (1/2)

Source: JICA Survey Team

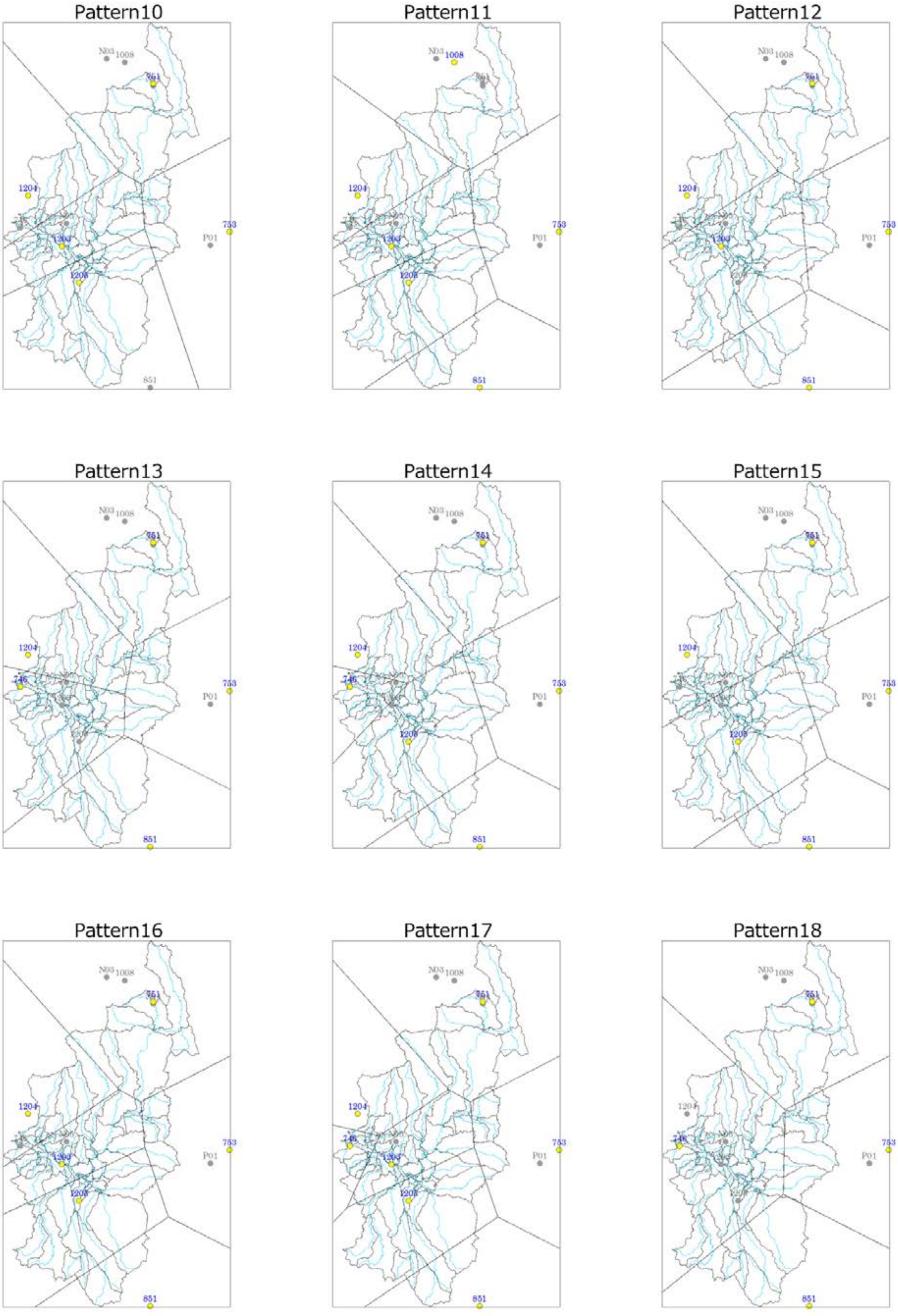


Figure 3.4.7 Area Division Patterns for Thiessen Method (2/2)

Source: JICA Survey Team

5) Evaporation

Weather stations which measure the evaporation rate are fewer than the rainfall gauge station, and only six (6) pan-evaporation stations within the Mindanao Island are available. As for the model application, MIT station (Station ID: N03, Recording Period: 1957-1973) which is the only station in the MRB was selected. Since the data is monthly basis record, the daily evaporation amount is assumed by dividing the days of each month.

Table 3.4.7 Pan-Evaporation Stations in the Mindanao Island

Station ID	Name of Location		Long. (°)	Lati (°)	Elevation (EL.m)	Record Period	Source
N01	Bula	General Santos	125.1904	6.1094	6	1957-1973	NIA
N02	Dadiangas	General Santos	125.1726	6.1182	19	1959-1965	NIA
N03	Mindanao Institute of Technology (MIT)	Kabacan	124.8391	7.1136	30	1957-1973	NIA
N04	Mindanao State University	Malawi	124.2605	7.9984	780	1969-1984	NIA
N05	Tagum	Davao del Norte	125.6298	7.5302	35	1977-1988	NIA
P01	PCA	Davao del Sur	125.5217	7.0367	8	2007-2016	PAGASA

Source: JICA Survey Team

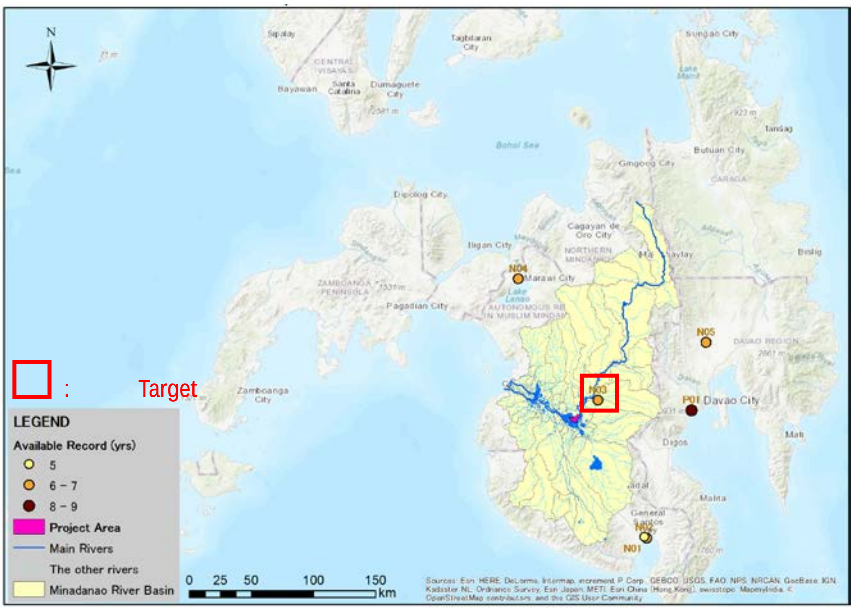
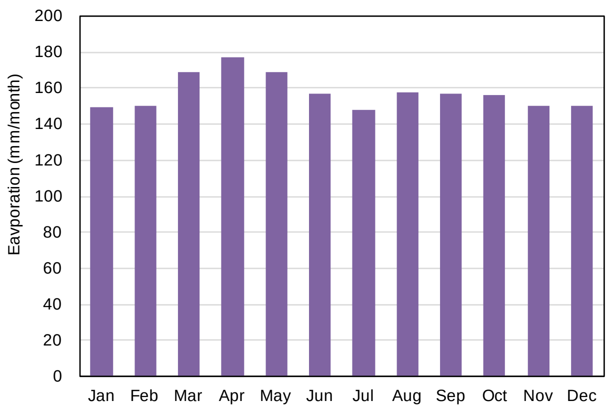


Figure 3.4.8 Location of the Pan-Evaporation Stations

Source: JICA Survey Team



	Evaporation (mm)	
	Monthly	Daily
Jan	149.6	4.8
Feb	150.2	5.4
Mar	169.0	5.5
Apr	176.9	5.9
May	168.7	5.4
Jun	156.7	5.2
Jul	147.6	4.8
Aug	157.3	5.1
Sep	156.9	5.2
Oct	156.4	5.0
Nov	150.2	5.0
Dec	150.4	4.9

Figure 3.4.9 Monthly and Daily Evaporation at MIT Station

Source: JICA Survey Team

6) Runoff Coefficient

Likewise, the roughness coefficient, the runoff coefficient is determined based on the land use type. Since the values utilized in this simulation have been chosen according to the Master Plan, the same values are applied as indicated in the Table 3.4.8.

Table 3.4.8 Runoff Coefficient by Land Use Category

ID	Category	SYMBOL	Runoff Coefficient
1	Closed forest, broadleaved	NF4F	0.55
4	Open forest, broadleaved	NF2B	0.55
7	Mangrove forest	NFM	0.80
8	Forest plantation, broadleaved	FPB	0.55
9	Forest plantation, coniferous	FPC	0.55
10	Other wooded land, shrubs	Sh	0.55
12	Other wooded land, wooded grassland	WGL	0.25
13	Other land, natural, barren land	BL	0.30
14	Other land, natural, grassland	GL	0.25
15	Other land, natural, marshland	ML	0.80
16	Other land, cultivated, annual crop	AC	0.25
17	Other land, cultivated, perennial crop	PC	0.25
19	Other land, fishpond	Fs	0.30
20	Other land, built-up area	BUA	0.50
21	Inland water	IW	0.80

Source: JICA Survey Team

3.4.3 Model Design

1) Model Area

Considering the very limited available data, area covering the maximum inundation area, which was analyzed in the Master Plan, and the river mouth are selected as the model area. The model area is therefore designed as the 82,000m x 62,000m of the rectangle area divided by 500 m mesh (Total: 165×125 = 20,625 meshes). Figure 3.4.10 and Table 3.4.9 show the model extent for the

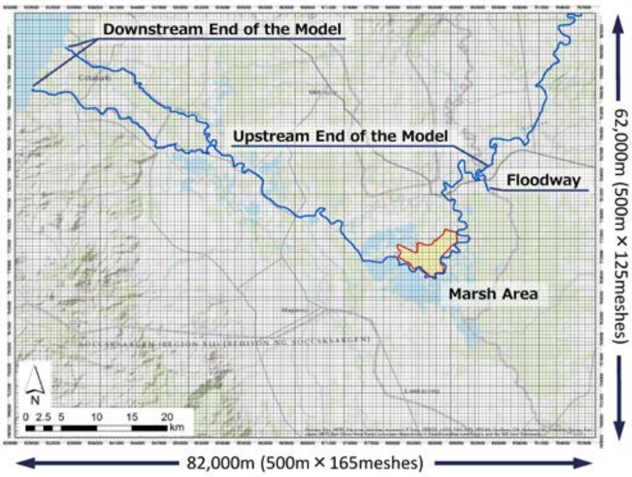


Figure 3.4.10 Model Area Selected in the Simulation
Source: JICA Survey Team

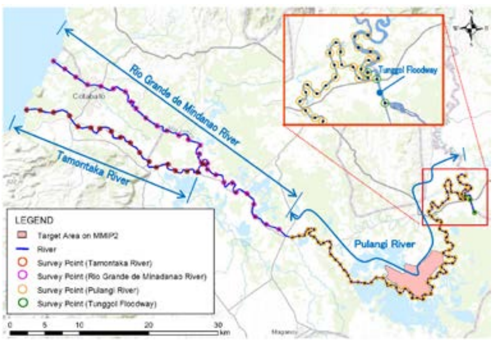
Table 3.4.9 Model Extent

Direction	Coordination (WGS84 UTM51N)			
	Minimum (m)	Maximum (m)	Mesh Size (m)	Total Mesh (nos)
X (E-W)	626,000	708,000	500	165
Y (N-S)	745,000	807,000	500	125

Source: JICA Survey Team

2) River Alignment and Cross Section

Though the model deals with the whole MRB, only the Pulangi, Rio Grande de Mindanao and Tamontaka rivers including the Tunggol floodway are considered in the model (see the blue lines in Figure 3.4.11). The alignment and cross sections of the rivers were surveyed from Nov. 2017 to Jan. 2018. The survey area and the cross sections with the interval 1.0 - 2.0 km are summarized below:



River	Number of the Cross Section
Pulangi	75
Tamontaka	18
Rio Grande de Mindanao	28
Tunggol Floodway	3
Total	124

Figure 3.4.11 Bathymetric Survey Area
Source: JICA Survey Team

3) River Alignment and Cross Section

Discharge volume at the upstream end of the model and at the confluences to the modeled rivers are calculated. According to the result of determination of the river alignment and basin boundaries (see “3.4.2 General Conditions of the Simulation, 2) River Alignments and Basin Boundaries”), 14 confluences to the modeled rivers are defined including the upstream end of the model and confluences to the Liguasan marsh (see Figure 3.4.12). Those 14 confluences are referred to as “input point”. The discharge volume of the input points is calculated by summing up the i) base flow and ii) flood discharge of the related sub-basins of all the 86 sub-basins. The procedures to determine the base flow and flood discharge in response to the rainfall amount at each input point is described below[11].

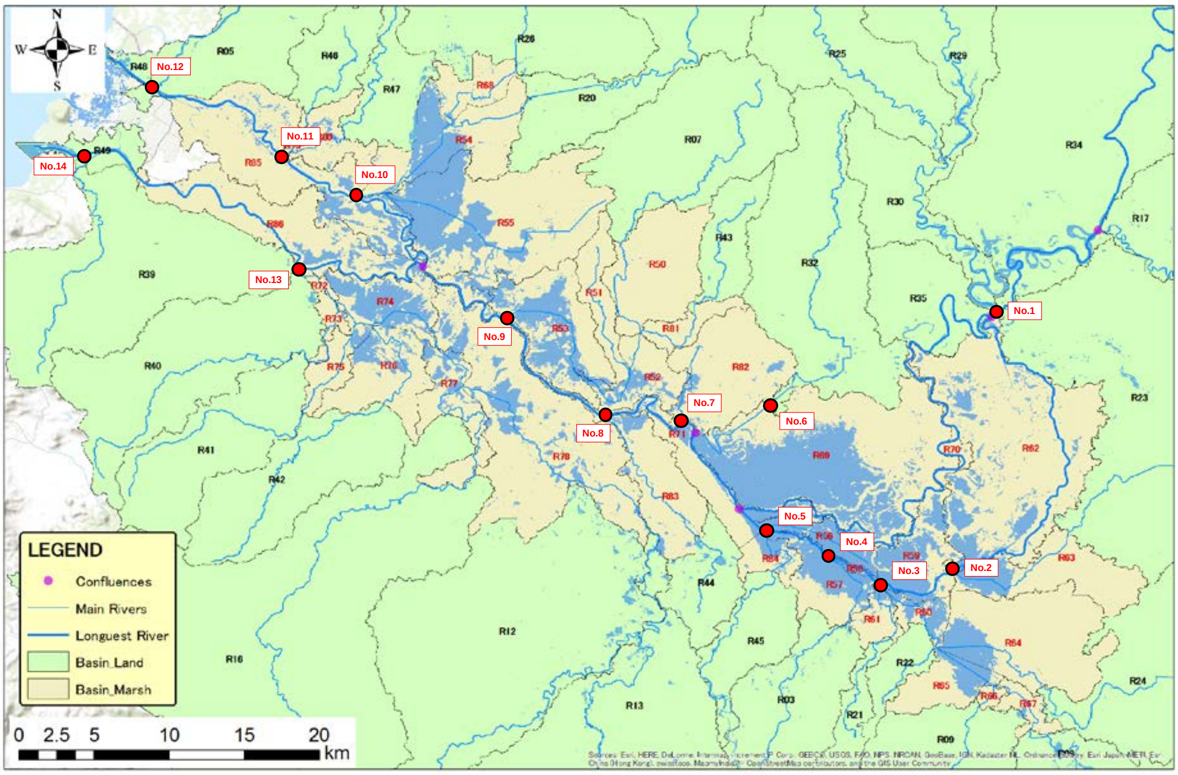


Figure 3.4.12 Discharge Input Points in the Simulation Model

Source: JICA Survey Team

i) Base Flow

✓ The water level at the time of base flow is assumed as EL.3.2m, which is based on the actual water level record at the end of the dry season in 1987 at Paidu Pulangi.

✓ Preliminary simulation without rainfall was conducted and 0.01485m^3/s/km^2 is estimated as the average specific discharge in the MRB, which results in the water level at Paidu Pulangi being EL. 3.2m.

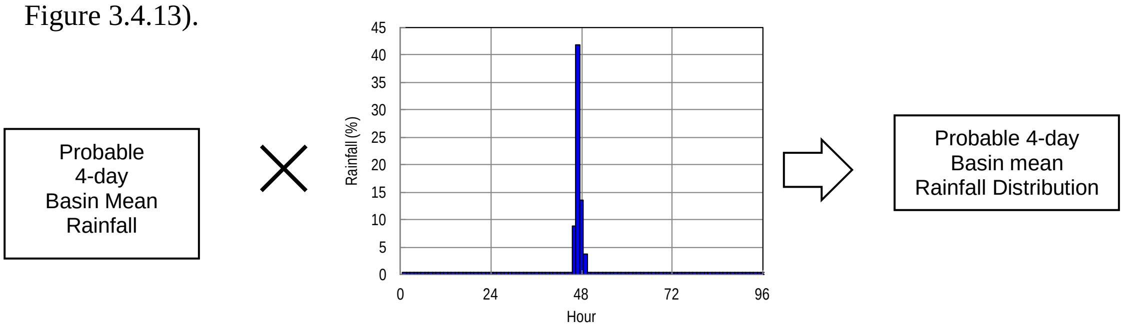
✓ Based on the average specific discharge, base flow discharge at each input point is determined considering each catchment area of the input points.

ii) Flood Discharge

✓ Probable 4-day basin mean rainfall amount in the MRB is calculated (see “3.4.2 General Conditions of the Simulation, 4) Rainfall”).

[11] Note that the discharge volume of the input point is calculated in response to the rainfall amount while the discharge sub-basins of the modeled rivers is directly calculated by the model, which means the rainfall parameter is given only on those sub-basins.

✓ Rainfall intensity (hourly rainfall distribution) is determined based on the center concentrated pattern which is the standard rainfall distribution for the MRB stated in the Master Plan (see Figure 3.4.13).



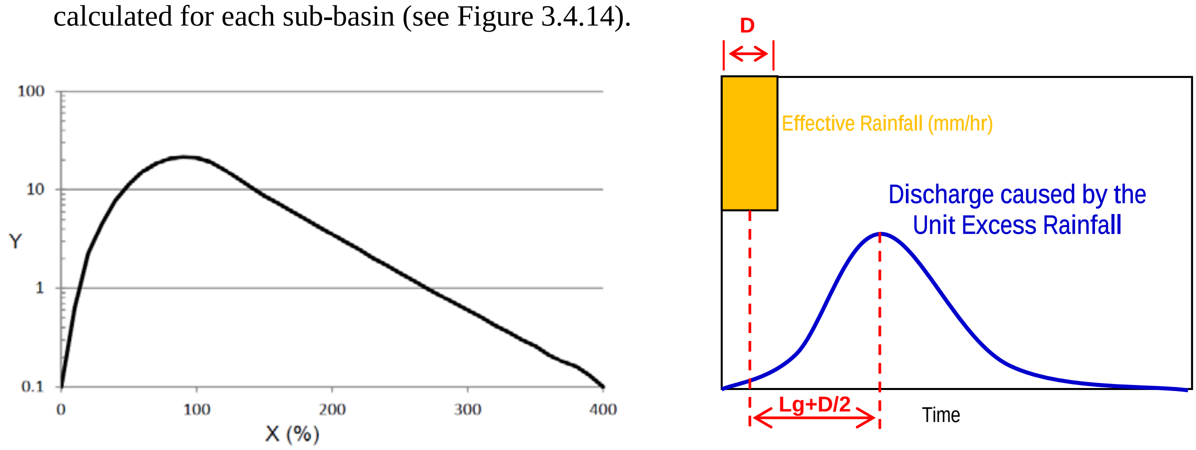
4 days rainfall distribution (%)
(*Hourly Rainfall Distribution)

Figure 3.4.13 Calculation Procedure of 4-Day Hourly Rainfall Distribution

Source: JICA Survey Team

✓ The effective rainfall to discharge is calculated by multiplying the runoff coefficient which is determined on "3.4.2 General Conditions of the Simulation, 6) Runoff Coefficient", which excludes the rainfall that becomes vapor or groundwater.

✓ Complying with the Master Plan, modified Snyder's Unit hydrograph method is applied to represent the time series discharge volume generated by unit effective rainfall. Basin lag time, the time from the beginning of the rainfall event to peak discharge at the outlet of the basin, was calculated for each sub-basin (see Figure 3.4.14).



X = % of (Lg+D/2)
$Lg=0.165(L \times Lca / S^{0.5})^{0.382}$

- Lg: Basin lag time (hr)
- L: Length of the longest river from the point of the interest to basin divide (km)
- Lca: Length of the river from the point of interest to the intersection of perpendicular from the centroid of the sub-basin to stream alignment (km)
- S: Overall slope of the longest river from the point of interest to basin divide
- D: Duration of unit excess rainfall (= 1hr)

Y = Q (Lg + D/2) / V

- Q: Discharge (m3/s)
- V: One day average excess rainfall volume (=Total excess rainfall volume within D / 24/ 60 /60)

Figure 3.4.14 Unit Hydro Graph for the Mindanao River Basin (MRB)

Source: JICA Survey Team

✓ Then, the times series data of the discharge volume in response to each hourly rainfall amount for each basin is calculated considering the river network and flow velocity on each sub-basin (see Figure 3.4.15). The flow velocity is calculated based on the Kraven Formula (see Table 3.4.10).

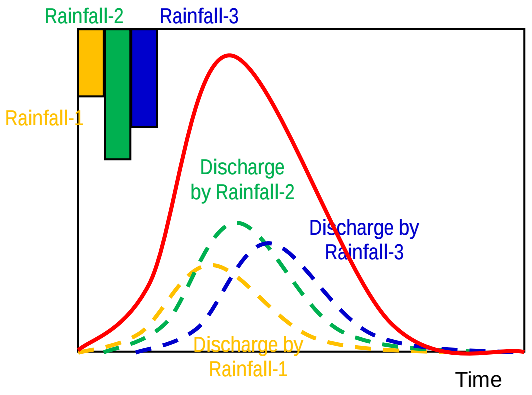


Figure 3.4.15 Image of the Superposition Method by each Unit Hydrograph
Source: JICA Survey Team

Table 3.4.10 Flood velocity by Kraven Formula

River bed slope	more than 1/100	1/100 - 1/200	less than 1/200
Flow Velocity (m/s)	3.5	3.0	2.1

Source: JICA Survey Team

iii) Time Series Discharge at an Input Point

A time series discharge at the input points is finally generated by accumulating the base flow and flood discharge from each sub-basin shown in Figure 3.4.16. Table 3.4.11 summarizes the sub-basin parameters for the 86 MRB sub-basins which characterize the flow time on the river and the lag time in response to the length of river, the shape of basin, and the river bed slope.

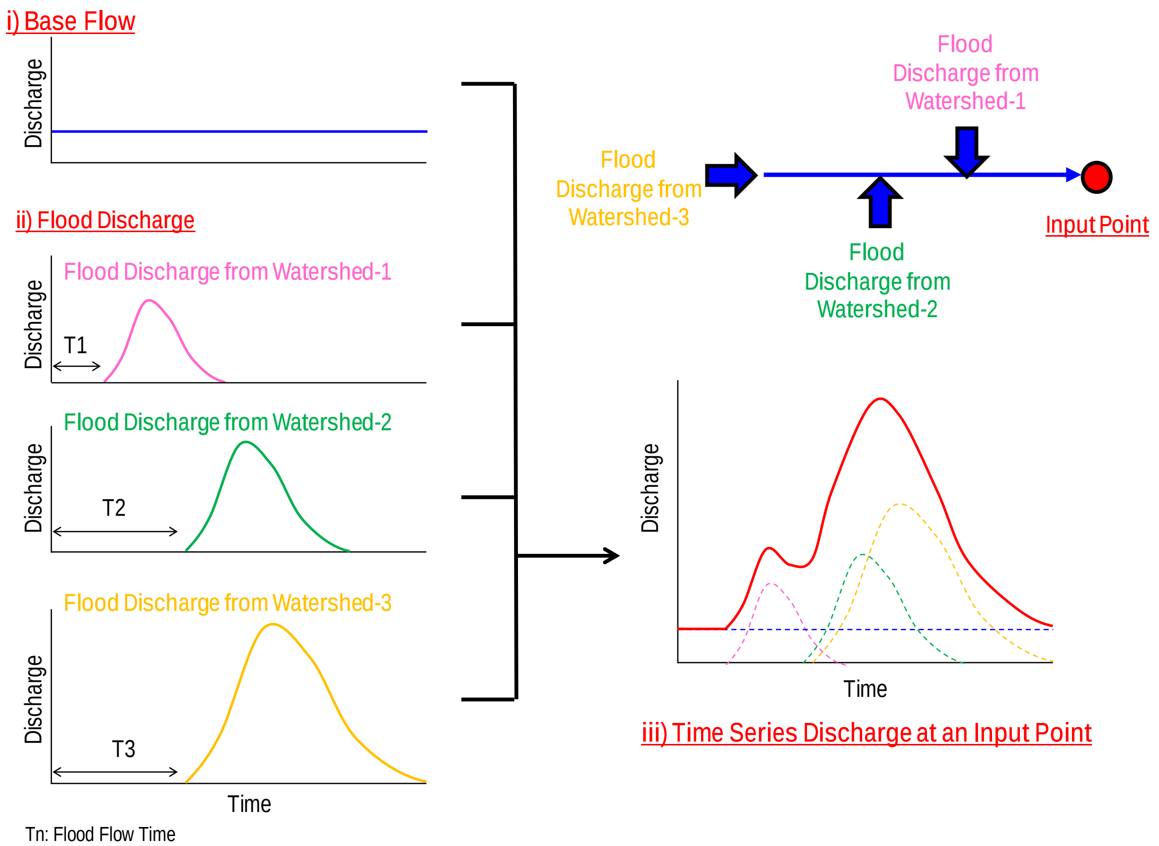


Figure 3.4.16 Image of Time Series Discharge at an Input Point
Source: JICA Survey Team

Table 3.4.11 Sub-basin Parameters

Basin_ID	BASIN	Subbasins	Area (km2)	River Length (km)	Elevation Start (EL.m)	Elevation End (EL.m)	Elevation Difference (m)	Slope Original (%)	Slope Modified*1 (%)	Lca (km)	Lg (hr)	Runoff Coefficient	Target Input Point	Flood Flow time*2 (hr)
R01	Pulangi	Ala_B01	570.3	64.4	1536.0	119.3	1,416.7	2.20	2.20	44.13	7.1	0.43	4	9.15
R02	Pulangi	Ala_B02	291.9	36.4	119.3	41.7	77.6	0.21	0.21	24.12	7.1	0.33	4	4.33
R03	Pulangi	Ala_B03	114.2	26.6	41.7	8.0	33.7	0.13	0.13	14.15	5.7	0.26	4	0.81
R04	Rio Grande	Ambal-Simuay_B01	585.4	54.9	1967.9	52.0	1,915.9	3.49	3.49	25.32	5.0	0.43	12	3.56
R05	Rio Grande	Ambal-Simuay_B02	107.0	26.9	52.0	1.0	51.0	0.19	0.19	14.66	5.4	0.29	12	0.00
R06	Pulangi	Banca_B01	679.5	93.3	1047.7	42.0	1,005.7	1.08	1.08	51.56	10.0	0.30	4	5.09
R07	Pulangi	Bulanan_B01	105.1	23.9	75.2	8.3	66.9	0.28	0.28	13.23	4.6	0.26	9	3.61
R08	Pulangi	Buluan_B01	1897.8	96.7	622.1	8.2	613.9	0.63	0.63	50.49	11.1	0.38	3	2.46
R09	Pulangi	Buluan_B02	230.3	41.2	91.7	6.4	85.3	0.21	0.21	17.18	6.6	0.27	3	1.95
R10	Tamontaka	Cabilanan_B01	704.7	98.3	1306.2	300.4	1,005.8	1.02	1.02	50.21	10.2	0.44	13	13.62
R11	Tamontaka	Cabilanan_B02	420.7	67.7	1201.7	300.4	901.3	1.33	1.33	42.41	7.9	0.45	13	13.62
R12	Tamontaka	Cabilanan_B03	330.9	52.3	300.4	13.0	287.4	0.55	0.55	21.66	6.5	0.32	13	6.71
R13	Tamontaka	Cabilanan_B04	517.1	79.9	675.8	7.7	668.1	0.84	0.84	45.49	9.4	0.31	13	4.99
R14	Pulangi	Calabugao_B01	1050.0	138.7	1455.5	302.0	1,153.5	0.83	0.83	83.43	14.7	0.41	1	23.58
R15	Pulangi	Calabugao_B02	321.9	39.9	1080.4	352.2	728.2	1.83	1.83	13.82	4.0	0.47	1	27.63
R16	Tamontaka	Dalika_B01	433.6	54.8	499.8	8.3	491.5	0.90	0.90	27.05	6.6	0.35	13	4.22
R17	Pulangi	Kabacan_B01	925.9	84.7	1912.6	17.5	1,895.1	2.24	2.24	47.98	8.2	0.32	1	2.07
R18	Pulangi	Kapingkong_B01	195.1	47.3	1411.0	119.3	1,291.7	2.73	2.73	26.55	5.0	0.42	4	9.15
R19	Pulangi	Kapingkong_B02	198.8	32.0	932.9	159.5	773.4	2.42	2.42	15.59	3.6	0.48	4	10.35
R20	Rio Grande	Libungan_B01	574.5	84.0	1991.8	7.8	1,984.0	2.36	2.36	46.21	7.9	0.35	10	2.00
R21	Pulangi	Liguasan_B01	22.5	11.4	18.3	8.0	10.3	0.09	0.09	10.15	3.9	0.25	3	0.66
R22	Pulangi	Liguasan_B02	16.2	7.3	14.4	6.8	7.6	0.10	0.10	4.00	2.2	0.26	3	1.08
R23	Pulangi	M'lang_B01	457.3	51.7	389.7	7.9	381.8	0.74	0.74	23.47	6.4	0.36	2	1.40
R24	Pulangi	M'lang_B02	709.9	73.4	1074.2	7.9	1,066.3	1.45	1.45	46.02	8.2	0.34	3	2.42
R25	Pulangi	Malitubog_B01	597.3	100.5	1484.8	19.5	1,465.3	1.46	1.46	57.26	10.1	0.37	1	3.13
R26	Rio Grande	Manuangan_B01	199.0	18.8	306.4	7.4	299.0	1.59	1.59	7.35	2.4	0.37	10	2.37
R27	Pulangi	Manupali_B01	487.4	67.6	2123.3	302.0	1,821.3	2.69	2.69	31.03	6.1	0.37	1	23.58
R28	Pulangi	Manupali_B02	519.9	54.3	1878.1	310.8	1,567.3	2.88	2.88	29.33	5.4	0.39	1	24.17
R29	Pulangi	Maridagao_B01	1438.2	151.1	1244.2	19.5	1,224.7	0.81	0.81	98.63	16.3	0.32	1	3.13
R30	Pulangi	Maridagao_B02	54.9	23.7	19.5	13.5	6.0	0.03	0.03	17.58	8.0	0.37	1	0.00
R31	Pulangi	Muleta_B01	1050.4	128.3	2175.8	27.5	2,148.3	1.67	1.67	53.46	10.5	0.30	1	5.72
R32	Pulangi	Panulapan_B01	140.1	34.4	78.0	6.0	72.0	0.21	0.21	16.62	6.1	0.30	6	0.00
R33	Pulangi	Pulangi_B01	1680.2	135.1	302.0	27.5	274.5	0.20	0.20	87.12	19.3	0.38	1	5.72
R34	Pulangi	Pulangi_B02	329.9	43.2	27.5	13.5	14.0	0.03	0.03	25.92	11.2	0.26	1	0.00
R35	Pulangi	Pulangi_B03	46.7	14.3	13.5	9.5	4.0	0.03	0.03	5.71	4.2	0.35	99	-
R36	Pulangi	Pulangi_B04	376.0	69.4	1178.6	50.9	1,127.7	1.62	1.62	57.29	8.6	0.53	1	10.55
R37	Pulangi	Pulangi_B05	177.8	39.2	1253.2	94.0	1,159.2	2.95	2.95	21.09	4.2	0.46	1	12.67
R38	Pulangi	Pulangi_B06	329.0	62.9	874.6	33.0	841.6	1.34	1.34	27.47	6.5	0.29	1	7.59
R39	Tamontaka	Residual_B01	165.3	22.8	530.4	1.0	529.4	2.32	2.32	10.98	2.8	0.34		0.00
R40	Tamontaka	Residual_B02	118.6	27.0	564.7	7.8	556.9	2.06	2.06	13.87	3.3	0.33	13	1.33
R41	Tamontaka	Residual_B03	76.6	19.7	675.4	6.7	668.7	3.40	3.40	11.30	2.5	0.35	13	1.88
R42	Tamontaka	Residual_B04	81.1	22.7	257.5	2.8	254.7	1.12	1.12	13.24	3.4	0.33	13	2.19
R43	Pulangi	Residual_B05	27.8	14.0	37.8	5.2	32.6	0.23	0.23	8.55	3.3	0.25	9	3.20
R44	Pulangi	Residual_B06	30.1	8.2	11.8	7.4	4.4	0.05	0.05	5.25	2.9	0.29	8	1.60
R45	Pulangi	Residual_B07	37.5	15.7	21.5	7.2	14.3	0.09	0.09	7.62	3.9	0.26	5	0.74
R46	Rio Grande	Residual_B08	30.9	9.8	28.4	4.5	23.9	0.24	0.24	5.76	2.4	0.25	11	2.61
R47	Rio Grande	Residual_B09	35.9	15.9	54.4	3.2	51.2	0.32	0.32	8.30	3.2	0.31	11	0.76
R48	Rio Grande	Rio Grande_B01	7.6	5.4	1.0	0.0	1.0	0.02	0.02	2.55	2.3	0.33	99	-
R49	Tamontaka	Tamontaka_B01	14.1	8.2	1.0	0.0	1.0	0.01	0.01	4.71	3.7	0.41	99	-
R50	Pulangi	Bulanan_M01	43.8	9.3	8.3	5.1	3.2	0.03	0.03	7.23	3.8	0.45	9	2.37
R51	Pulangi	Bulanan_M02	17.7	12.0	8.2	4.1	4.1	0.03	0.03	6.97	4.1	0.42	9	1.92
R52	Pulangi	Bulanan_M03	18.9	9.6	5.1	4.5	0.6	0.01	0.01	6.33	4.6	0.44	9	1.11
R53	Pulangi	Bulanan_M04	43.2	8.4	4.5	4.0	0.5	0.01	0.01	4.29	3.8	0.29	9	0.00
R54	RioGrande	Libungan_M01	41.8	15.1	7.8	3.0	4.8	0.03	0.03	7.85	4.8	0.69	10	0.00
R55	Rio Grande	Libungan_M02	91.6	18.0	13.1	3.5	9.6	0.05	0.05	11.79	5.4	0.59	10	0.28
R56	RioGrande_Marsh	Liguasan_M01	11.5	7.8	7.8	6.4	1.4	0.02	0.02	4.73	3.4	0.79	5	0.00
R57	Plangi	Liguasan_M02	22.0	13.6	8.0	6.4	1.6	0.01	0.01	8.35	5.7	0.54	99	-
R58	Pulangi	Liguasan_M03	1.5	4.4	6.8	6.8	0.0	0.00	0.01	2.09	2.2	0.79	99	-
R59	RioGrande_Marsh	Liguasan_M04	25.5	6.0	7.4	6.8	0.6	0.01	0.01	4.96	3.5	0.75	99	-
R60	Pulangi	Liguasan_M05	8.5	8.2	6.8	6.8	0.0	0.00	0.01	3.89	3.6	0.67	3	0.00
R61	Pulangi	Liguasan_M06	8.7	5.0	8.0	6.8	1.2	0.02	0.02	3.20	2.3	0.28	3	0.00
R62	Pulangi	Liguasan_M07	125.4	27.8	13.5	7.4	6.1	0.02	0.02	15.63	8.4	0.72	99	-
R63	Pulangi	Liguasan_M08	35.9	10.6	7.9	7.4	0.5	0.00	0.01	7.75	5.2	0.80	2	0.00
R64	Pulangi	Liguasan_M09	62.3	10.1	7.9	6.8	1.1	0.01	0.01	5.25	4.3	0.80	3	1.08
R65	Pulangi	Liguasan_M10	18.1	4.6	6.8	6.8	0.0	0.00	0.01	1.80	2.1	0.48	3	1.08
R66	Pulangi	Liguasan_M11	2.4	1.9	6.4	6.8	-0.4	(0.02)	0.01	0.88	1.2	0.80	3	1.69
R67	Pulangi	Liguasan_M12	8.2	5.8	8.2	6.8	1.4	0.02	0.02	3.59	2.6	0.73	3	1.69
R68	RioGrande	Manuangan_M01	14.8	8.8	7.4	3.5	3.9	0.04	0.04	3.79	2.8	0.65	10	1.20
R69	Pulangi	Panulapan_M01	118.9	8.0	6.0	6.0	0.0	0.00	0.01	7.95	4.7	0.56	99	-
R70	Pulangi	Pulangi_M01	16.6	39.8	9.5	6.4	3.1	0.01	0.01	18.43	11.9	0.55	99	-
R71	Pulangi	Pulangi_M02	30.4	36.2	6.4	3.4	3.0	0.01	0.01	21.84	12.3	0.54	99	-
R72	Tamontaka	Residual_M01	2.1	3.9	2.6	2.6	0.0	0.00	0.01	2.16	2.2	0.80	13	0.00
R73	Tamontaka	Residual_M02	5.3	6.1	7.8	2.6	5.2	0.09	0.09	2.08	1.7	0.74	13	0.52
R74	Tamontaka	Residual_M03	24.3	8.2	2.7	2.6	0.1	0.00	0.01	5.27	4.0	0.71	13	0.52
R75	Tamontaka	Residual_M04	11.8	8.1	6.7	2.7	4.0	0.05	0.05	3.41	2.5	0.57	13	0.81
R76	Tamontaka	Residual_M05	31.2	9.3	2.8	2.7	0.1	0.00	0.01	7.68	4.9	0.69	13	0.96
R77	Tamontaka	Residual_M06	24.5	19.7	8.3	2.7	5.6	0.03	0.03	9.29	5.7	0.64	13	1.61
R78	Tamontaka	Residual_M07	108.5	19.8	7.7	3.1	4.6	0.02	0.02	6.88	5.3	0.46	13	2.37
R79	Rio Grande	Residual_M08	2.0	3.7	4.5	1.1	3.4	0.09	0.09	1.74	1.3	0.25	11	0.00
R80	Rio Grande	Residual_M09	16.0	5.1	3.2	2.2	1.0	0.02	0.02	3.80	2.6	0.25	11	0.09
R81	Pulangi	Residual_M10	10.2	6.2	5.2	5.1	0.1	0.00	0.01	5.57	3.7	0.54	9	2.37
R82	Pulangi	Residual_M11	46.5	6.0	5.5	5.4	0.1	0.00	0.01	4.16	3.3	0.31	7	0.00
R83	Pulangi	Residual_M12	32.9	12.1	7.4	4.8	2.6	0.02	0.02	7.17	4.6	0.32	8	0.00
R84	Pulangi	Residual_M13	9.6	5.6	7.2	6.4	0.8	0.01	0.01	1.92	2.2	0.47	5	0.00
R85	Rio Grande	Rio Grande_M01	73.8	28.1	3.4	1.0	2.4	0.01	0.01	11.21	8.6	0.38	99	-
R86	Tamontaka	Tamontaka M01	53.0	27.8	3.4	1.0	2.4	0.01	0.01	12.55	9.0	0.48	99	-

*1: In case difference of the elevation is 0 or negative, 1/10,000 is adopted to river slope.
*2: "-" means the watersheds which outflow flows into the modeled rivers directly.

Source: JICA Survey Team

3.4.4 Simulation Theory

To represent both the flow on the river and on the flood plain, the integrated model of one and two-dimensional model is selected. The governing equations are shown as below and the simulation is executed with software namely "MIKE Series", which is produced by DHI, a Danish company, which is widely used all over the world.

1) Fundamental Equation for One (1) Dimension Model (for River Flow)

a) Continuity equation

$$\frac{\partial Q}{\partial x}+\frac{\partial A}{\partial t}=q$$

b) Motion equation

$$\frac{\partial Q}{\partial t}+\frac{\partial\left(\alpha\frac{Q^2}{A}\right)}{\partial t}+gA\frac{\partial h}{\partial t}+\frac{gQ|Q|}{C^2AR}=0$$

Where;

Q:	Discharge (m^3/s)
A:	Cross-section area of flow (m^2)
q:	Lateral inflow (m^3/s) *This values show outflow volume from river to flood plain or inflow volume from flood plain to river
t:	time (s)
α:	Coefficient for momentum distribution
g:	Acceleration of gravity (m/s^2)
h:	Water depth (m)
C:	Chezy resistance ($m^{0.5}/s$)
R:	Wetted perimeter (m)

2) Fundamental Equation for Two (2) Dimension Model (for Flood Plain)

a) Continuity equation

$$\frac{\partial\varsigma}{\partial t}+\frac{\partial p}{\partial x}+\frac{\partial q}{\partial y}=\frac{\partial d}{\partial t}$$

b) Motion equation

X direction

$$\frac{\partial p}{\partial t}+\frac{\partial}{\partial x}\left(\frac{p^2}{h}\right)+\frac{\partial}{\partial y}\left(\frac{pq}{h}\right)+gh\frac{\partial\varsigma}{\partial x}+$$
$$+\frac{gp\sqrt{p^2+q^2}}{C^2h^2}-\frac{1}{p_w}\left[\frac{\partial}{\partial x}(h\tau_{xx})+\frac{\partial}{\partial y}(h\tau_{xy})\right]-\Omega q+\Omega p$$
$$-fVV_x-\frac{h}{p_w}\frac{\partial}{\partial x}(p_a)=0$$

Y direction

$$\frac{\partial q}{\partial t}+\frac{\partial}{\partial y}\left(\frac{q^2}{h}\right)+\frac{\partial}{\partial x}\left(\frac{pq}{h}\right)+gh\frac{\partial\varsigma}{\partial y}+$$
$$+\frac{gp\sqrt{p^2+q^2}}{C^2h^2}-\frac{1}{p_w}\left[\frac{\partial}{\partial y}(h\tau_{yy})+\frac{\partial}{\partial x}(h\tau_{xy})\right]+\Omega p$$
$$-fVV_y-\frac{h}{p_w}\frac{\partial}{\partial y}(p_a)=0$$

Where;

h(x,y,t)	Water depth (=ζ-d, m)
d(x,y,t)	Time varying water depth (m)
ζ	Surface Elevation (m)
p,q(x.y,t)	flux densities in x- and y-directions (m3/s/m) = (uh, vh); (u,v)= depth averaged velocities in x- and y-directions
C(x,y)	Chezy resistance ($m^{1/2}/s$)
g	Acceleration due to gravity (m/s^2)
f(V)	wind friction factor
V,Vx,V(x,y,t)	Wind speed and components in x- and y-direction (m/s)
Ω(x,y)	Coriolis parameter, latitude dependent (s^{-1})
p_a(x,y,t)	Atmospheric pressure (kg/m/s2)
p_w	Density of water (kg/m3)
x,y	space coordinates (m)
t	time(s)
τxx, τxy,τyy	Components of effective shear stress

3.5 Flood Simulation with/without Dike

The dike would have a significant impact on the beneficially area in LMSA, while it cause some adverse effects. Since total flood volume is not changed by the dike construction, the overflowed discharge to the Liguasan marsh will be increased due to smaller flow area upon construction of the dyke (see Figure 3.5.1). The flood simulation with/without dike is conducted to assess such impact focusing on the change of water level of the Liguasan marsh and the Pulangi river, and change in inundation area of the Liguasan marsh between with and without the dike.

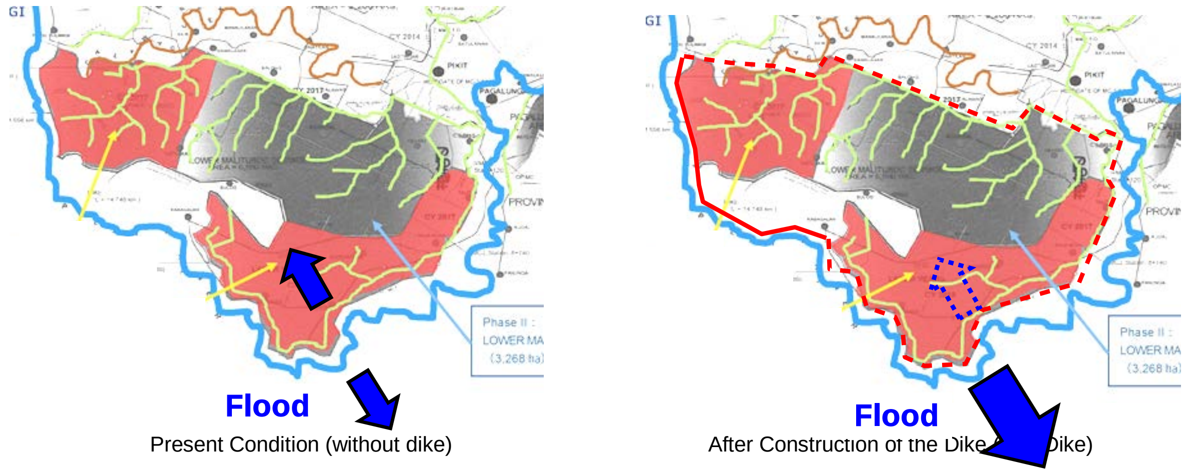


Figure 3.5.1 Image of Flood Condition With/Without Dike

Source: JICA Survey Team

3.5.1 Specific Conditions for Flood Simulation with/without Dike

1) Simulation Cases

Return periods of the 4-day mean rainfall of the catchments area are 2, 10, 20, 30, 50 and 100 years, and those are applied into the both two cases (with and without dike). In total, the simulation is executed in 12 cases (see Table 3.5.1).

Table 3.5.1 Simulation Cases for With/Without Dike

Simulation Case \ Probability	Return Period					
	2	10	20	30	50	100
1. Present Condition (without dike)	○	○	○	○	○	○
2. After Construction of the Dike (With Dike)	○	○	○	○	○	○

Source: JICA Survey Team

2) Simulation Period

The simulation period for one flood event is set at 480 hours considering the flood retardant time. In addition to the simulation period, 240 hours for warm-up time is prepared to make the model steady[1] to run.

3) Dike

The dike is placed along the right bank of the Pulangi river encompassing the LMSA. The height of the dike is set to be enough tall to avoid any flood water from the Pulangi river to come into the LMSA.

[1] Initial condition of the water level and discharge is determined by the preliminary simulation, and the initial surface water area is determined by the simulation of 2-year return period.

3.5.2 Simulation Result-1 (Inundation Area)

Assuming the red solid line area in Figure 3.5.2 as the Liguasan marsh, maximum inundation area by each return period is calculated. Table 3.5.2 shows the comparison of maximum inundation area between (1) Present condition (without dike) and (2) After construction of the dike (with dike). The results indicate the inundation area is increased by at least 19% in case of 2-year return period rainfall after construction of the dike, and is increased by as much as 34% in case of 100-year return period, which is the design return period for the flood control structure according to the DPWH standard.

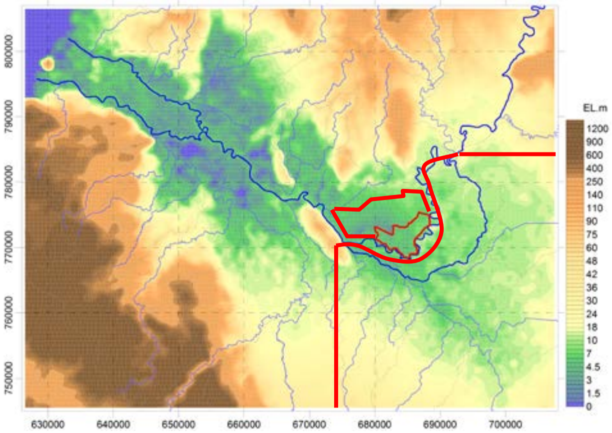


Figure 3.5.2 Area of the Liguasan Marsh

Source: JICA Survey Team

Table 3.5.2 Maximum Inundation area in the Liguasan Marsh

Return Period (year)	Inundation Area (km^2)		(3)Increase ratio (=(2)/(1))
	(1) Present Condition (without Dike)	(2) After Construction of the Dike	
2	181	215	1.19
10	204	244	1.20
20	214	265	1.24
30	220	275	1.25
50	229	299	1.31
100	241	323	1.34

Source: JICA Survey Team

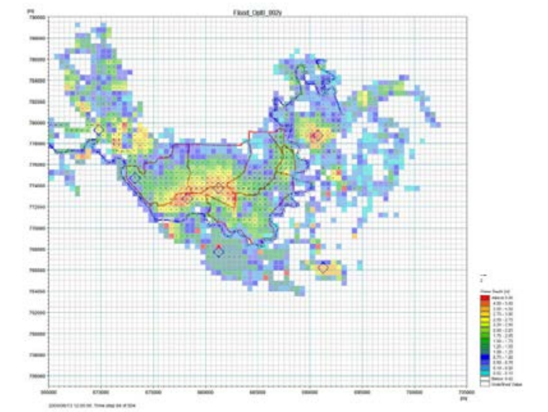
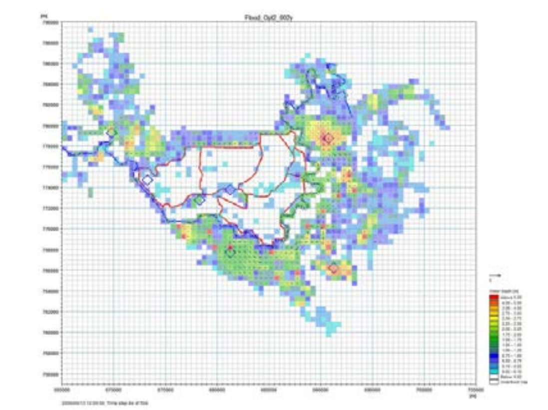
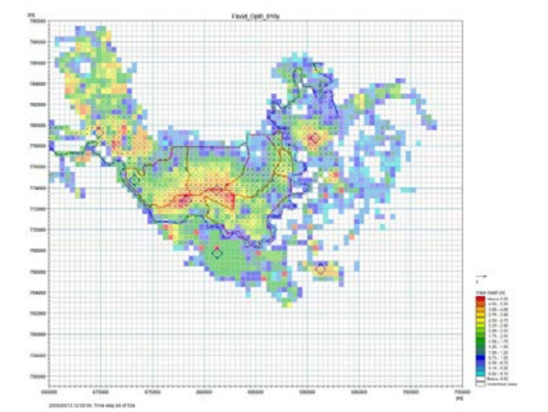
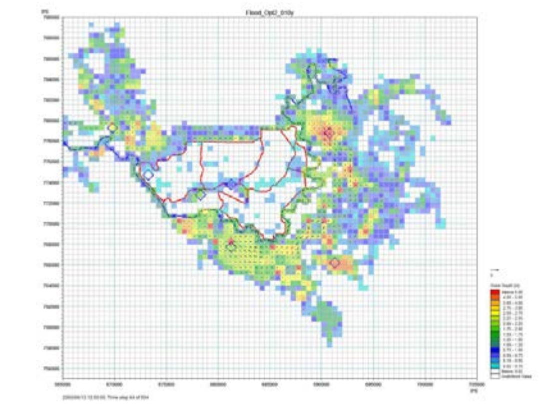
Return Period	Present Condition (without Dike)	After Construction of the Dike (with Dike)
2 year	 Maximum Inundation area in the Liguasan Marsh: 181 km^2	 Maximum Inundation area in the Liguasan Marsh: 215 km^2
10 year	 Maximum Inundation area in the Liguasan Marsh: 214 km^2	 Maximum Inundation area in the Liguasan Marsh: 244 km^2

Figure 3.5.3 Simulation Results (Maximum Inundation Area) (1/2)

Source: JICA Survey Team

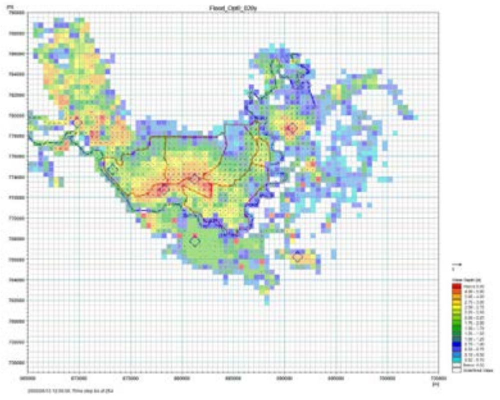
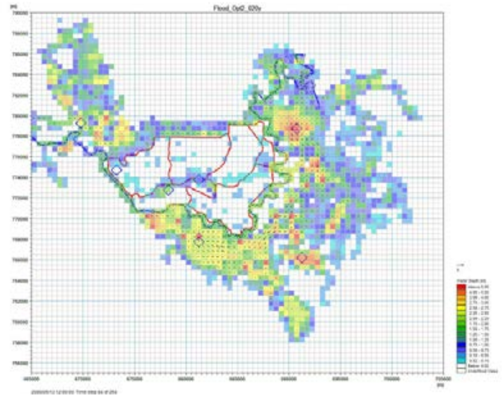
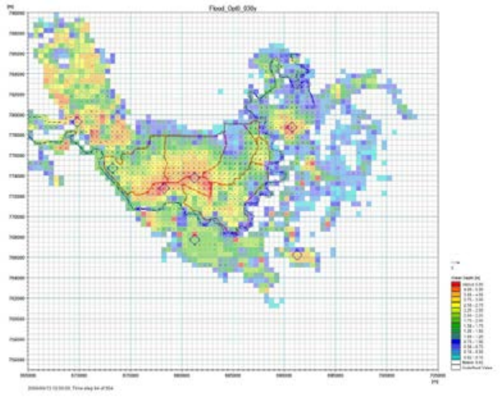
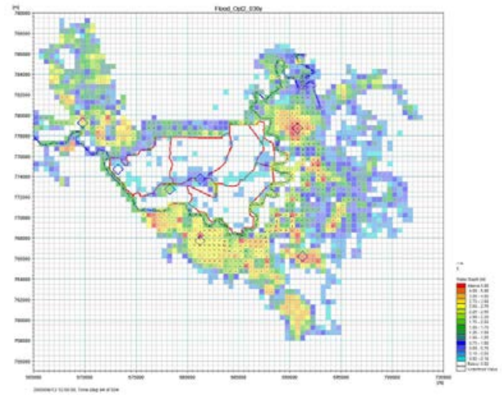
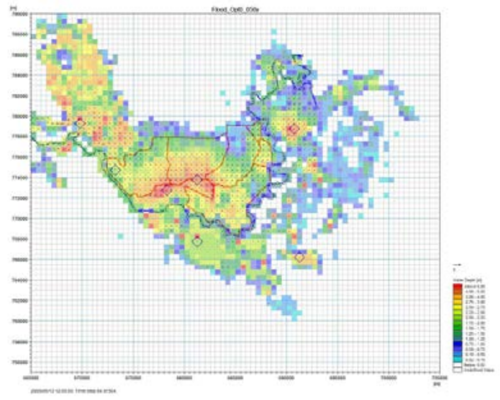
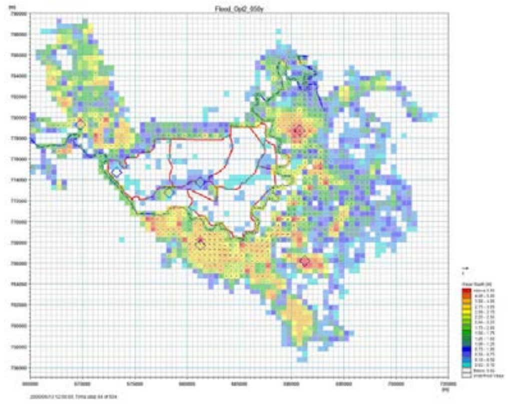
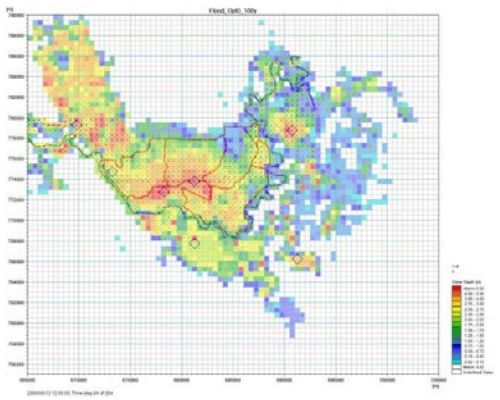
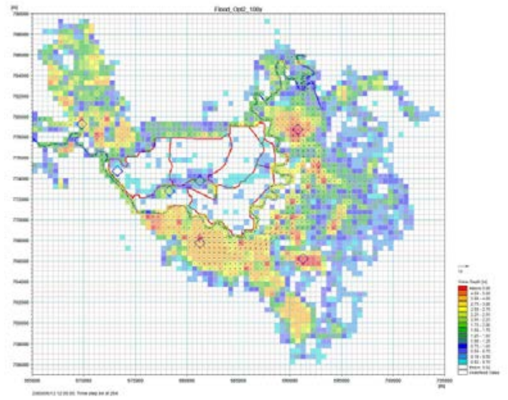
Return Period	Present Condition (without Dike)	After Construction of the Dike (with Dike)
20 year	 Maximum Inundation area in the Liguasan Marsh: 214 km^2	 Maximum Inundation area in the Liguasan Marsh: 265 km^2
30 year	 Maximum Inundation area in the Liguasan Marsh: 220 km^2	 Maximum Inundation area in the Liguasan Marsh: 275 km^2
50 year	 Maximum Inundation area in the Liguasan Marsh: 229 km^2	 Maximum Inundation area in the Liguasan Marsh: 299 km^2
100 year	 Maximum Inundation area in the Liguasan Marsh: 241 km^2	 Maximum Inundation area in the Liguasan Marsh: 323 km^2

Figure 3.5.3 Simulation Results (Maximum Inundation Area) (2/2)

Source: JICA Survey Team

3.5.3 Simulation Result-2 (Flood Water Level)

As an indicator of the water level in the Liguasan marsh, the point "Marsh 2" is selected for the evaluation purpose (see Figure 3.5.4). Table 3.5.3 shows the maximum flood water level at Marsh 2 during the flood event at each of the return periods. The results indicate the maximum flood water level at the Marsh 2 rises by 65 to 81cm because of the dike, which means more river water overflows to the left bank of the Pulangi river and is stored in the Liguasan marsh.

Figure 3.5.4 Location of "Marsh 2" Point
Source: JICA Survey Team

Table 3.5.3 Maximum Flood Water Level at "Marsh 2" Point

Return Period (year)	Maximum Flood Water Level (EL.m) (1) Present Condition (without Dike)	(2) After Constructon of the Dike	(3) Difference (=(2)-(1)) (m)
2	7.23	8.02	0.79
10	7.62	8.42	0.80
20	7.85	8.50	0.65
30	8.02	8.70	0.68
50	8.21	9.02	0.81
100	8.49	9.29	0.80

Source: JICA Survey Team

Meanwhile, maximum water level of the Pulangi river at "Paidu Pulangi" (see Figure 3.5.5) shows an opposite trend due to the impact of the dike. Table 3.5.4 compares the maximum water level at this point with and without the dike, which indicates the maximum water level after the construction of the dike becomes lower (-13 to -70cm) than the one under the present condition. This phenomenon is caused by the change of the flood path due to the dike construction as below and shown in Figure 3.5.6.

- ✓ Under the present condition, flood water from the upstream flows to the LMSA and the Liguasan marsh, and concentrates at the bottleneck point formed by the residual hills (bottleneck point-1). Considering the topographic condition, the bottleneck point-1 has relatively smaller discharge capacity, so that the inundation area spreads from the bottleneck point-1 to the upstream area.
- ✓ After the construction of the dike, the flood water diverges at the north-east edge of the dike, mostly toward the south (to the Liguasan marsh) and partly toward the west (to the north of the LMSA). It is because that the flood water flows along the limited paths, the discharge volume to the south becomes larger compared to that under the condition without dike. Then, another bottleneck point is formed between the residual hill and the dike (bottleneck point-2), so that larger volume of flood water concentrates at the bottleneck point-2, and inundation area spreads from this point. Since the point-1, Paidu Pulangi, is located at the downstream side of the bottleneck point-2, the discharge volume at this point becomes smaller due to the storage effect at bottleneck point-2.

Figure 3.5.5 Location of "Paidu Pulangi" Point
Source: JICA Survey Team

Table 3.5.4 Maximum Water Level at "Paidu Pulangi" Point

Return Period (year)	Maximum Flood Water Level (EL.m) (1) Present Condition (without Dike)	(2) After Constructon of the Dike	(3) Difference (=(2)-(1)) (m)
2	6.93	6.80	-0.13
10	7.42	7.00	-0.42
20	7.65	7.13	-0.52
30	7.80	7.25	-0.55
50	8.00	7.43	-0.57
100	8.28	7.58	-0.70

Source: JICA Survey Team

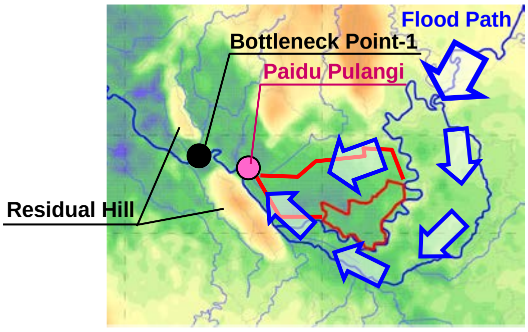
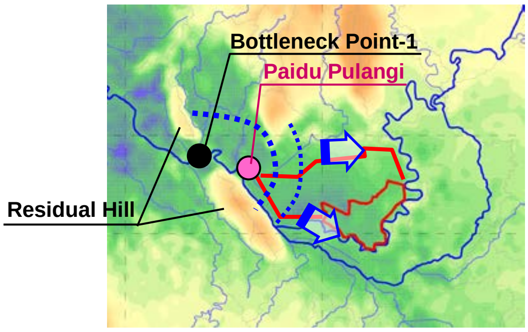
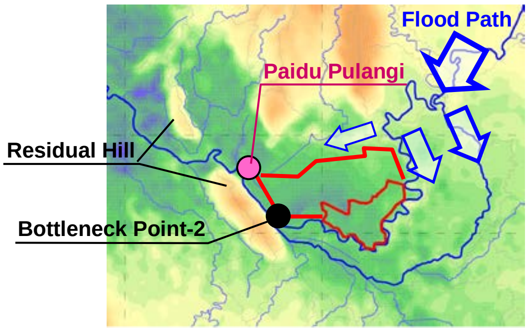
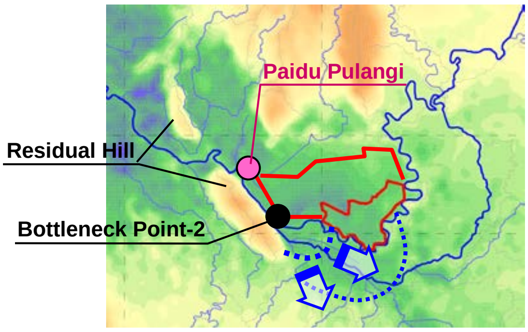
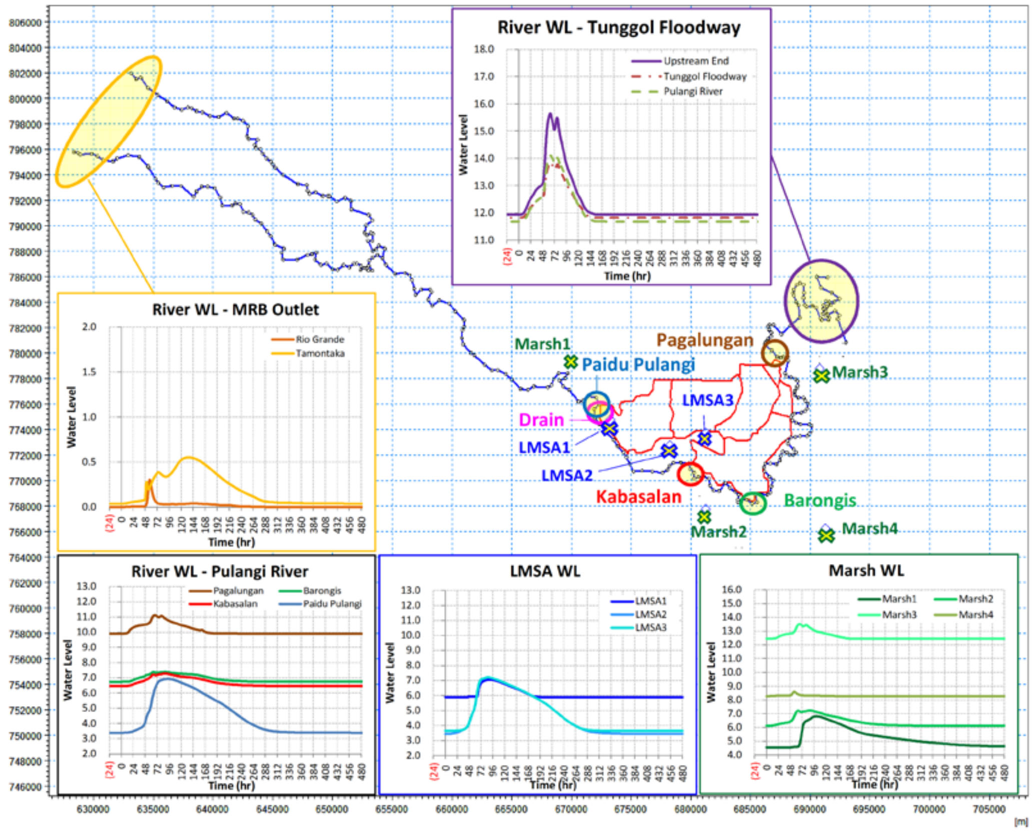
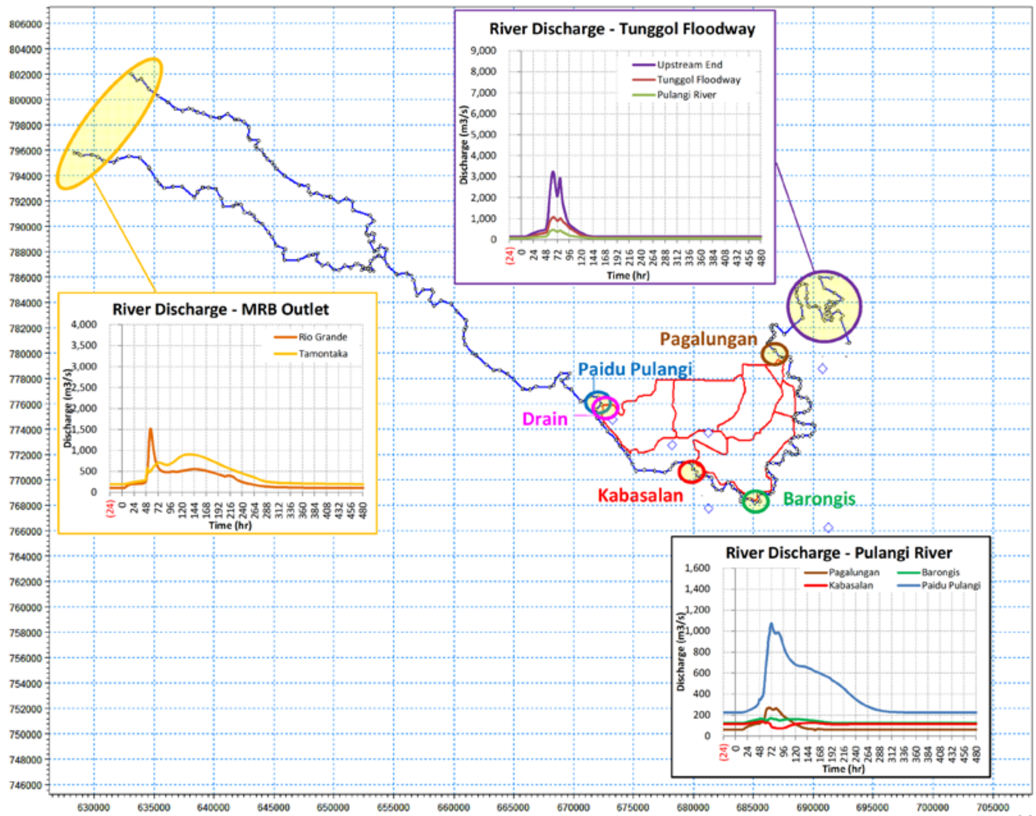
Flood Path	Area of the storage effects
1) Flood Path under present condition  Flood water flows on the LMSA.	 Inundation area spreads from Bottleneck Point-1.
2) Flood Path after Construction of the Dike  Flood water is diverged by the Dike.	 Inundation area spreads from Bottleneck Point-2.

Figure 3.5.6 Comparison of the Flood Path between with/without the Dike
Source: JICA Survey Team

Change of water level and discharge at each point for 2-year to 100-year return period is summarized in Figures 3.5.7 to 3.5.18, showing that water level at Paidu Pulangi keeps longer peak water level after the dike construction compared to that of the present condition.



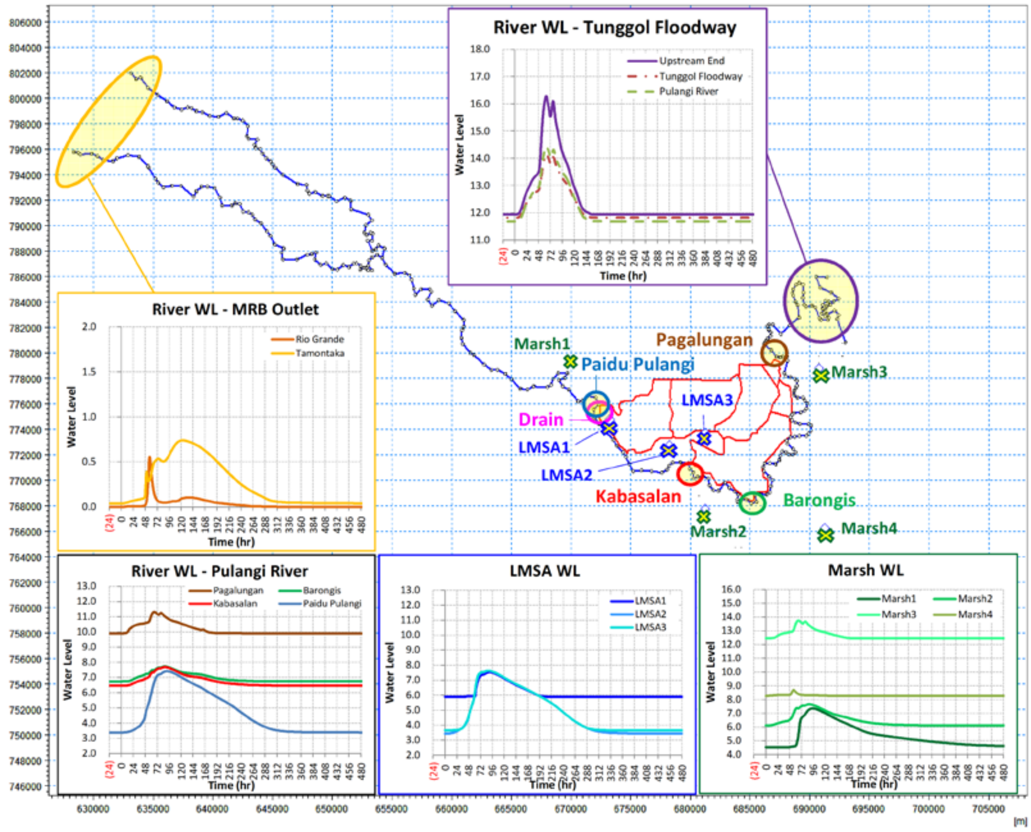
Flood Water Level



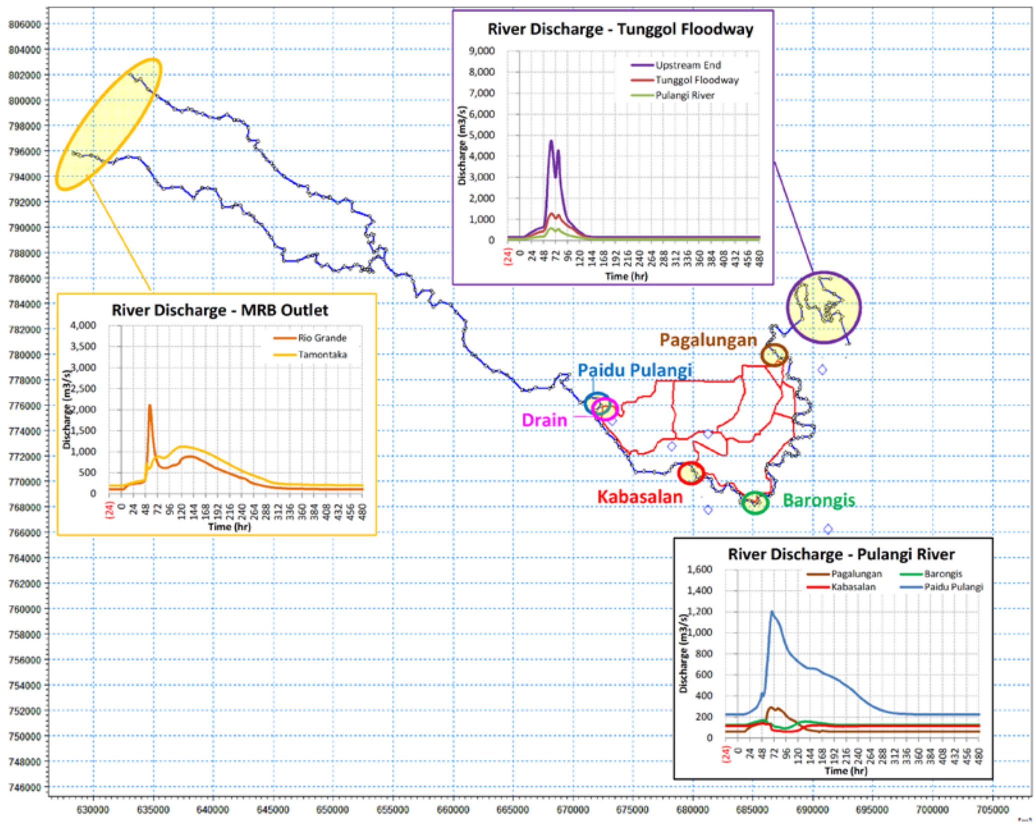
River Discharge

Figure 3.5.7 Flood Water Level and River Discharge (Present Condition) (Return Period: 2 year)

Source: JICA Survey Team



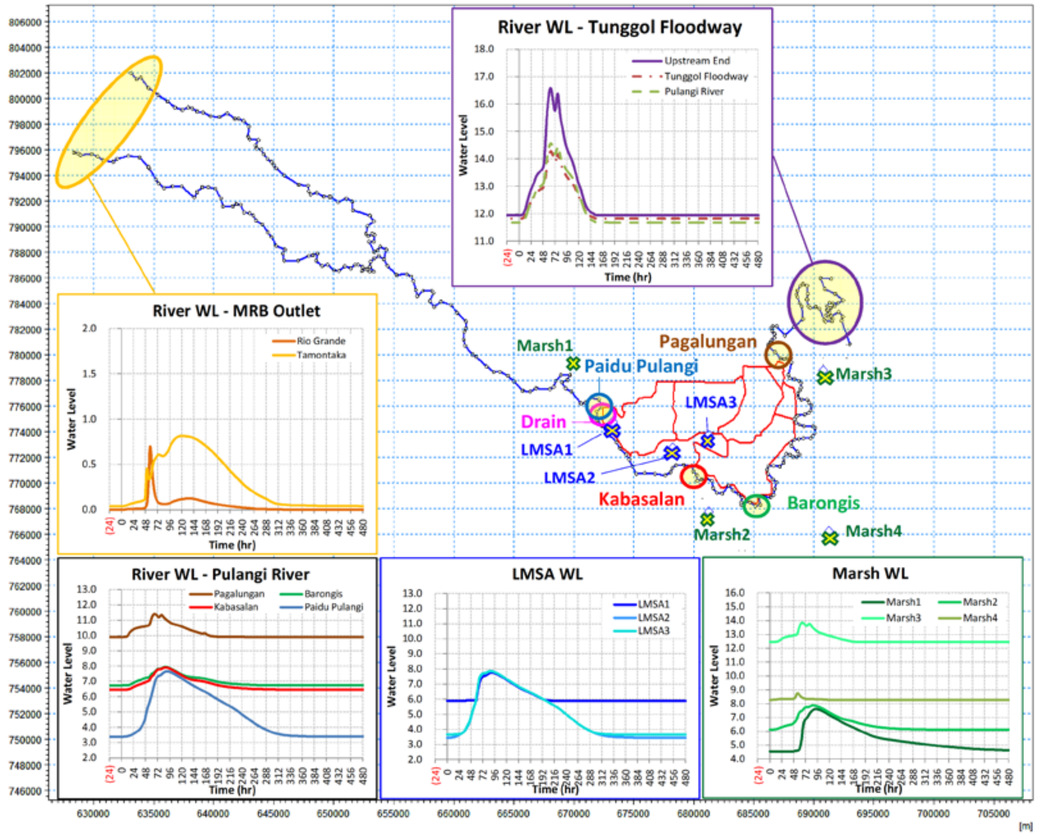
Flood Water Level



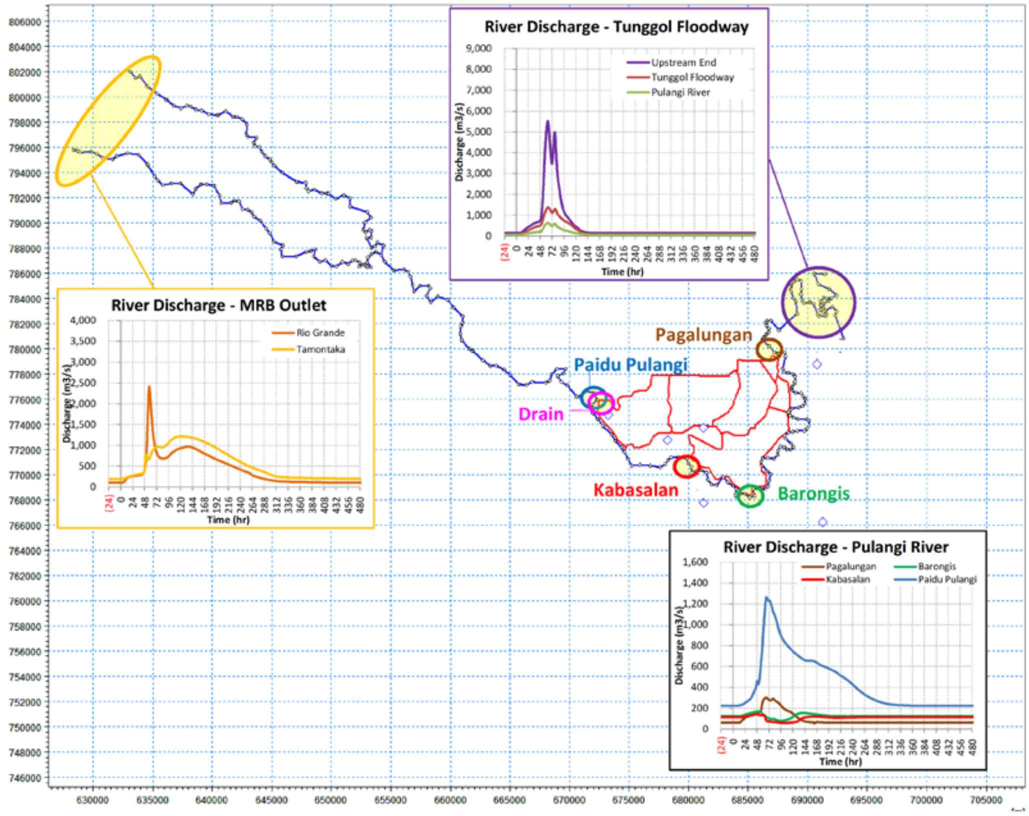
River Discharge

Figure 3.5.8 Flood Water Level and River Discharge (Present Condition) (Return Period: 10 year)

Source: JICA Survey Team



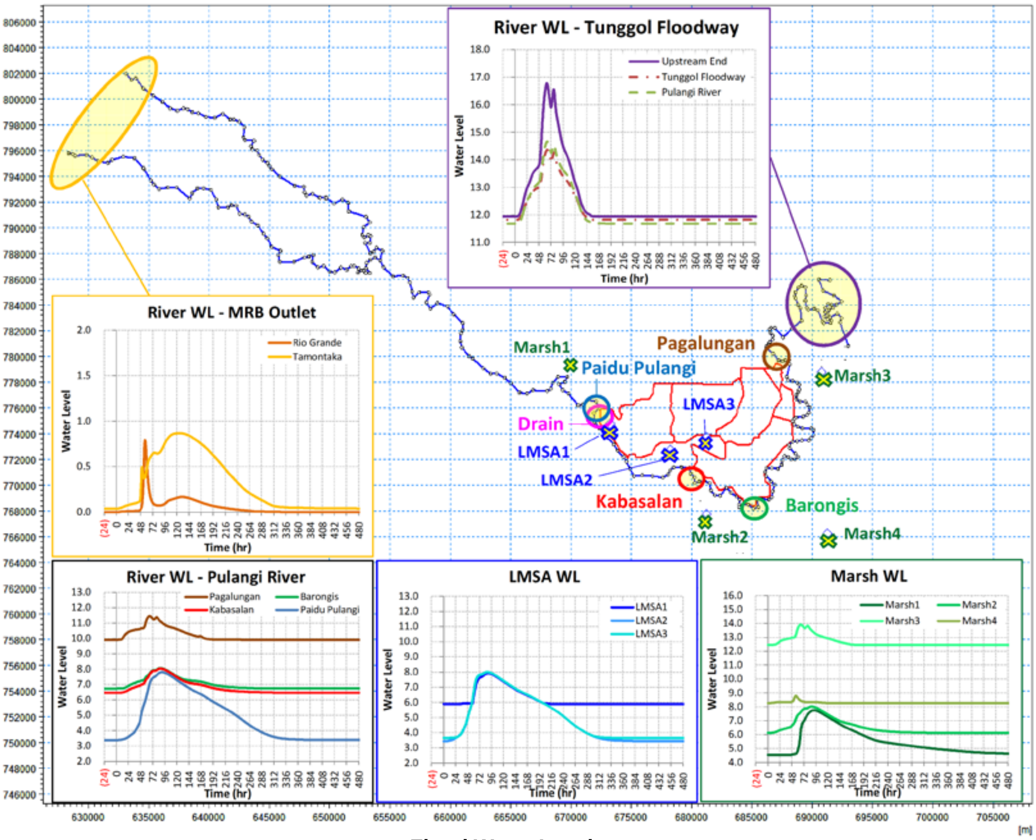
Flood Water Level



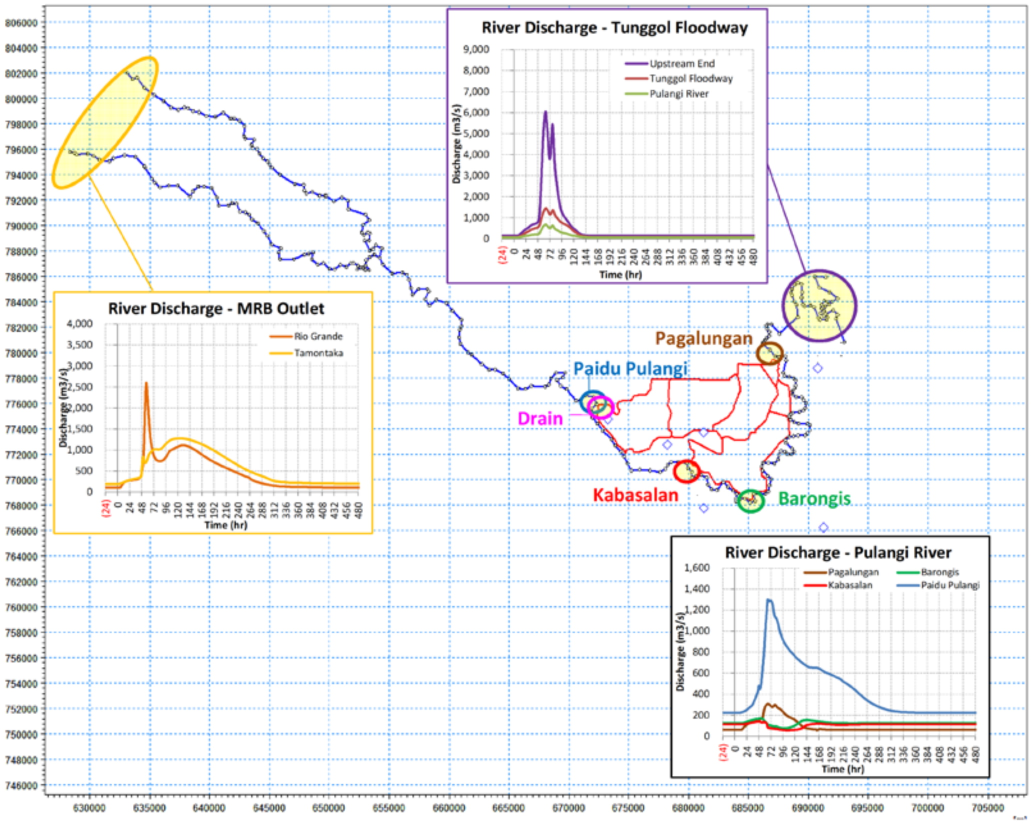
River Discharge

Figure 3.5.9 Flood Water Level and River Discharge (Present Condition) (Return Period: 20 year)

Source: JICA Survey Team



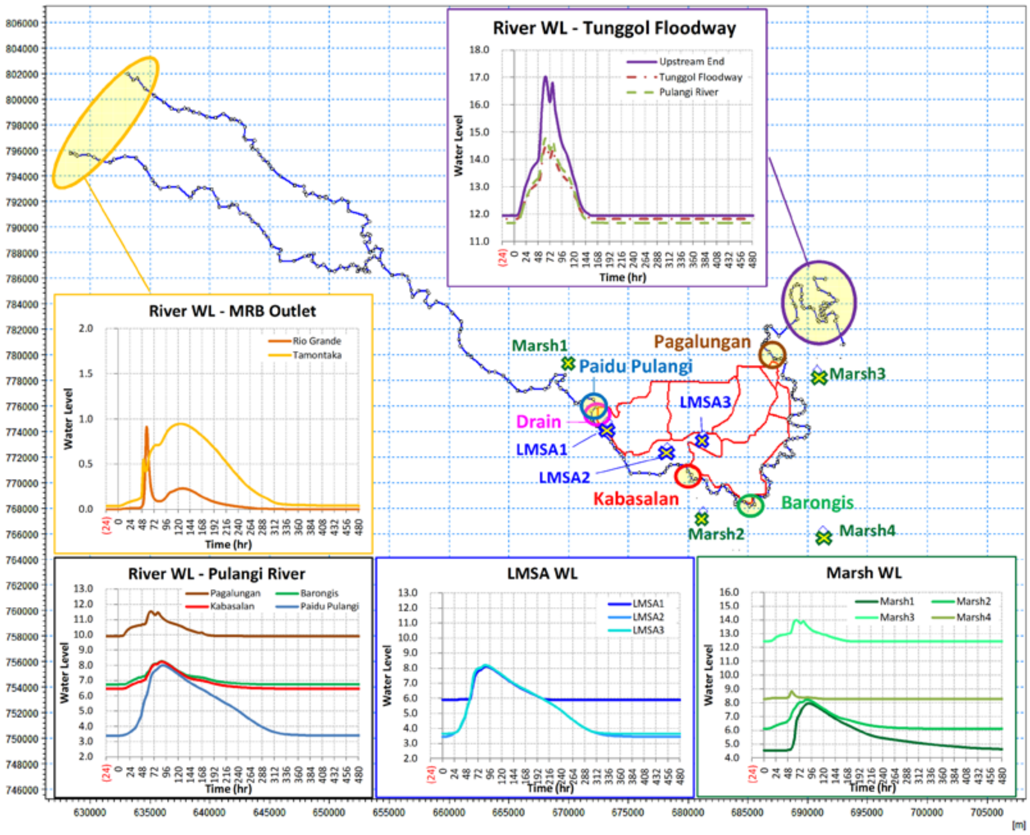
Flood Water Level



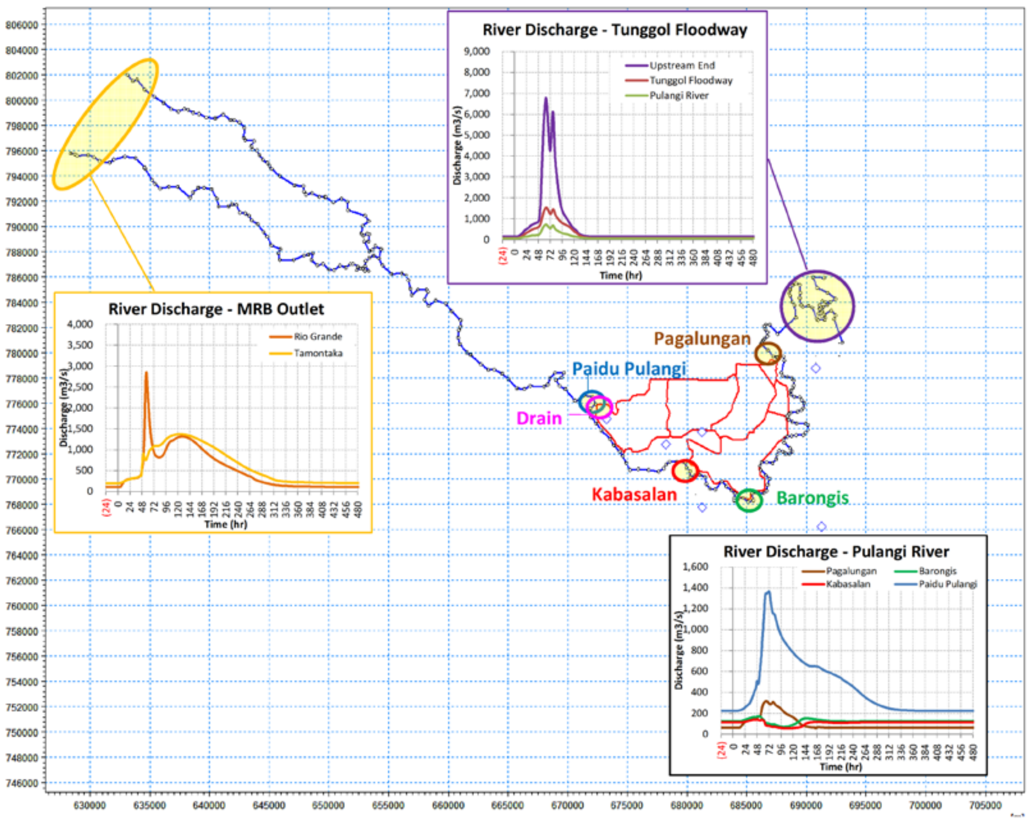
River Discharge

Figure 3.5.10 Flood Water Level and River Discharge (Present Condition) (Return Period: 30 year)

Source: JICA Survey Team



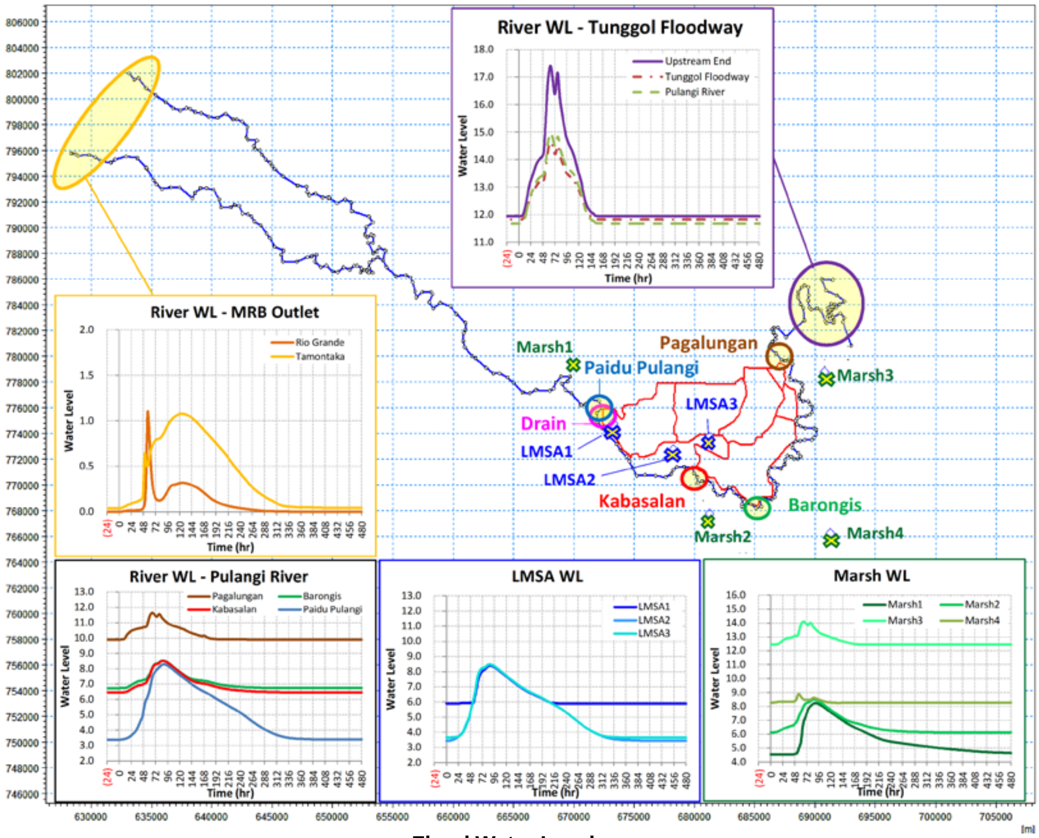
Flood Water Level



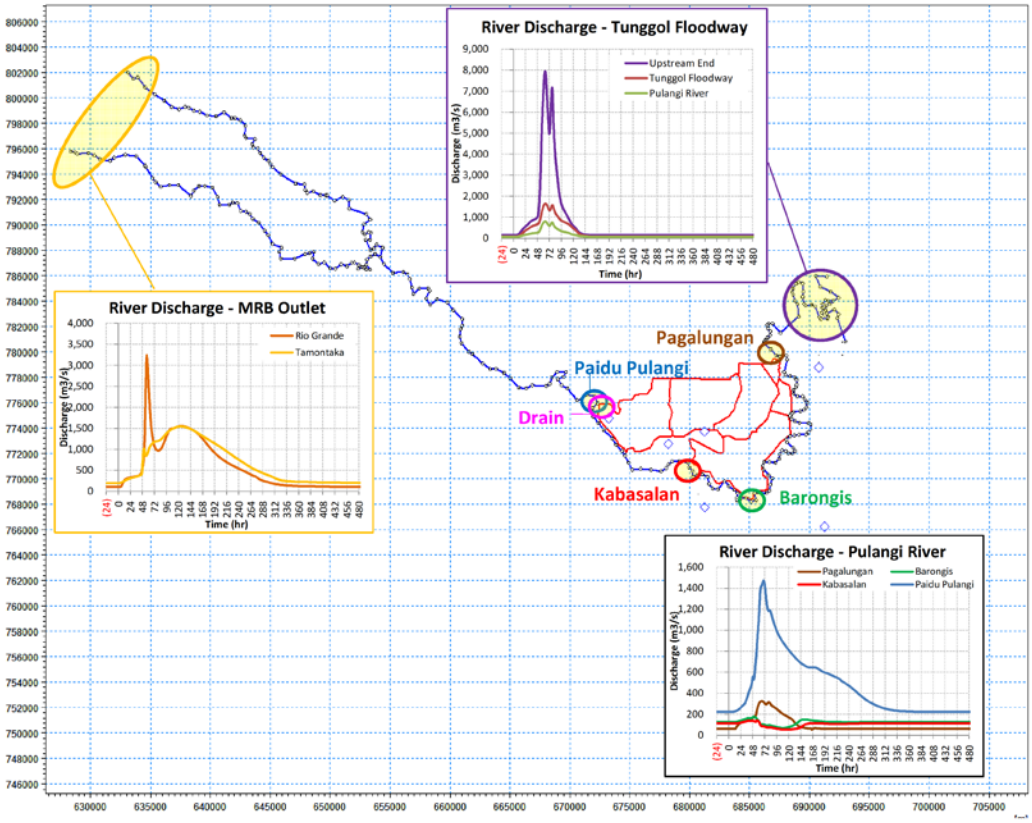
River Discharge

Figure 3.5.11 Flood Water Level and River Discharge (Present Condition) (Return Period: 50 year)

Source: JICA Survey Team



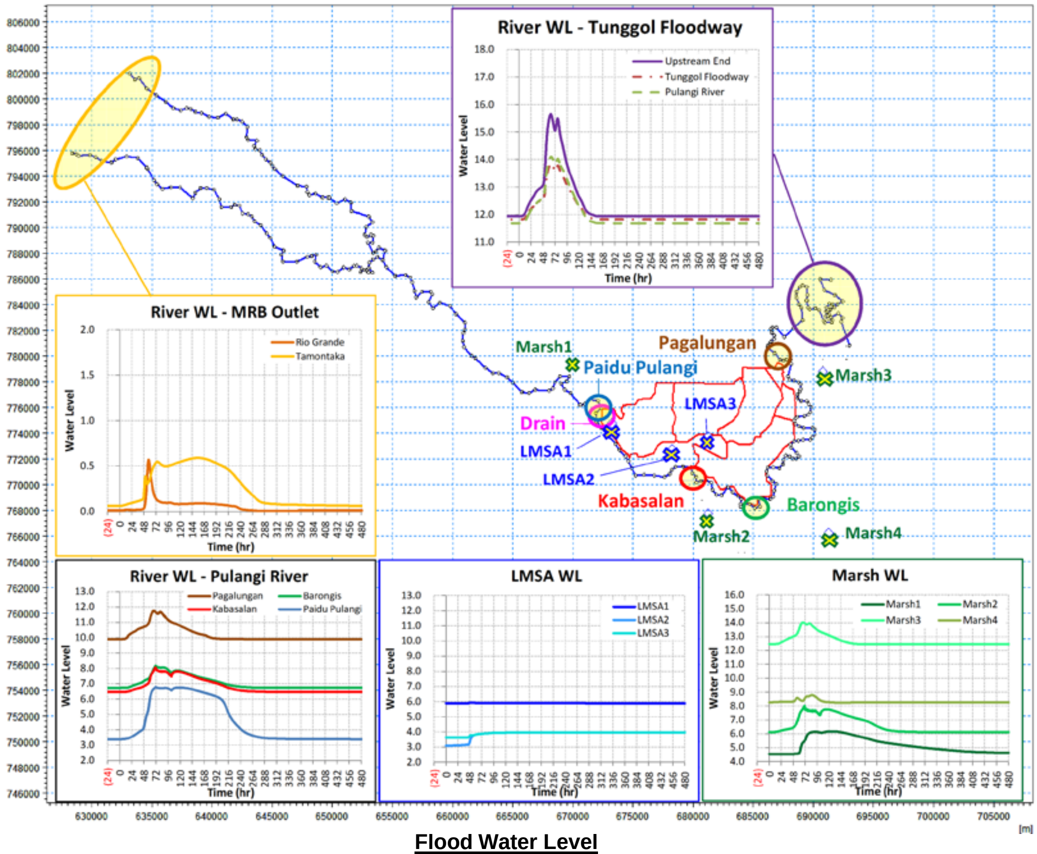
Flood Water Level



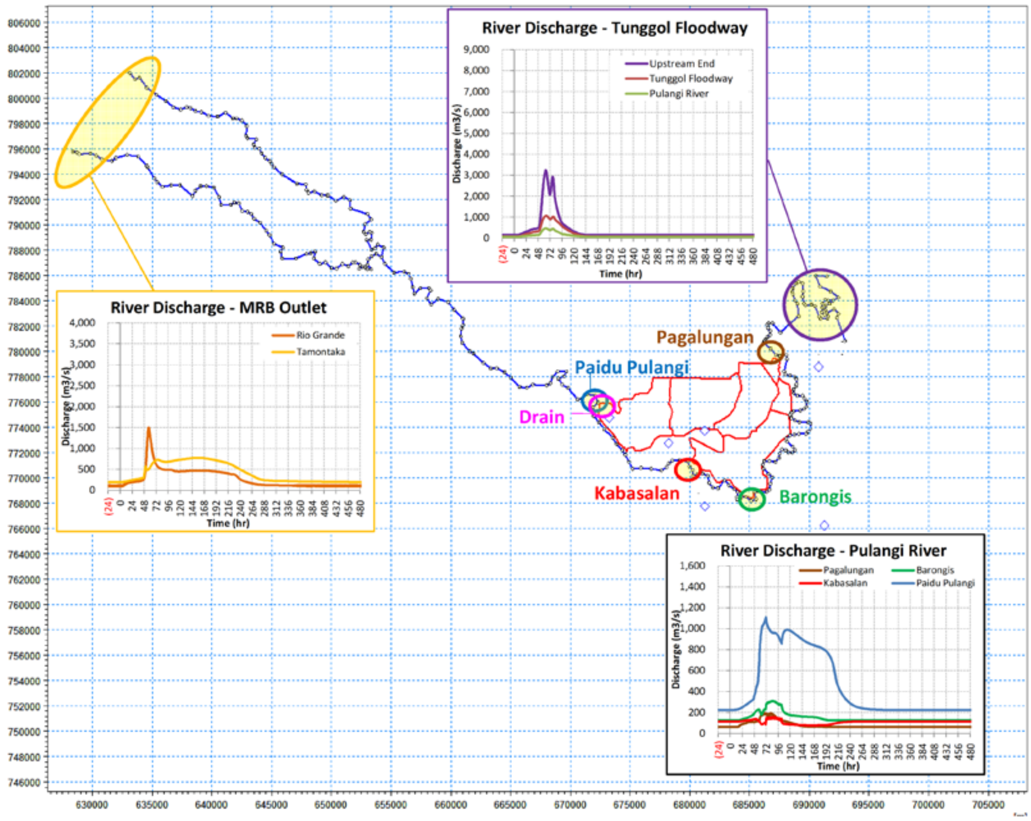
River Discharge

Figure 3.5.12 Flood Water Level and River Discharge (Present Condition) (Return Period: 100 year)

Source: JICA Survey Team



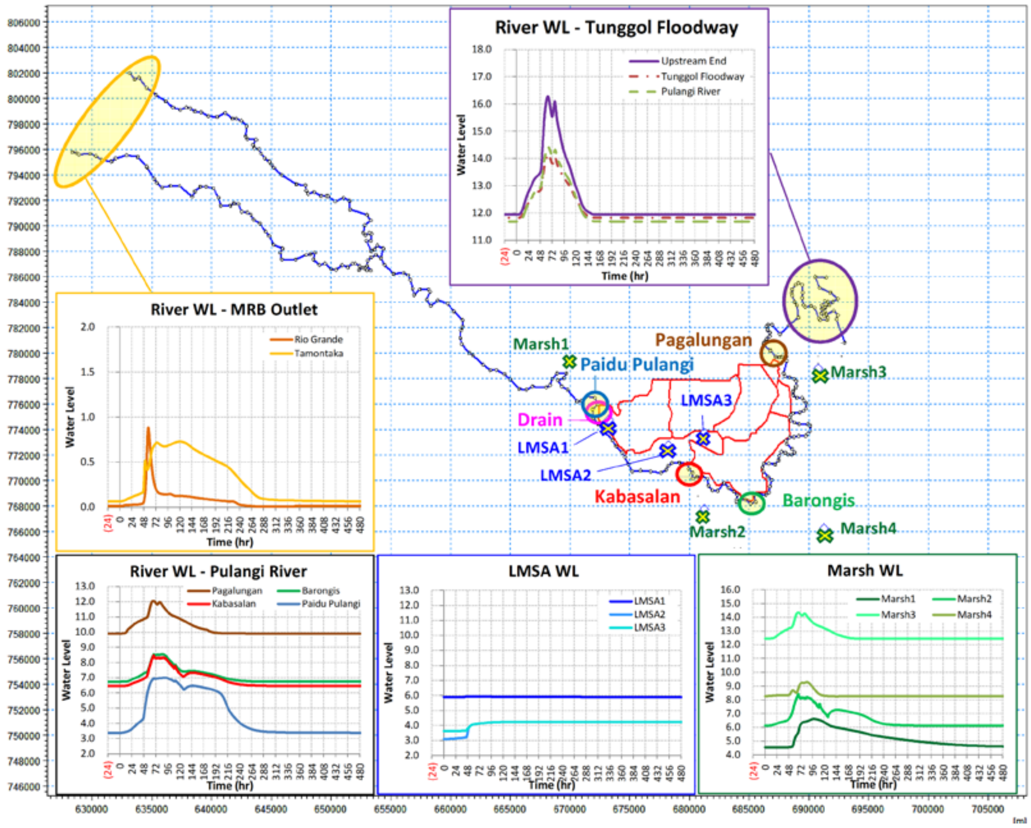
Flood Water Level



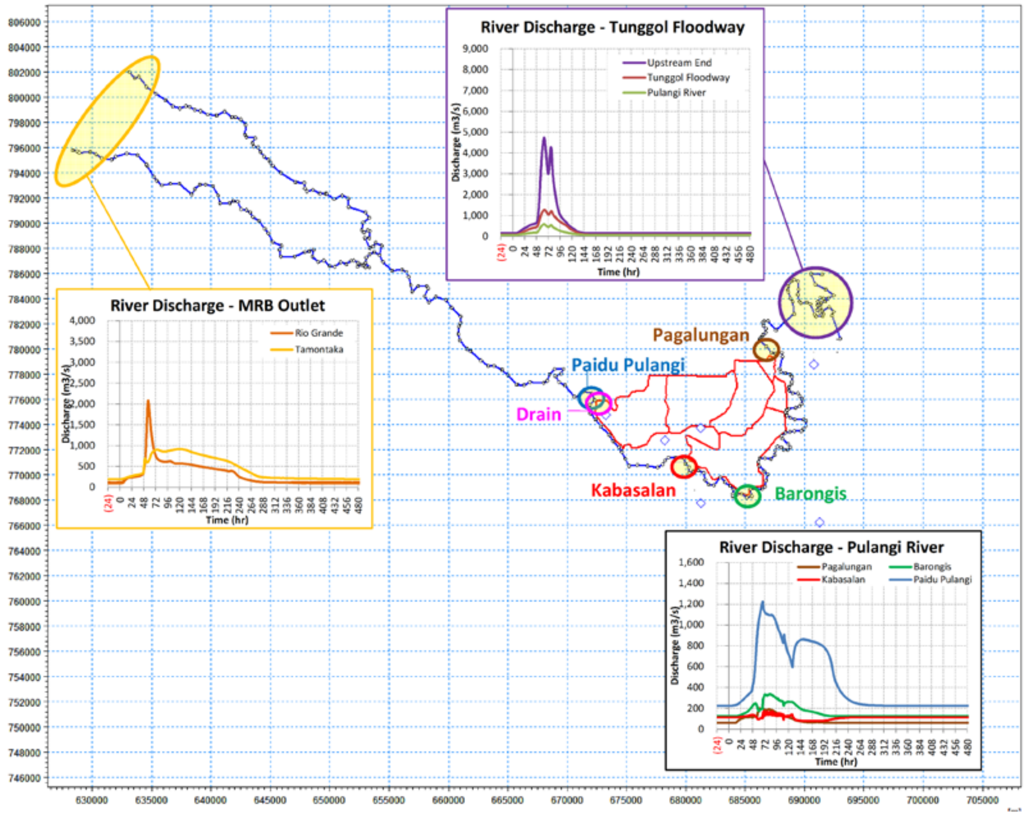
River Discharge

Figure 3.5.13 Flood Water Level and River Discharge (After Construction of the Dike) (Return Period: 2 year)

Source: JICA Survey Team



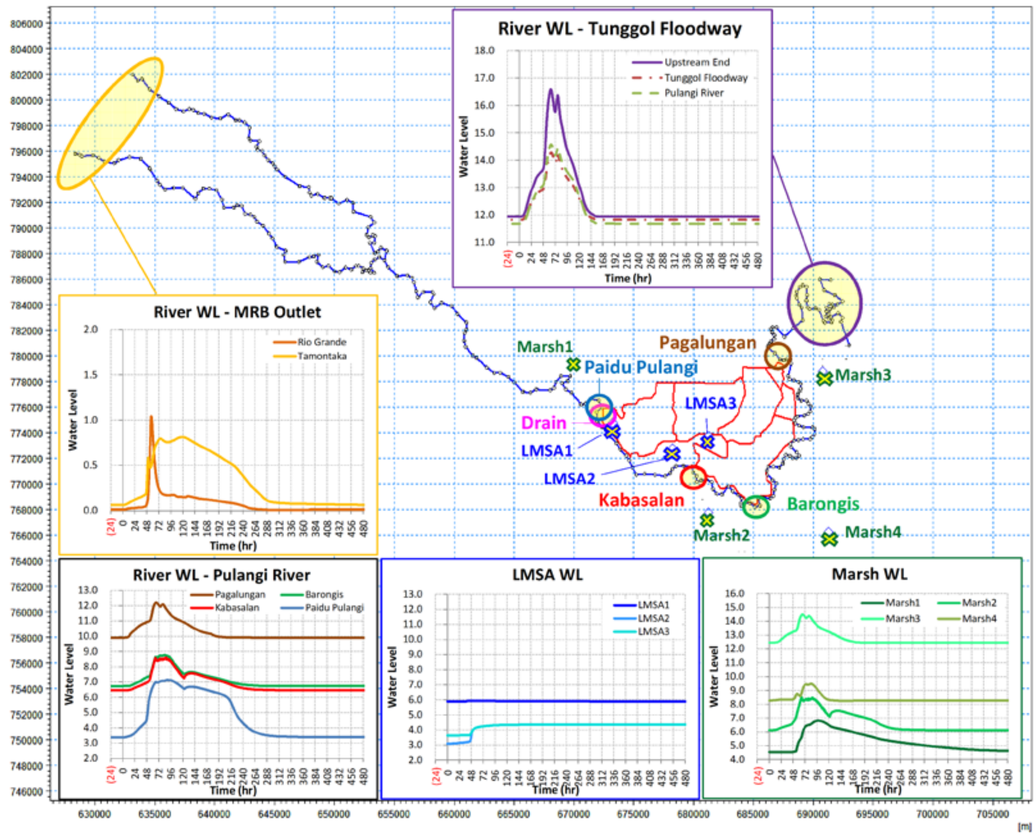
Flood Water Level



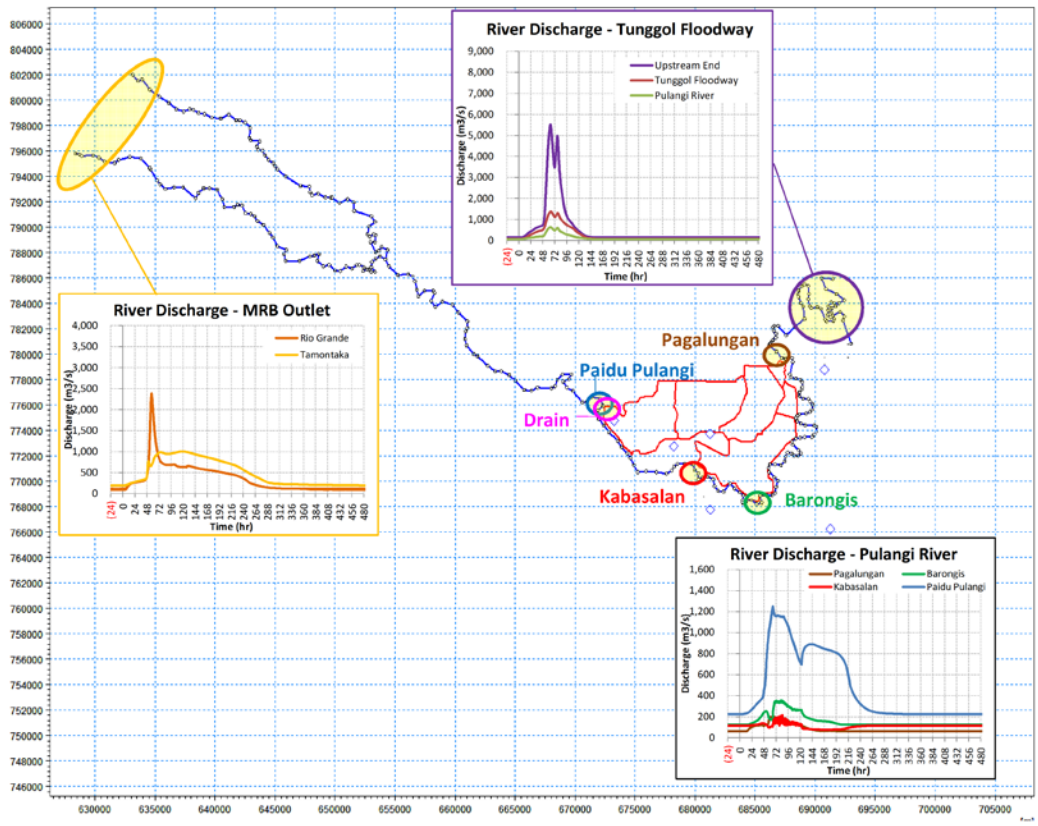
River Discharge

Figure 3.5.14 Flood Water Level and River Discharge (After Construction of the Dike) (Return Period: 10 year)

Source: JICA Survey Team



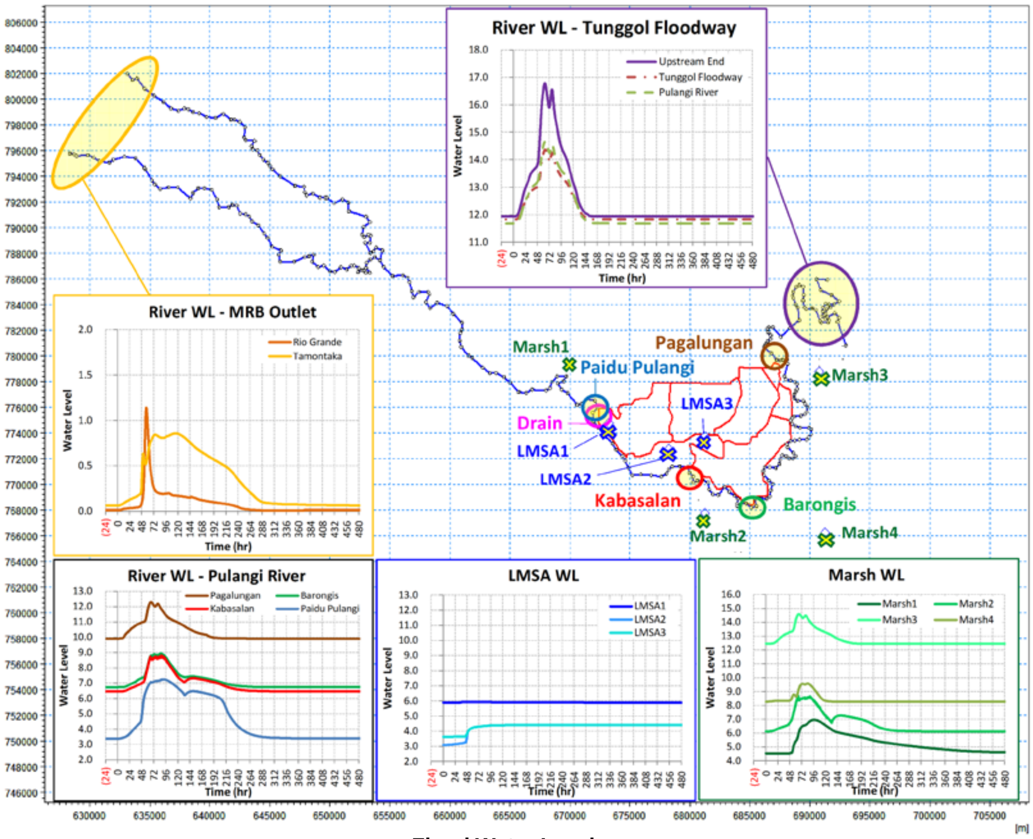
Flood Water Level



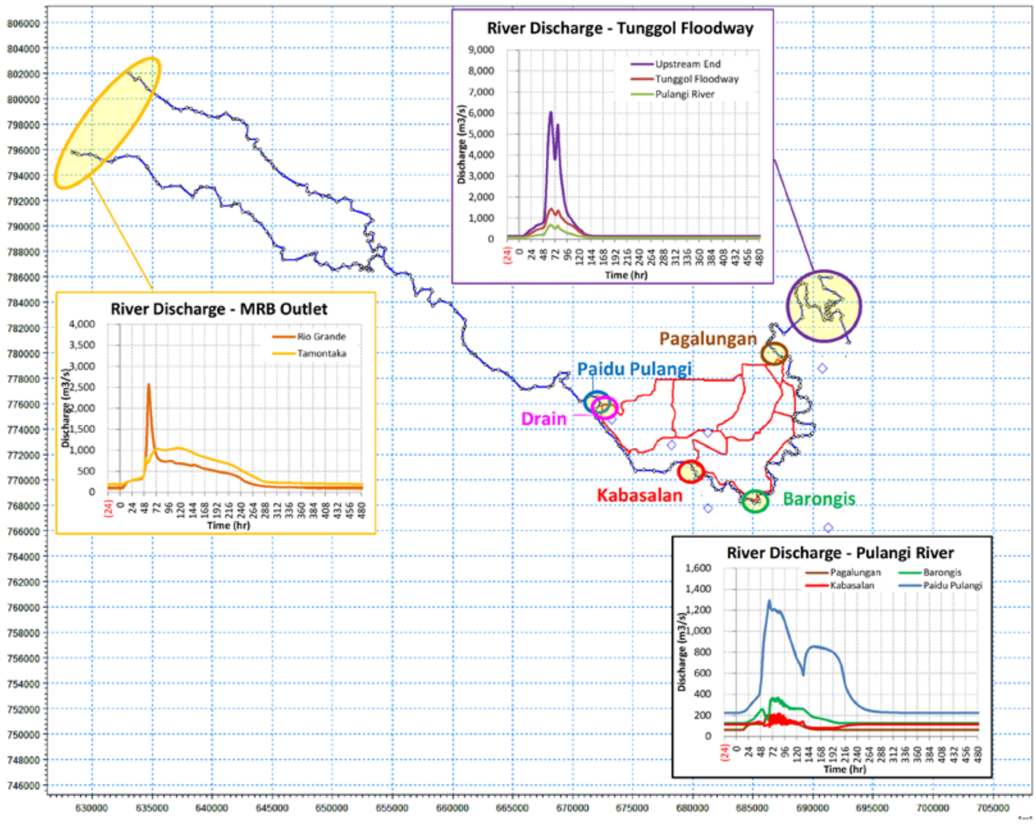
River Discharge

Figure 3.5.15 Flood Water Level and River Discharge (After Construction of the Dike) (Return Period: 20 year)

Source: JICA Survey Team



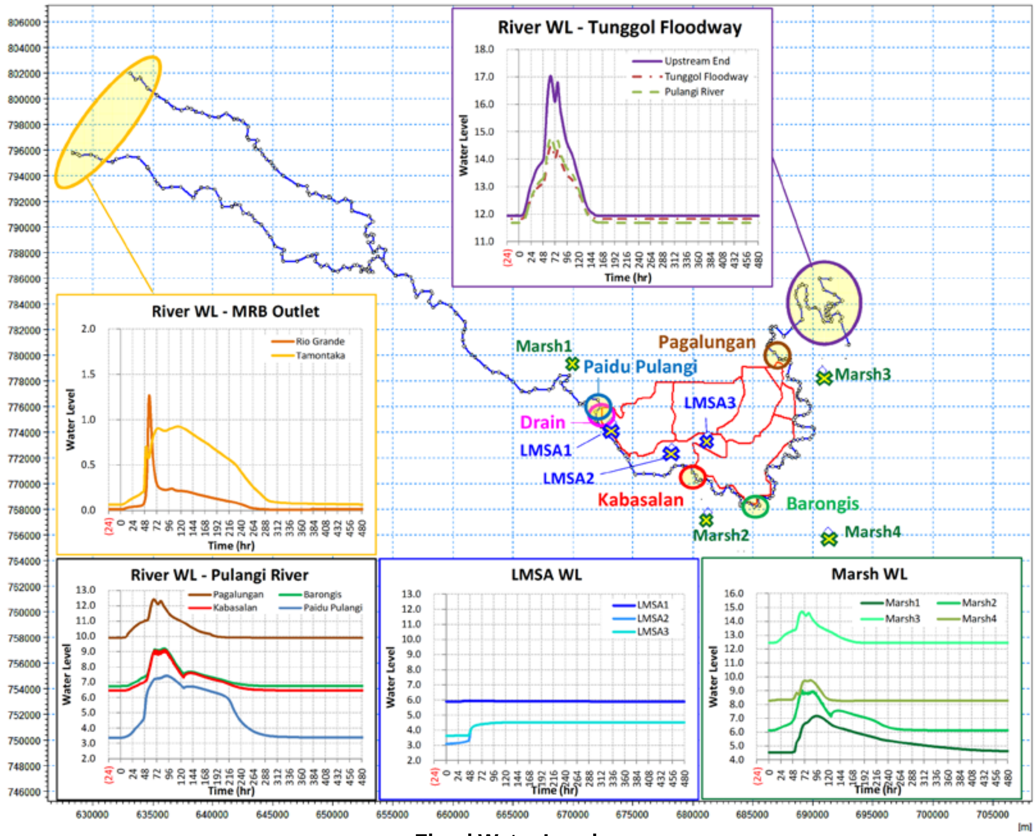
Flood Water Level



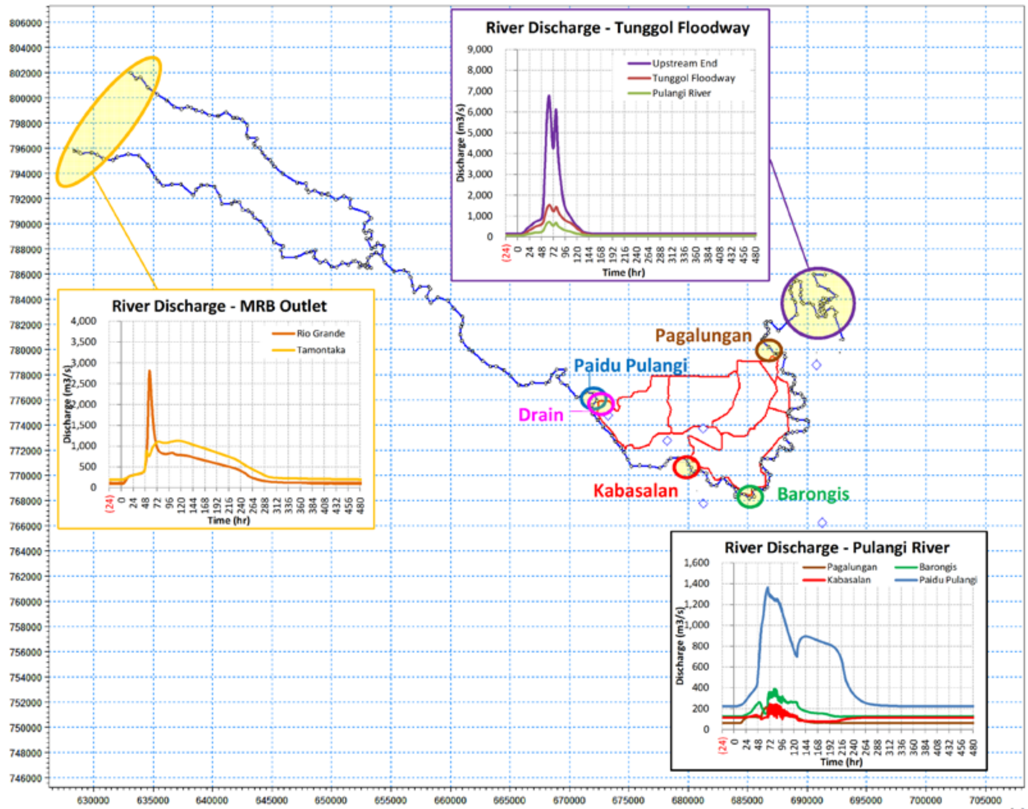
River Discharge

Figure 3.5.16 Flood Water Level and River Discharge (After Construction of the Dike) (Return Period: 30 year)

Source: JICA Survey Team



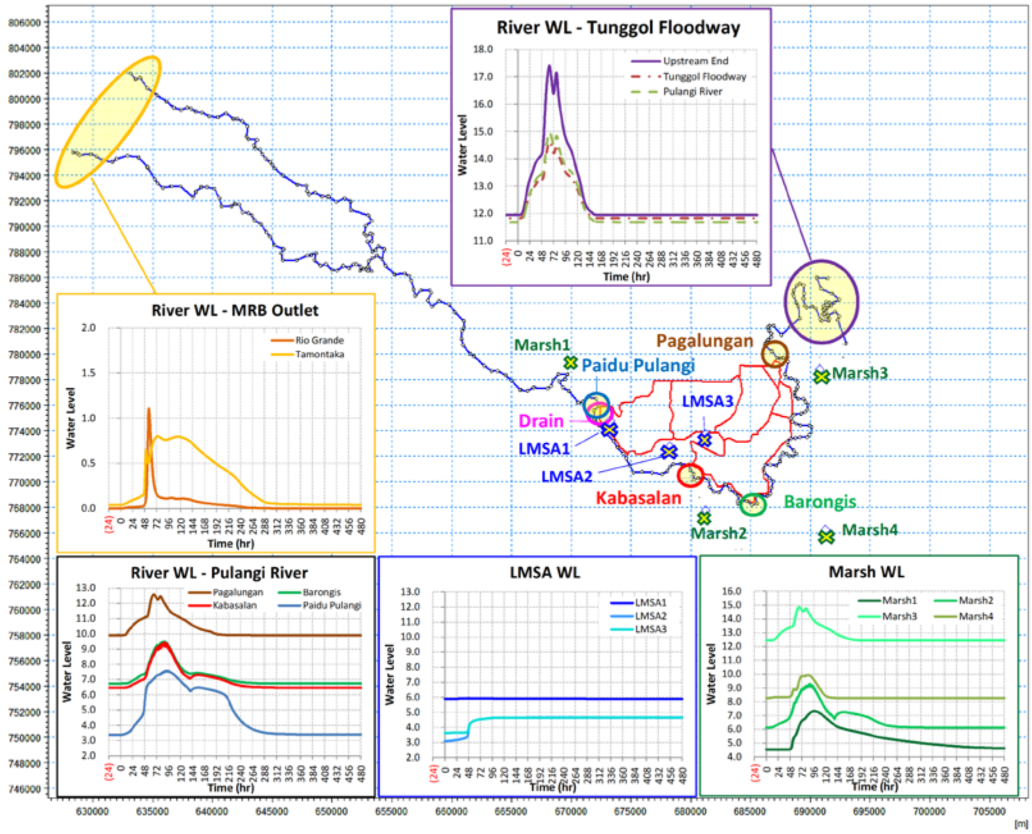
Flood Water Level



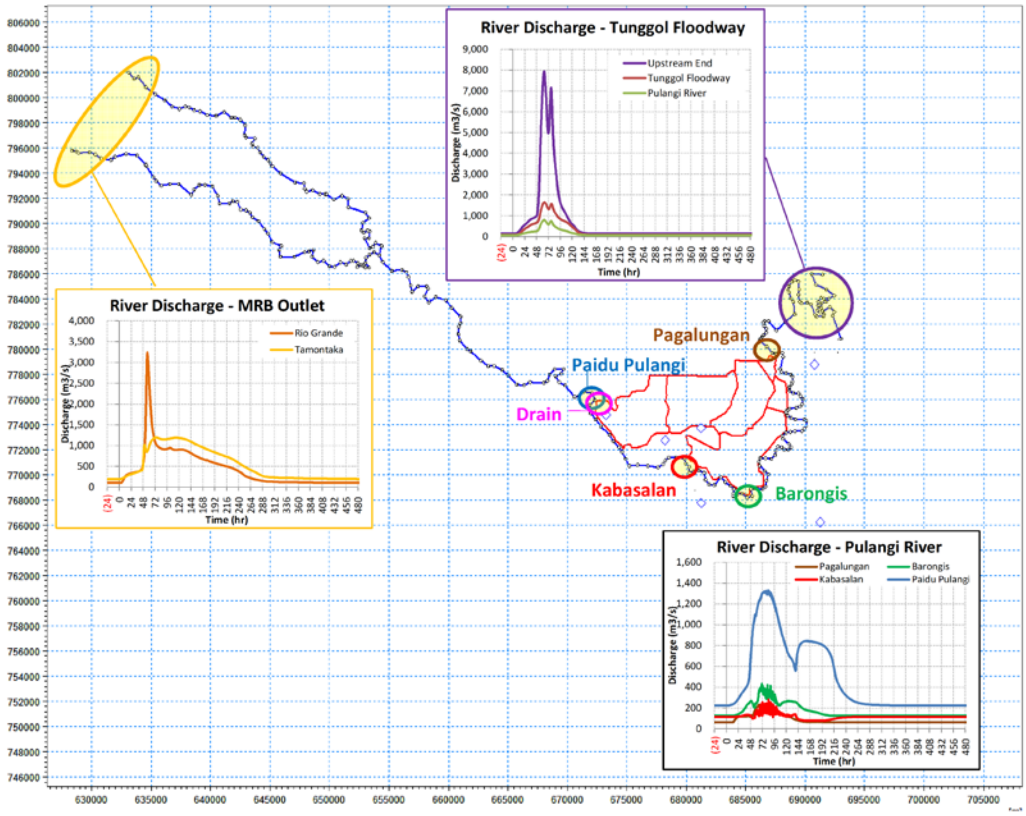
River Discharge

Figure 3.5.17 Flood Water Level and River Discharge (After Construction of the Dike) (Return Period: 50 year)

Source: JICA Survey Team



Flood Water Level



River Discharge

Figure 3.5.18 Flood Water Level and River Discharge (After Construction of the Dike) (Return Period: 100 year)

Source: JICA Survey Team

According to the aforementioned simulation results, flood water level of the Liguasan marsh would become higher after the dike construction. Current design height of the dike was determined by NIA based on the past maximum flood water level (under present condition), and the rise in water level by the dike has not been taken into account. In this context, the present dike design by NIA is evaluated as follows:

Current design is based on the flood water level observed in 2009, which is EL. 8.01 at the bottleneck point-2 (see Figure 3.5.6). Table 3.5.5 shows the simulation results of the maximum water level at the bottleneck point-2. EL.8.01m can be regarded as approximately 40-year return period flood event, and the water level would become 50cm higher at that time by the dike. Thus, the result implies that the dike height should be 50cm higher than that of the current design.

Table 3.5.5 Maximum Flood Water Level at "Bottleneck Point-2"

Return Period (year)	(1) Present Condition (without Dike) (EL.m)	(2) After Construction of the Dike (with Dike) (EL.m)	(3)Difference (=(2)-(1)) (m)
2	7.14	7.71	0.57
10	7.59	8.10	0.51
20	7.81	8.19	0.38
30	7.96	8.39	0.43
50	8.16	8.70	0.54
100	8.44	9.02	0.58

EL.8.01m can be regarded as approximately 40-year return period flood water

Flood water level would become 50 cm higher by the construction of the dike.

Source: JICA Survey Team

In case that the dike height is 50cm higher than the current design height, the construction cost (direct cost) of the dike becomes [redacted] PHP ([redacted] JPY).

Table 3.5.6 Construction Cost (Direct Cost) of the Dike (Height is 50cm Higher than the Current Design)

Work Items	(1) Quantity		(2) Unit Cost (PHP)	(3) Total (=(1) x (2))	
				(million PHP)	(million JPY)
Back Filling of the Dike	988,000	m^3	[redacted]	[redacted]	[redacted]
Founding Treatment (Sand Compaction Pile Works)	84,797	piles	[redacted]	[redacted]	[redacted]
Grand Total				[redacted]	[redacted]

Source: JICA Survey Team

3.6 Inland Inundation Simulation with/without Drainage Structures

After the construction of the dike, the LMSA will be closed by the surrounding dikes (see Figure 3.6.1). Under such condition, rainfall will be stored in the LMSA, if there is no drainage systems, which makes some areas in the LMSA inundated according to the results of the simple rainfall- evaporation model (see "3.3.3 Inland Inundation Simulation by Simple Rainfall Evaporation Model"). In this case, the beneficiary area would be smaller than the expected one, since any agricultural activities cannot be done in the inundation area. Therefore, the

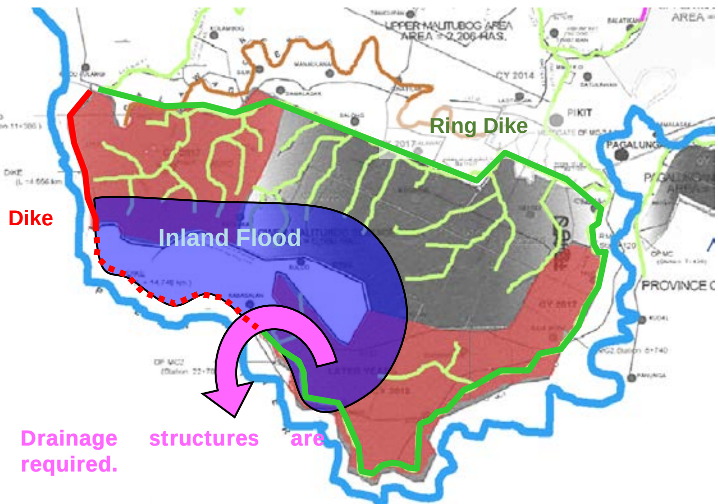


Figure 3.6.1 Image of Inland Flood Caused by Rainfall

Source: JICA Survey Team

drainage structures are necessary to reduce such inundation area, and to realize the purpose of the dike construction.

According to the preliminary examination by the simple rainfall-evaporation model, installation of pumps for drainage was considered to be unfeasible. Then, sluices which are generally used as drainage structures are selected as the target drainage structures in the simulation. Sluices can drain the inland flood when the river water level at the outlet of the sluice becomes lower than that in LMSA. Therefore, simulation able to know both water levels on the river and LMSA should be conducted as follows:

3.6.1 Specific Conditions for Inland Inundation Simulation with/without Drainage Structures

1) Simulation Period

In the simulation, the inundation area in the LMSA spreads by rainfall, and is reduced by evaporation and drainage by the structures. In order to identify the trend of those phenomena and to assess the maximum inundation area, a long term simulation is required. Additionally, in order to make the impact of the sluice clear, 1-year calculation is repeated twice continuously.

2) Rainfall

Since the simulation period is one year as mentioned above, 1-year time series rainfall data should be required. In this simulation, the following two types of the rainfall data are prepared.

a) Rainfall for the calculation of discharge at the input points

✓ Daily basin mean rainfall is selected.

✓ To consider the high accuracy as much as possible, rainfall data in 1973 are selected as a base rainfall pattern. This is because that the year has the largest number of rainfall gauge stations' data, and the data in this year has clear difference in rainfall pattern between dry and rainy season.

✓ Probability analysis for the annual basin mean rainfall of the MRB (from 52 years available data) is carried out for n-year return period (Rn). 2, 10, 20, 30, 50, 100-year return periods are examined in the simulation (see Table 3.6.1).

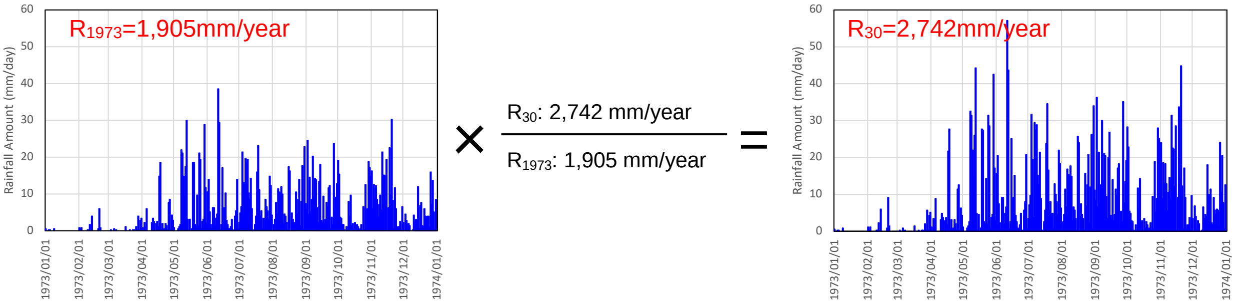
✓ One-year time series rainfall for n-year return period is created based on the base rainfall pattern in 1973 by multiplying the ratio between Rn and R_{1973} (see Figure 3.6.2).

Table 3.6.1 Annual Basin Mean Rainfall Amount in the MRB[2]

Return Period	Exp	Gumbel	**Gev**
2	1737.2	1819.8	**1905.4**
10	2595.2	2544.2	**2513.9**
20	2964.7	2821	**2667.9**
30	3180.9	2980.3	**2742.2**
50	3453.2	3179.3	**2822.7**
100	3822.7	3447.8	**2912.8**
SLSC	0.111	0.083	**0.059 (Applied)**

Source: JICA Survey Team

[2] The 52-year record was applied to each probability distribution model, namely, Exponential distribution (Exp), Gumbel distribution, Generalized extreme value distribution (Gev), and Generalized extreme value distribution was selected as the most appropriate model based on the Standard Least Squares Criterion (SLSC).



Time series rainfall in 1973 Time series of 30-year return period rainfall

Figure 3.6.2 Example of the Method to Create Time Series Mean Rainfall in the MRB (30-year return period)

Source: JICA Survey Team

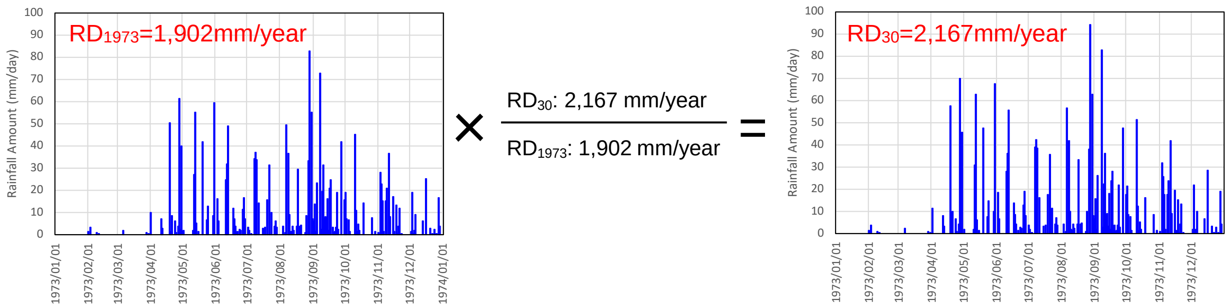
b) Rainfall in the LMSA

- ✓ Rainfall data at Datu Piang rainfall gauge station which is located at the nearest to the LMSA among the target stations is selected.
- ✓ Rainfall data in 1973 are selected as a base rainfall pattern due to the same reason as a).
- ✓ Probability analysis for annual rainfall amount at Datu Piang rainfall gauge station is carried out for n-year return period (RDn) in the same manner of a) (see Table 3.6.2)..
- ✓ Time series rainfall for n-year return period is created based on the base rainfall pattern in 1973 by multiplying the ratio between RDn and RD1973 (see Figure 3.6.3).

Table 3.6.2 Annual Rainfall Amount at Datu Piang Rainfall Gauge Station

Return Period	Gumbel	**Iwai**	Ishitaka	Gev	SqrtEt
2	1399.3	**1423.7**	1427.9	1414.7	1389.7
10	1933	**1909.5**	1902.5	1931.3	1952.2
20	2136.9	**2074.9**	2059.2	2110.3	2190.3
30	2254.2	**2166.6**	2145.1	2208.9	2333.1
50	2400.9	**2278.3**	2248.9	2328	2517.4
100	2598.7	**2424.7**	2383.7	2481.5	2776.4
SLSC	0.037	**0.031 (applied)**	0.033	0.035	0.04

Source: JICA Survey Team



Base rainfall pattern in 1973 30 year probable rainfall pattern

Figure 3.6.3 Example of the Method to Create Time Series Rainfall at Datu Piang (30-year return period)

Source: JICA Survey Team

c) Discharge

Since sluices can drain inland flood water when river water level at the outlet of the sluice becomes lower than inland flood water level in the LMSA, both the river and the inland flood water level shall be prepared as input data for the simulation.

The aforementioned unit hydrograph method (see Figure 3.4.14) illustrates the concept of the conversion from rainfall during a unit time (one hour in that case) to the time series discharge. This concept is also applied in this simulation, and one-year time series discharge data is created as the following procedures.

- ✓ The base flow is regarded as the constant value (see "3.4.3 Model Design" for the concept of the base flow").
- ✓ As for the hourly rainfall pattern in a day, it is assumed that the rainfall continues in the same intensity through a whole day because the only daily rainfall data is available.
- ✓ Time series discharge at the input points is calculated on the hourly basis, and the organized on the daily basis to apply the simulation model.
- ✓ This estimation is made for every rainy day, and daily discharge is calculated by superposition of the calculated discharges from each rainfall.

Figure 3.6.4 illustrates the schematic image of the determination method to create the discharge volume from the hourly rainfall data.

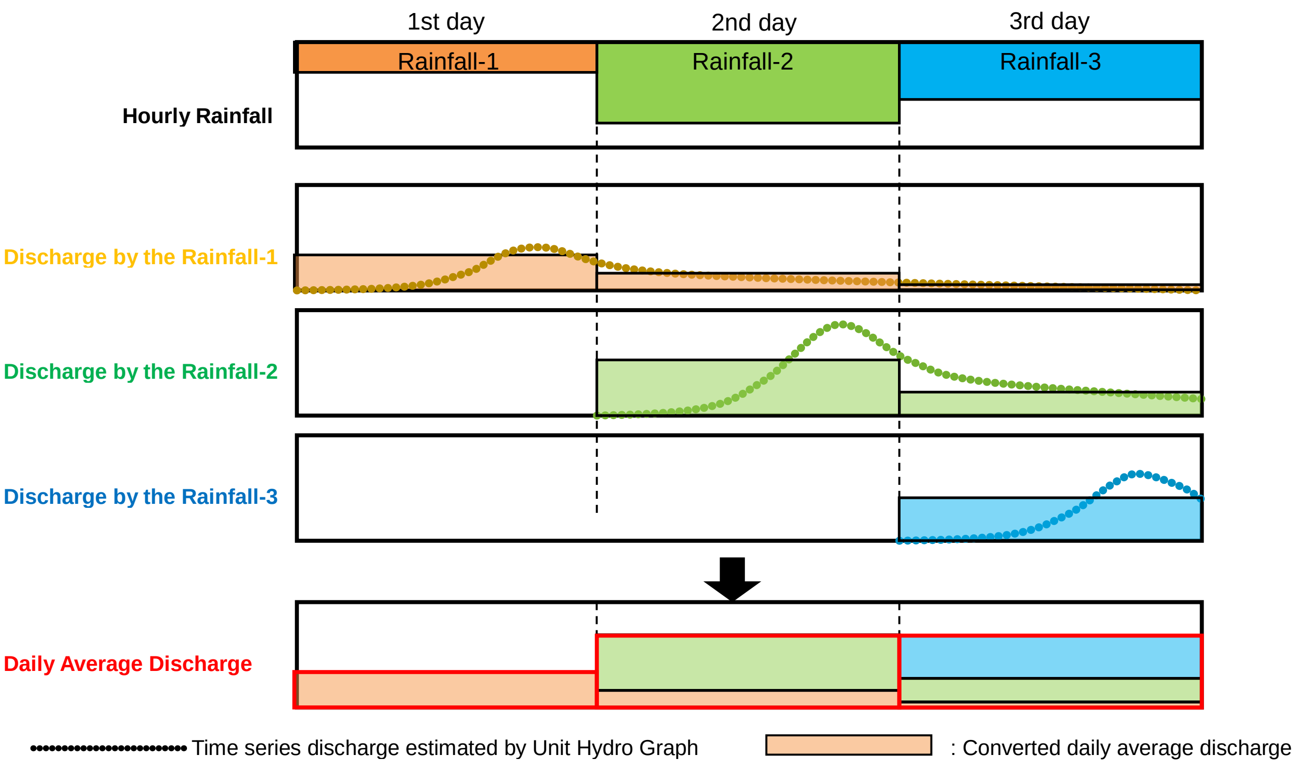


Figure 3.6.4 Schematic Image of the Time Series Discharge Data

Source: JICA Survey Team

d) Sluice

As for the scale, a sluice of 2m height and 2m width is applied assuming that the height of the dike is 4m, and sluice is set at the bottom of the dike. Moreover, the bottom elevation of the sluice is set as the same elevation of the lowest elevation in the LMSA, namely, EL. 4.5m, so that the sluice can discharge whole inland flood in the beneficially area of the LMSA.

According to the results of the Flood Simulation with/without dike, the water level in the Liguasan marsh becomes higher, and river water level at Paidu Pulangi becomes lower after the construction of the dike. Therefore, the location of the sluice is selected at Paidu Pulangi to make the discharge opportunity most effective due to the difference in the water level between the Pulangi river and the inland water in the LMSA. In this case, drainage canals are additionally required from the pond of the inland water to the sluices because the area where the elevation is lower than EL. 4.5m is mainly situated on the southern part of the LMSA (see Figure 3.6.5).

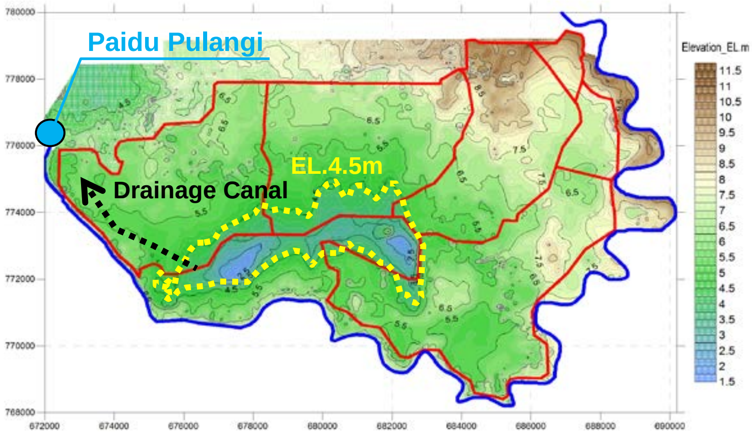


Figure 3.6.5 Location of Drainage Point and Drainage Canal
Source: JICA Survey Team

e) Simulation Cases

Simulation is executed only in the case of after the construction of the dike, and for 2, 10, 20, 30, 50, 100-year return periods rainfall with 0, 2, 10, 30, 50, 100 sluices are considered. In total, 36 cases are examined (see Table 3.6.3).

Table 3.6.3 Simulation Cases for Inland Inundation Simulation

Probability / Simulation Case	Return Period						Number of Sluices						Total Case
	2	10	20	30	50	100	0	2	10	30	50	100	
1. Present Condition (without dike)	-	-	-	-	-	-	-	-	-	-	-	-	0
2. After Construction of the Dike (With Dike)	○	○	○	○	○	○	○	○	○	○	○	○	36

3.6.2 Simulation Result

Table 3.6.4 to 3.6.9 and Figure 3.6.6 to 3.6.11 show the results of the simulation. Although 1-year calculation is repeated twice continuously, 1.5-year result is shown in the Figures. From these results, followings can be concluded.

✓ The number of the sluice is important to shorten the duration of the inundation time when the situation fulfills the drainage requirement. The more the sluices are installed, the shorter duration of the inundation time becomes.

✓ The difference of the maximum inland flood water level in the LMSA between 2 and 100 sluices under 2-year return period rainfall is only 12cm (= 5.81m - 5.69m), which indicates the impact of the number of sluices is not significant on the water level. Moreover, the result is almost the same in the other return period cases.

✓ Difference in the maximum inundation area between 2 and 100 sluices under 2-year return period rainfall is also small (42.3 km^2 for 100 sluices and 45.3 km^2 for 2 sluices so that the difference in ratio is 42.3/45.3 = 93%) and almost the same ratios are found in the other cases as well.

✓ The results indicate that the number of the sluices is not important to mitigate both the maximum inland flood water level and the maximum inundation area. It is because the sluices cannot function from May to October, since the river water level is higher than the inland water level. During this season, all the rainfall in the LMSA is stagnated and the maximum inland water level and the maximum inundation area are identified.

Table 3.6.4 Summary of the Results (Return Period: 2 year)

Number of the Sluice	Maximum Inland Flood Water Level in the LMSA (EL.m)	Maximum Inundation Area in the LMS (km^2)	Inundated Ratio (%)	
			Whole the LMSA	ODA Target Area
0	5.86	46.3	52.9	50.3
2	5.81	45.3	51.9	49.2
10	5.78	45.3	51.9	49.2
30	5.73	45.3	51.9	49.2
50	5.71	42.3	48.1	45.9
100	5.69	42.3	48.1	45.9

Table 3.6.5 Summary of the Results (Return Period: 10 year)

Number of the Sluice	Maximum Inland Flood Water Level in the LMSA (EL.m)	Maximum Inundation Area in the LMS (km^2)	Inundated Ratio (%)	
			Whole the LMSA	ODA Target Area
0	6.77	68.3	72.1	74.2
2	6.35	6.00	69.2	64.9
10	6.30	5.78	67.3	62.8
30	6.22	5.78	67.3	62.8
50	6.19	5.48	63.5	59.5
100	6.17	5.48	63.5	59.5

Table 3.6.6 Summary of the Results (Return Period: 20 year)

Number of the Sluice	Maximum Inland Flood Water Level in the LMSA (EL.m)	Maximum Inundation Area in the LMS (km^2)	Inundated Ratio (%)	
			Whole the LMSA	ODA Target Area
0	6.91	7.05	75.0	76.6
2	6.81	6.83	72.1	74.2
10	6.64	6.43	69.2	69.8
30	6.38	6.03	70.2	65.5
50	6.35	6.00	69.2	65.2
100	6.33	6.00	69.2	65.2

Table 3.6.7 Summary of the Results (Return Period: 30 year)

Number of the Sluice	Maximum Inland Flood Water Level in the LMSA (EL.m)	Maximum Inundation Area in the LMS (km^2)	Inundated Ratio (%)	
			Whole the LMSA	ODA Target Area
0	6.94	74.0	81.7	80.4
2	6.87	70.5	75.0	76.6
10	6.72	66.8	74.0	72.6
30	6.64	66.0	71.2	71.7
50	6.55	64.3	69.2	69.8
100	6.43	62.8	71.2	68.2

Table 3.6.8 Summary of the Results (Return Period: 50 year)

Number of the Sluice	Maximum Inland Flood Water Level in the LMSA (EL.m)	Maximum Inundation Area in the LMS (km^2)	Inundated Ratio (%)	
			Whole the LMSA	ODA Target Area
0	6.97	7.40	81.7	80.4
2	6.93	7.25	78.8	78.8
10	6.81	6.90	75.0	75.0
30	6.74	6.90	75.0	75.0
50	6.72	6.90	75.0	75.0
100	6.72	6.68	74.0	72.6

Table 3.6.9 Summary of the Results (Return Period: 100 year)

Number of the Sluice	Maximum Inland Flood Water Level in the LMSA (EL.m)	Maximum Inundation Area in the LMS (km^2)	Inundated Ratio (%)	
			Whole the LMSA	ODA Target Area
0	7.06	7.53	84.6	81.8
2	6.97	7.33	81.7	79.9
10	6.85	7.28	79.8	79.1
30	6.84	7.13	77.0	77.4
50	6.83	7.13	77.9	77.4
100	6.83	7.13	77.9	77.4

Source: JICA Survey Team (for Table 3.6.4 to Table 3.6.9)

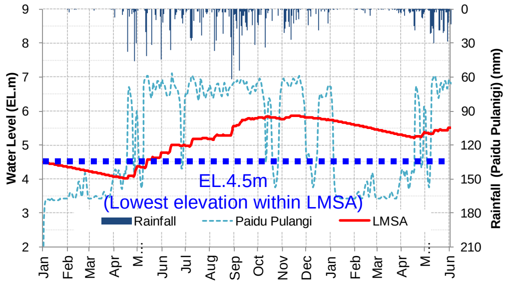
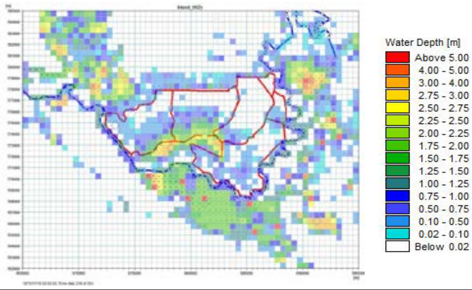
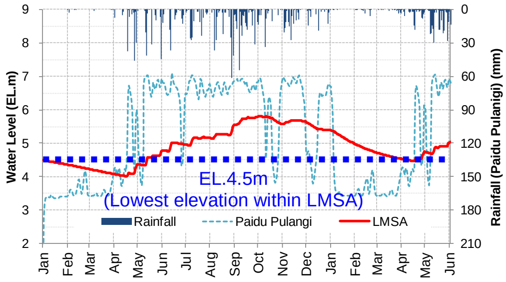
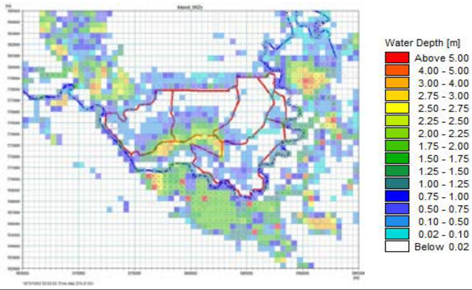
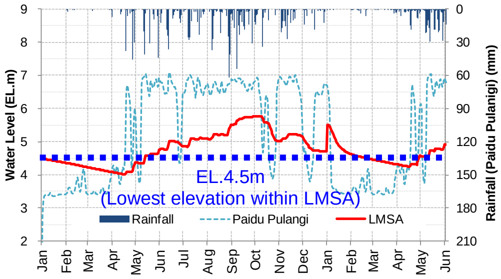
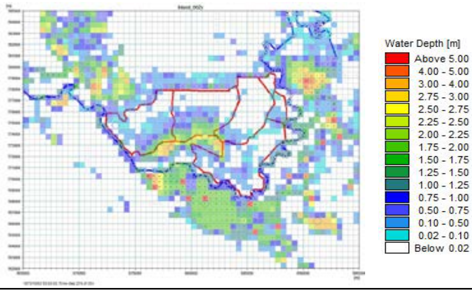
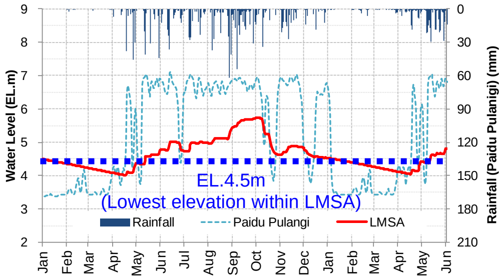
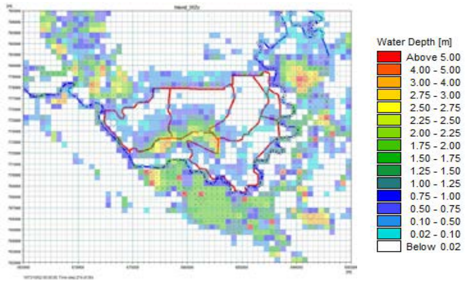
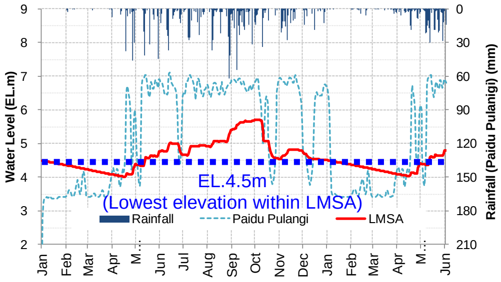
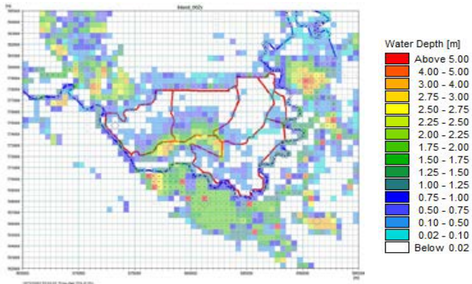
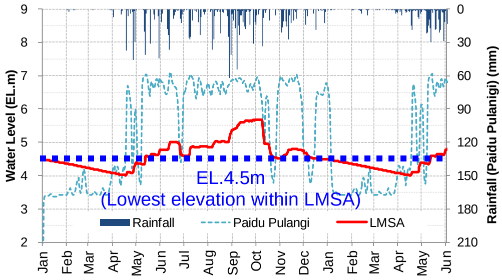
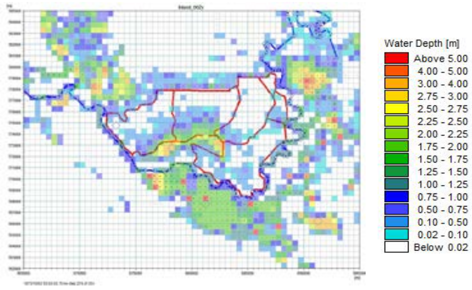
Number of the Sluice	Water Level	Inundation Situation (at the timing with maximum inundation area)
0		
2		
10		
30		
50		
100		

Figure 3.6.6 Water Level and Inundation Situation (Return Period: 2 year)

Source: JICA Survey Team

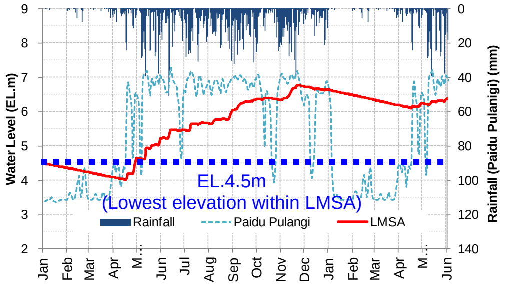
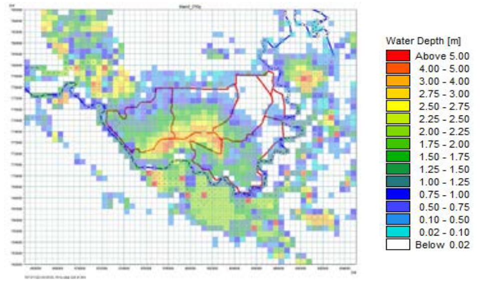
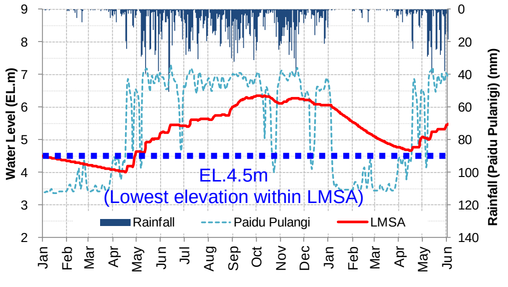
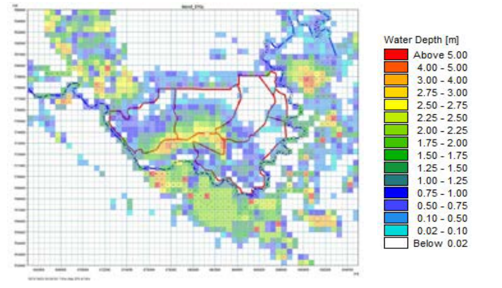
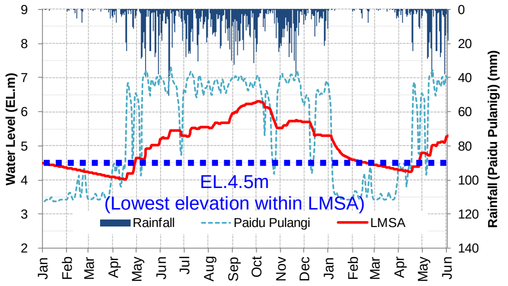
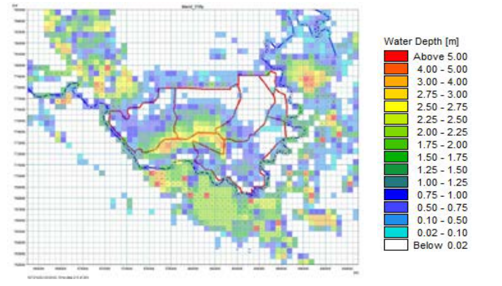
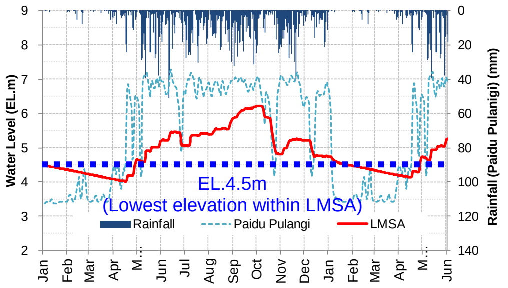
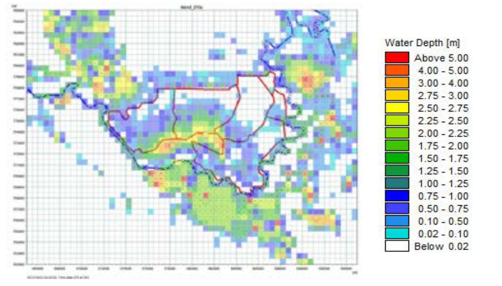
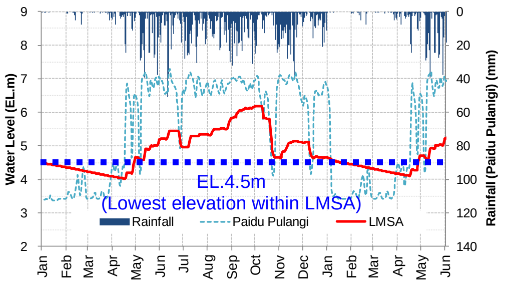
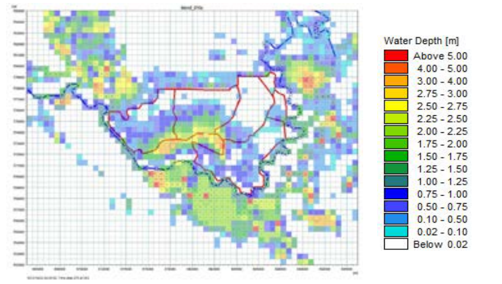
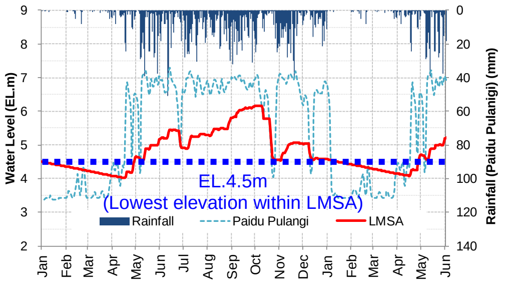
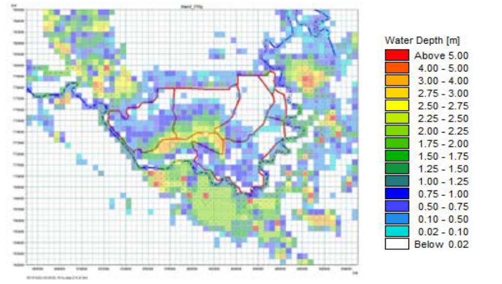
Number of the Sluice	Water Level	Inundation Situation (at the timing with maximum inundation area)
0		
2		
10		
30		
50		
100		

Figure 3.6.7 Water Level and Inundation Situation (Return Period: 10 year)

Source: JICA Survey Team

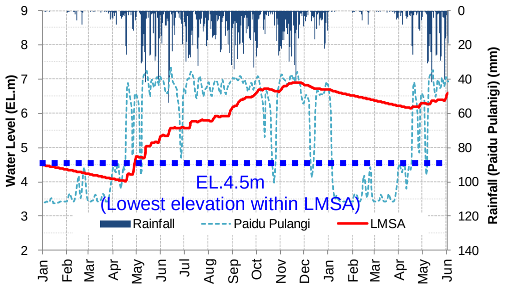
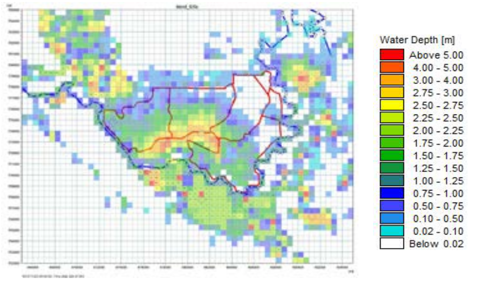
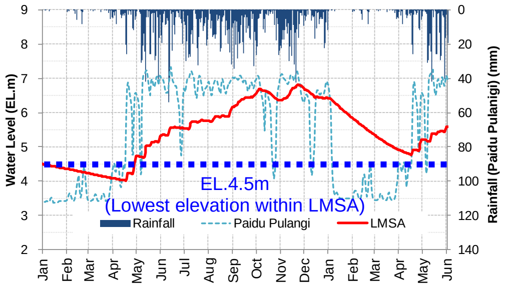
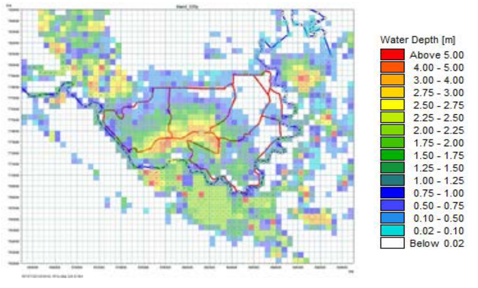
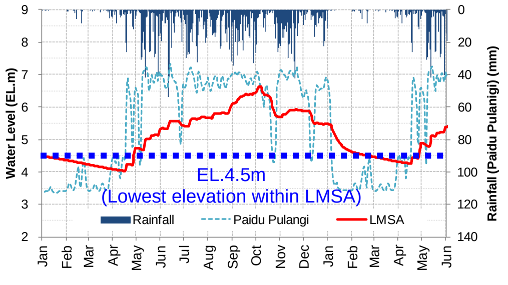
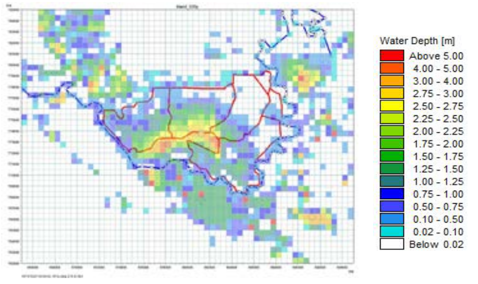
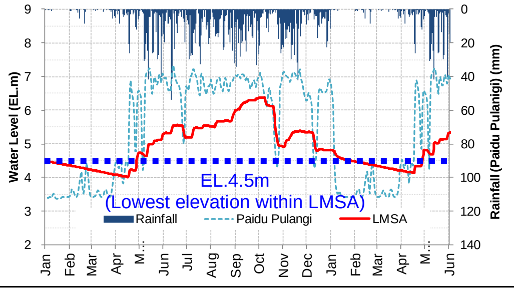
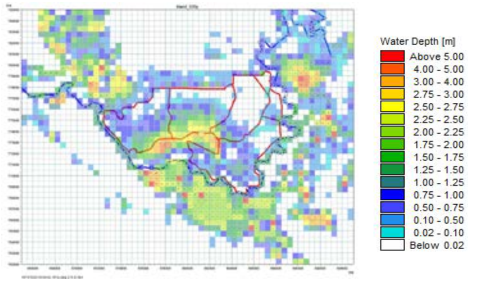
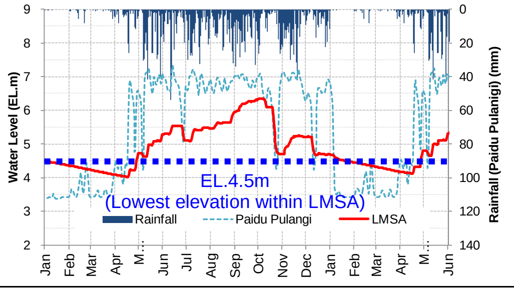
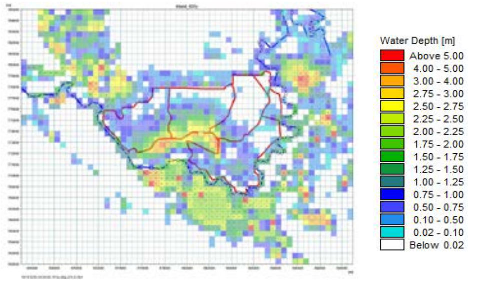
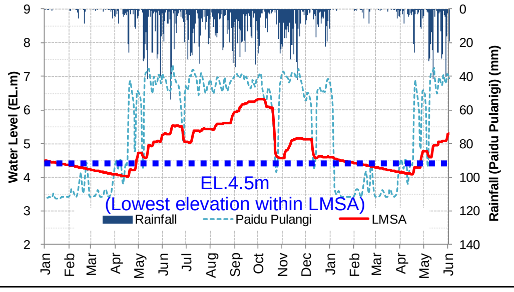
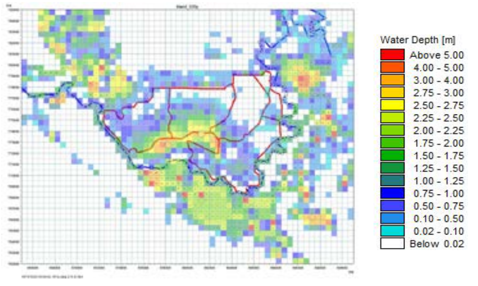
Number of the Sluice	Water Level	Inundation Situation (at the timing with maximum inundation area)
0		
2		
10		
30		
50		
100		

Figure 3.6.8 Water Level and Inundation Situation (Return Period: 20 year)

Source: JICA Survey Team

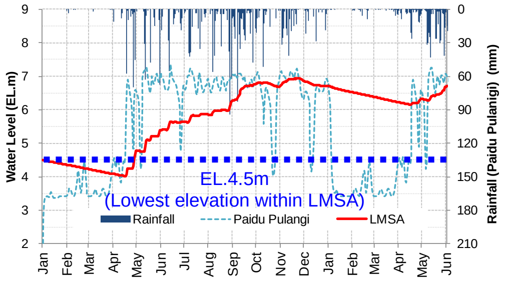
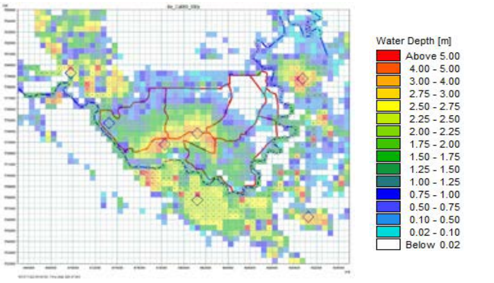
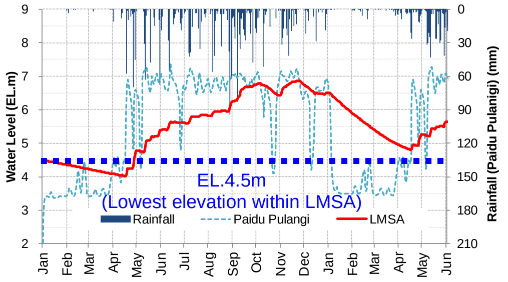
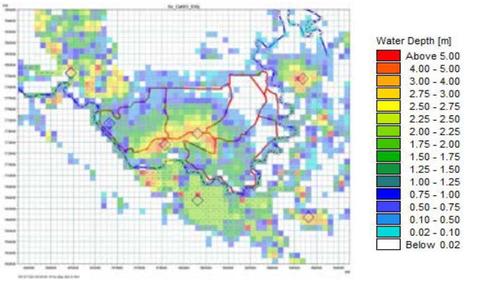
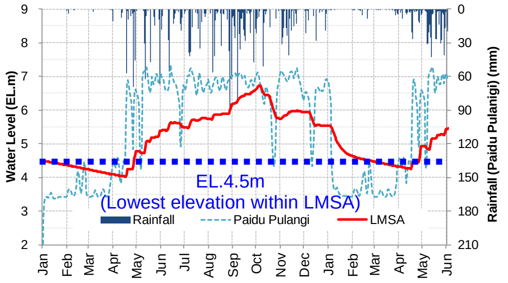
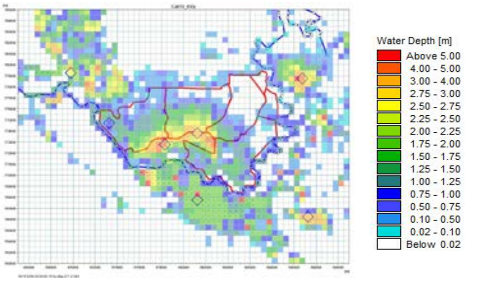
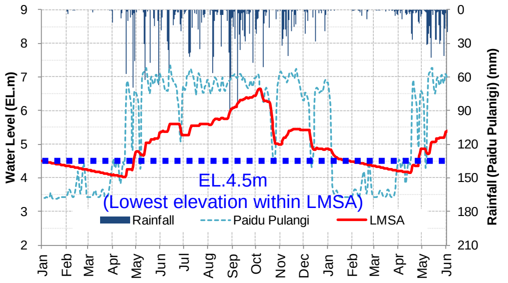
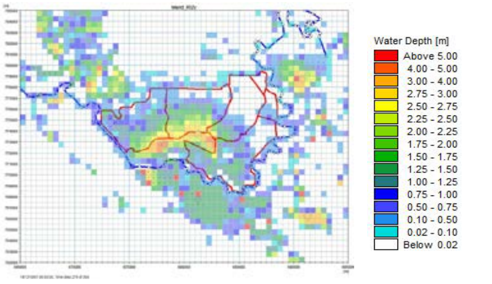
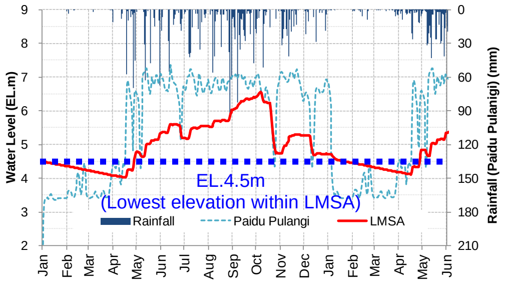
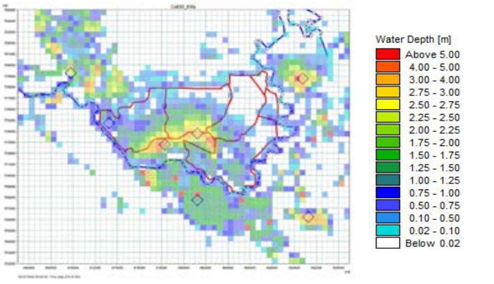
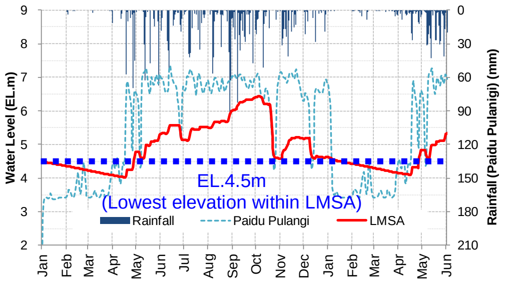
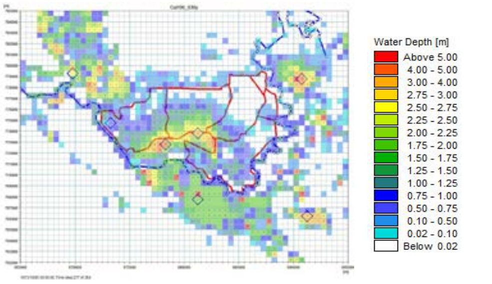
Number of the Sluice	Water Level	Inundation Situation (at the timing with maximum inundation area)
0		
2		
10		
30		
50		
100		

Figure 3.6.9 Water Level and Inundation Situation (Return Period: 30 year)

Source: JICA Survey Team

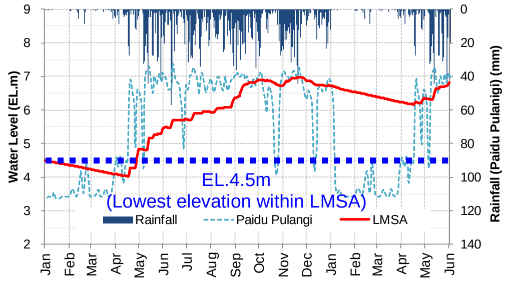
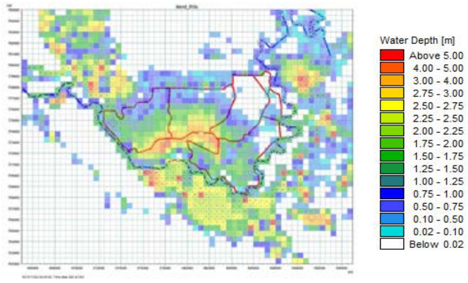
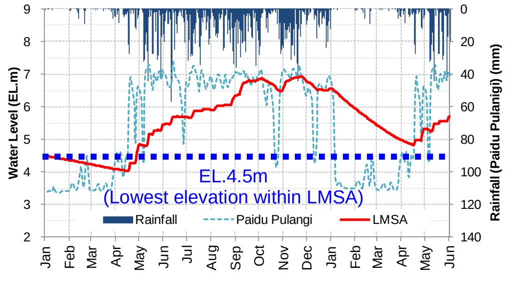
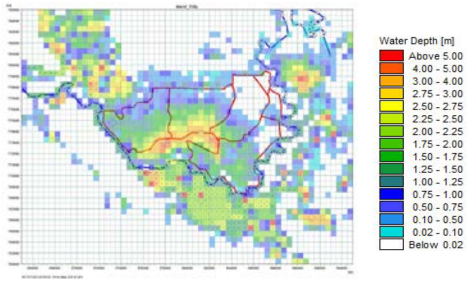
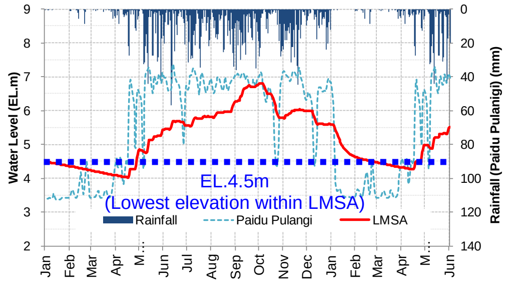
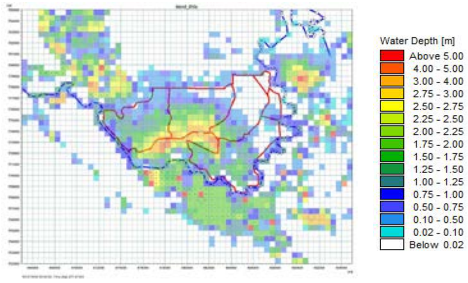
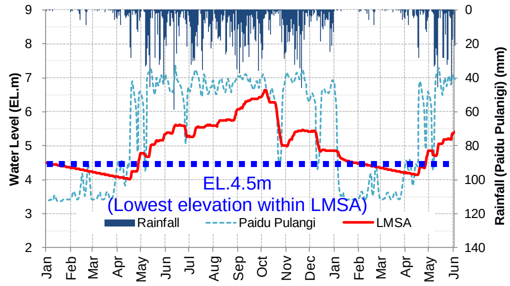
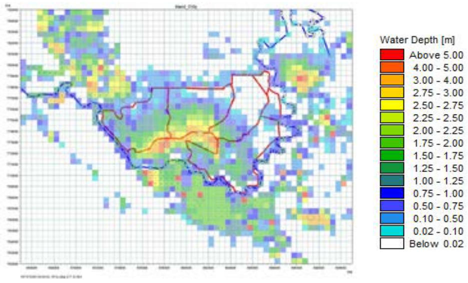
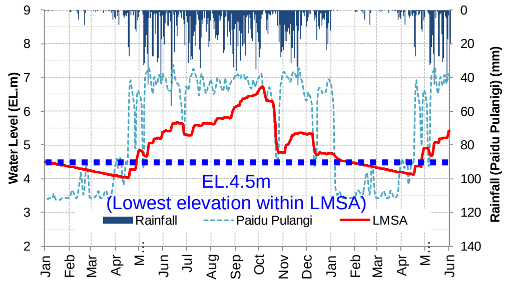
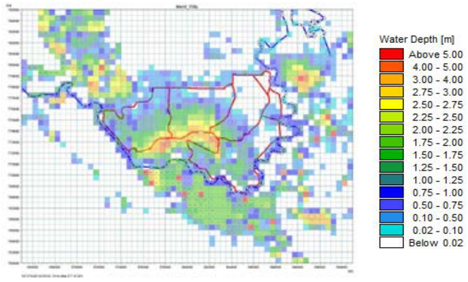
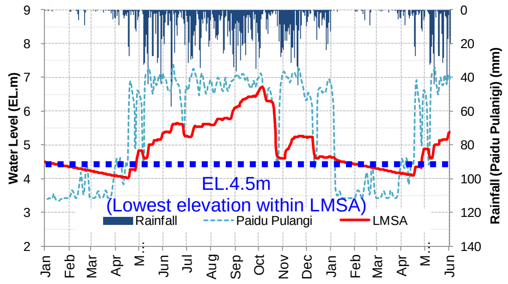
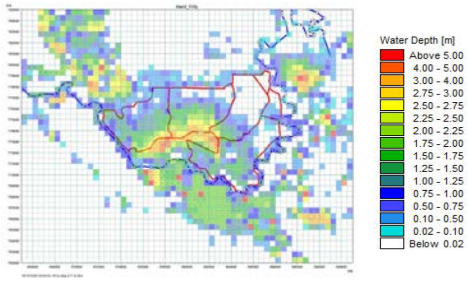
Number of the Sluice	Water Level	Inundation Situation (at the timing with maximum inundation area)
0		
2		
10		
30		
50		
100		

Figure 3.6.10 Water Level and Inundation Situation (Return Period: 50 year)

Source: JICA Survey Team

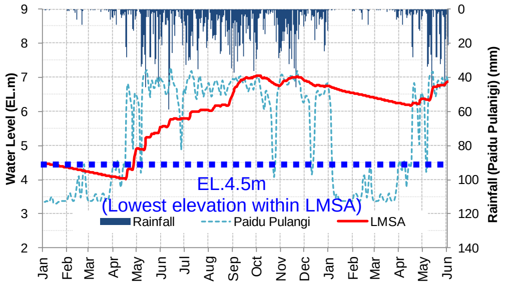
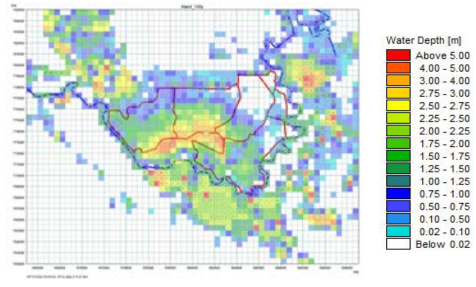
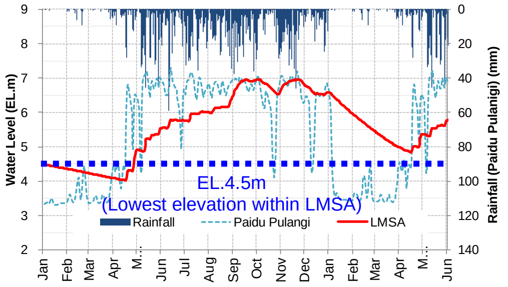
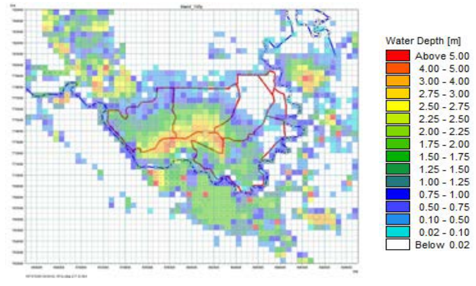
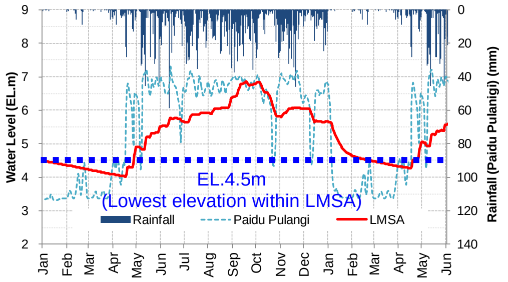
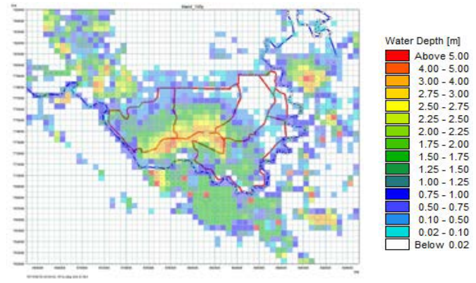
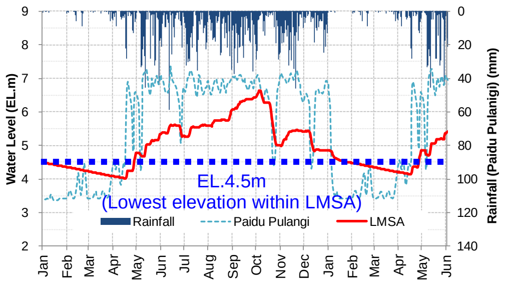
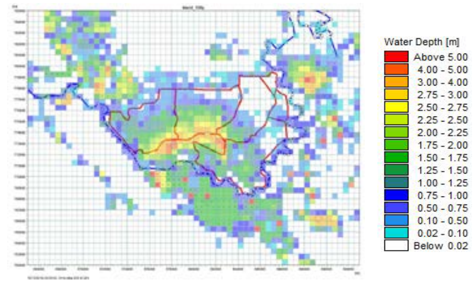
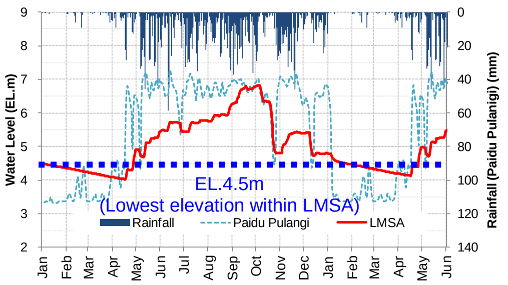
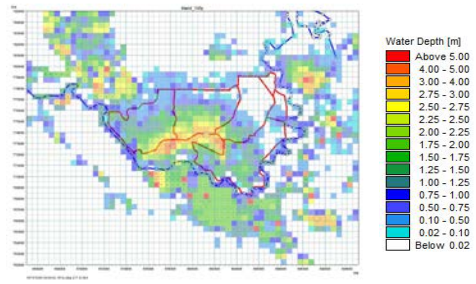
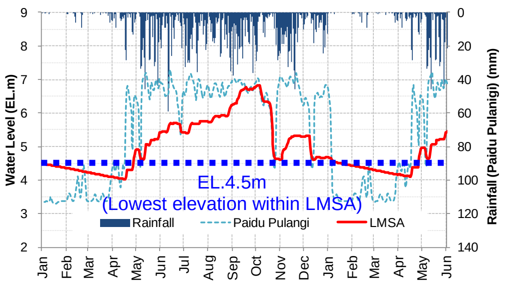
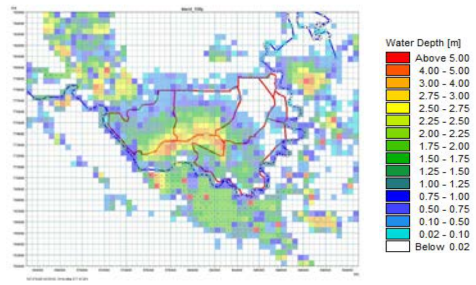
<table>
<tr><th>Number of the Sluice</th><th>Water Level</th><th>Inundation Situation
(at the timing with maximum inundation area)</th></tr>
<tr><td>0</td><td></td><td></td></tr>
<tr><td>2</td><td></td><td></td></tr>
<tr><td>10</td><td></td><td></td></tr>
<tr><td>30</td><td></td><td></td></tr>
<tr><td>50</td><td></td><td></td></tr>
<tr><td>100</td><td></td><td></td></tr>
</table>

Figure 3.6.11 Water Level and Inundation Situation (Return Period: 100 year)

Source: JICA Survey Team

3.6.3 Required Number of the Sluices

Even in a case for 2-year return period (average-year) rainfall, 30 sluices are required to start the agricultural activities according to the planned cropping pattern (see Figure 3.6.12). The inland flood water level shall be lower than EL. 4.5m before the beginning of November which is the timing of land preparation for dry-season rice cropping. If more than 30 sluices are constructed, this condition is achieved. The construction cost for 30 sluices is almost [redacted] PHP ([redacted] JPY) as shown in the Table 3.6.10.

However, the inland flood water level would become 50cm higher than EL. 4.5m at the middle of November (see Table 3.6.4 and Figure 3.6.6). Therefore, it is required to postpone the timing of the land preparation for one month, namely, to the beginning of December.

For the rainy-season cropping from May to October, almost half of the LMSA is under inappropriate condition for cropping due to the inundation (see Table 3.6.4). This situation cannot be solved even though more sluices are installed. To cope with the situation, pumping stations should be constructed, however it is not financially feasible, or otherwise there should be another measure, e.g. dredging.

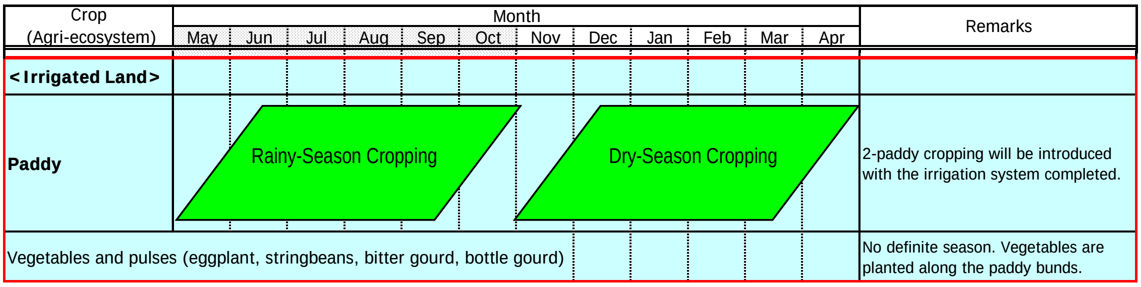


Figure 3.6.12 Planned Cropping Pattern in LMSA (paddy)
Source: JICA Survey Team

Table 3.6.10 Construction Cost (Direct Cost) of the 30 Sluices

Work Items		(1) Quantity	(2) Unit Cost (PHP)*	(3) Total (=(1) x (2)) (million PHP)	(million JPY)	Remarks
Dike	Back Filling of the Dike	[redacted] m^3	[redacted]	[redacted]	[redacted]	Same amount as Table 3.5.6
	Founding Treatment (Sand Compaction Pile Works)	[redacted] piles	[redacted]	[redacted]	[redacted]	Same amount as Table 3.5.6
Sluice	Concrete	[redacted] m^3	[redacted]	[redacted]	[redacted]	154.7m^{3}x 30 Sluices
	Steel Bar	kg				100kg/concrete 1m^3
	Gate (H2.0m x B2.0m)	num				
Drainage Canal	Excavation	[redacted] m^3	[redacted]	[redacted]	[redacted]	
			Sum	[redacted]	[redacted]	

Source: JICA Survey Team
*provided by NIA

3.7 Flood Simulation with/without Dredging

As already mentioned, the dyke would act as a physical border dividing the vicinity area socially and environmentally. Magindanaon ethnic group, a part of Moro group, resides in this region. The dike therefore would make physical and social separation for the dwellers as a boarder. On one hand, dredging work on the Pulangi river can be an effective measure to mitigate or eliminate flood damage without dyke. Therefore, the necessary dredging volume is examined through the flood simulation.

3.7.1 Specific Conditions for Flood Simulation with/without Dredging

1) Basic Concept of the Simulation

The maximum flood water level of the Pulangi river shall be kept lower than EL. 4.5m which is the lowest elevation in the LMSA, to mitigate or eliminate flood damage to the LMSA. Therefore, the target river water level is determined as EL. 4.5m at the Paidu Pulangi in the simulation.

2) Target Sections of Dredging

Target sections of the dredging are from the junction of the Pulangi river and the Tunggol floodway to the junction among the Tamontaka, the Rio Grande de Mindanao, and Pulangi river (see Figure 3.7.1).

3) Target Cross Sections

Dredging shape is examined at the 10 points (see Figure 3.7.1). Among these 10 points, current cross sections at 2 points of the river mouths are kept, while remaining 8 points are reshaped by the dredging. The cross sections between the target points are given by interpolation.

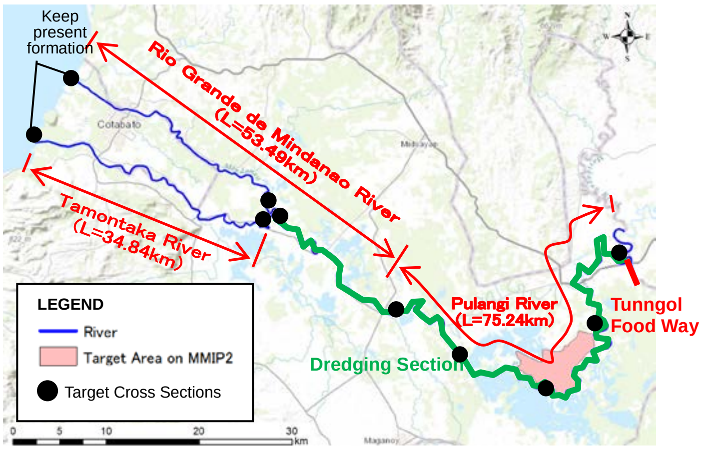


Figure 3.7.1 Dredging Sections and the Target Cross Sections

Source: JICA Survey Team

4) Basic concept of the Dredging

The original cross sections are confirmed based on the result of the bathymetric survey conducted from November 2017 to January 2018. Then, for the effective discharge, the original cross sections are reshaped, changing the shape of cross section by dredging. The methodology of the simulation is the same as the Flood Simulation under the present condition (without dike) except for the shape of the cross sections. Basically, design shape of cross sections after dredging is complied with the following two principles (see Figure 3.7.2).

a) The shape of the cross sections is expanded horizontally

After the bathymetric survey along the Pulangi river, it was found that some of the river bottom along the LMSA is already under sea level. Therefore vertical dredging is considered to have a limited contribution to the drawdown of the river water level due to the back water from the sea.

b) The river is expanded to the left side

River expansion toward the right bank will affect the beneficially area of LMSA. To avoid any interference on LMSA, the LMSA shall not be shaved off by the dredging.

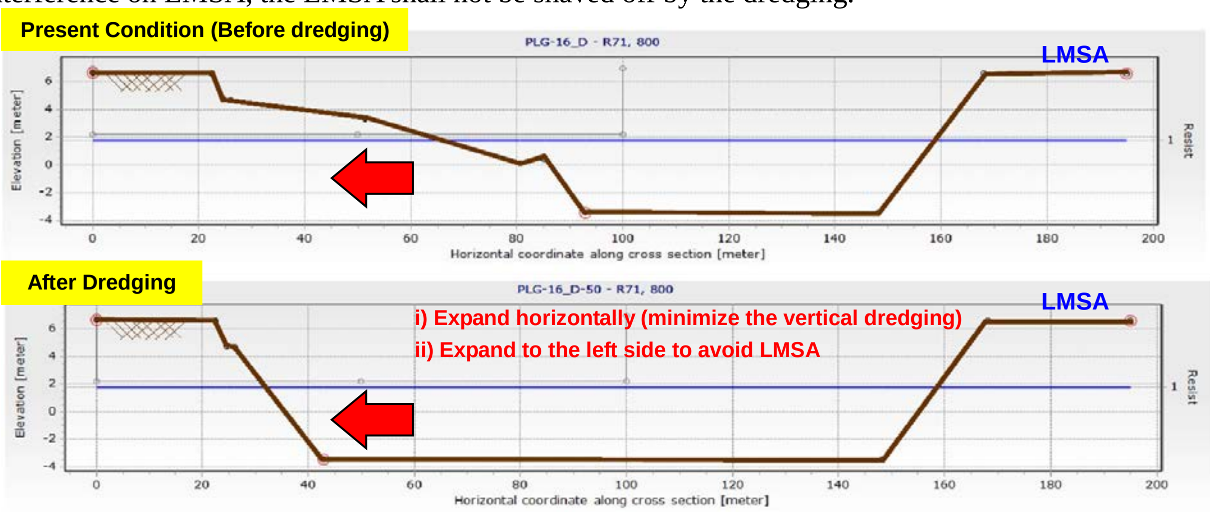


Figure 3.7.2 Example of the Cross Section before and after Dredging

Source: JICA Survey Team

5) Simulation Cases

2-year return period rainfall is the target rainfall and 5 cases, 0(original), 50, 100, 300, 500m dredge expansion are carried out under this rainfall.

Table 3.7.1 Simulation Cases of Flood Simulation with/without Dredging

Probability / Simulation Case	Return Period						Scale of Dredging					Total Case
	2	10	20	30	50	100	0	50	100	300	500	
1. Present Condition (without dike)	○	-	-	-	-	-	○	○	○	○	○	5
2. After Construction of the Dike (With Dike)	-	-	-	-	-	-	-	-	-	-	-	0

Source: JICA Survey Team

3.7.2 Simulation Result

Figure 3.7.3 illustrates the longitudinal profile of the maximum flood water level by each simulation case. The water level tends to be lower as expansion width becomes wider. The result indicates that more than 500m expansion by dredging is required to mitigate the flood damage, which is more than twice width (3 to 5 times for some river sections) of the current river width.

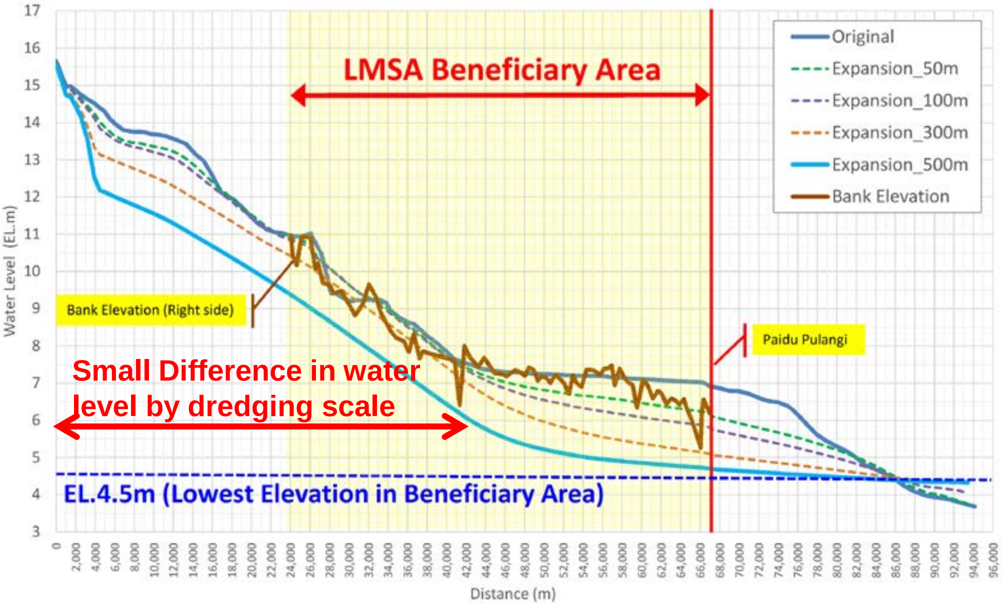


Figure 3.7.3 Longitudinal Profile of the Maximum Flood Water Level

Source: JICA Survey Team

Table 3.7.2 Dredging Amount and Maximum Water Level on the Pulangi River after Dredging

Expansion Width	Dredging Amount	Maximum Water Level on the Plangi river (EL.m)			
		Pagalungan	Barongis	Kabasalan	Paidu Pulangi
Original	-	11.12	7.38	7.29	6.93
50m	44 $m^3 \times 10^6$	11.10	7.24	6.95	6.17
100m	77 $m^3 \times 10^6$	11.07	7.14	6.75	5.81
300m	209 $m^3 \times 10^6$	10.68	6.76	6.24	5.10
500m	345 $m^3 \times 10^6$	9.70	5.83	5.42	4.71

Source: JICA Survey Team

The difference of water level between the original case and other cases up to 300m expansion seems not to be significant on the section of the upstream (see Figure 3.7.3). This is caused by the following reasons;

✓ Under the present condition, the Tunggol Floodway is functioning when a flood event occurs, which limits the discharge volume to the Pulangi river to some extent.

✓ By the dredging, the flow capacity of the Pulangi river is improved. However, because the total flood volume does not change, Pulangi river attracts more water which was discharged to the Tunggol Floodway (therefore, the discharge volume on the Tunggol Floodway becomes drastically small as the expansion width get wider as shown in Figure 3.7.4).

✓ The flood water remains flowing into the Pulangi river, exceeding its capacity until the cases up to 300m dredging expansion. As a result, water level on the Pulangi river does not change much even though the flow capacity of the Pulangi river is improved.

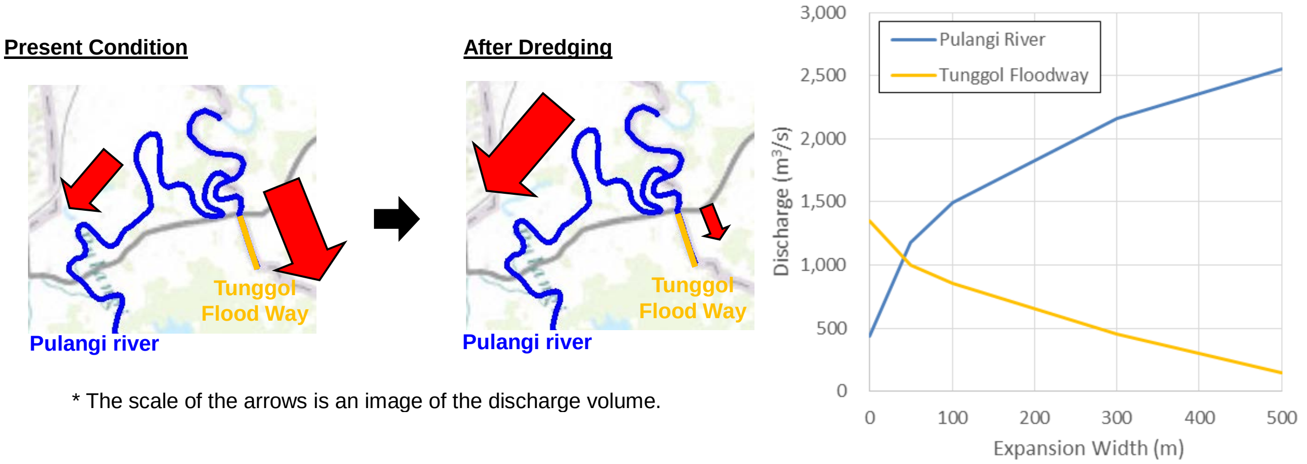


Figure 3.7.4 Change of the Discharge Volume by Dredging
Source: JICA Survey Team

As discussed before, more than 500m river expansion is required to mitigate the flood damage to the LMSA. To achieve this case practically, 345 MCM of the dredging is required and its construction cost is estimated as [redacted] PHP ([redacted] JPY). It is the cost for the dredging to mitigate the flood damage caused by only 2-year return period rainfall.

Table 3.7.3 Construction Cost (Direct Cost) of the Dredging

Work Item	(1) Quantity	(2) Unit Cost (PhP)	(3) Total (=(1) x (2)) (million PhP)	(3) Total (=(1) x (2)) (million JPY)	Remark
Dredging	[redacted] m^3	[redacted]	[redacted]	[redacted]	DPWH's unit cost

Source: JICA Survey Team

The cost mentioned above is dredging cost only. In addition to that, the costs for dehydration, transportation of the dredged soil, land acquisition of disposal pit must be considered. Moreover, it is worthy to say that the cost is estimated based on the case of 2-year return period rainfall, which also means the dredging becomes far more costly.

Furthermore, the purpose of the simulation is designed to consider the LMSA only; therefore the target section for the dredging is until the diversion point of the Tamontaka and the Rio Grande de Mindanao rivers. This means more flood water flows to the downstream of the end of the dredging section after the dredging. If the residential areas and properties along those rivers, such as Cotabato city, should be protected as well, the target dredging section must extend until the river mouths. In that case, additional 70-80km dredging is required, which makes the dredging volume and cost more enormous.

Finally, adverse effect on the Liguasan marsh should also be considered. Because the flood discharge to the Liguasan marsh becomes much smaller (1,354m^3/s under the present condition without dredging and 148m^3/s in case of 500m expansion), the wet area of the Liguasan marsh definitely shrinks.

3.8 Flood Simulation with/without Partial Dredging

According to the results of "3.5 Flood Simulation with/without Dike", low flow capacity at the bottle neck point is considered as one of the main factors, which causes the flood damage to LMSA (see Figure 3.5.6). Therefore, the dredging around the bottle neck point only may be considered as another measure to mitigate flood damage to the LMSA, and flood simulation to examine the effect of this partial dredging is conducted as follows:

3.8.1 Specific Conditions for Flood Simulation with/without Partial Dredging

1) Target Sections of Dredging

Target sections of the dredging are from the PLG-12 which is about 3 km upstream from Paidu Pulangi to RIO-52 that is about 10 km downstream from the Paidu Pulangi and target river length of the dredging comes to about 13 km (see Figure 3.8.1).

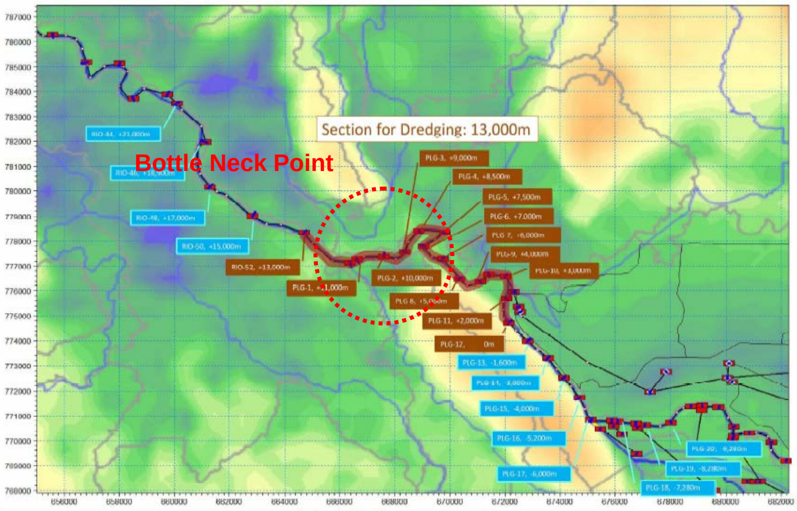


Figure 3.8.1 Target Sections for Dredging

Source: JICA Survey Team

2) Simulation Cases

The target return period for flood volume should be estimated based on the river catchment area with three patterns of return period rainfall; namely, 2-year (average year), 30-year (target period for economic evaluation) and 100-year (target return period prescribed in DPWH's standard) are selected. Further, the flood simulation of such three cases of dredging width as 100m, 200m, 500m are carried out under each of the target return period flood:

Table 3.8.1 Simulation Cases of Flood Simulation with/without Partial Dredging

Probability / Simulation Case	Return Period of Flood			Total Case
	2-year	30-year	100-year	
100m Dredging Expansion	O	O	O	9 Cases
200m Dredging Expansion	O	O	O	
500m Dredging Expansion	O	O	O	

Source: JICA Survey Team

3) Formation of Cross Sections

The cross section formations with each dredging expansion are diverted from those utilized in "3.7 Flood Simulation with/without Dredging".

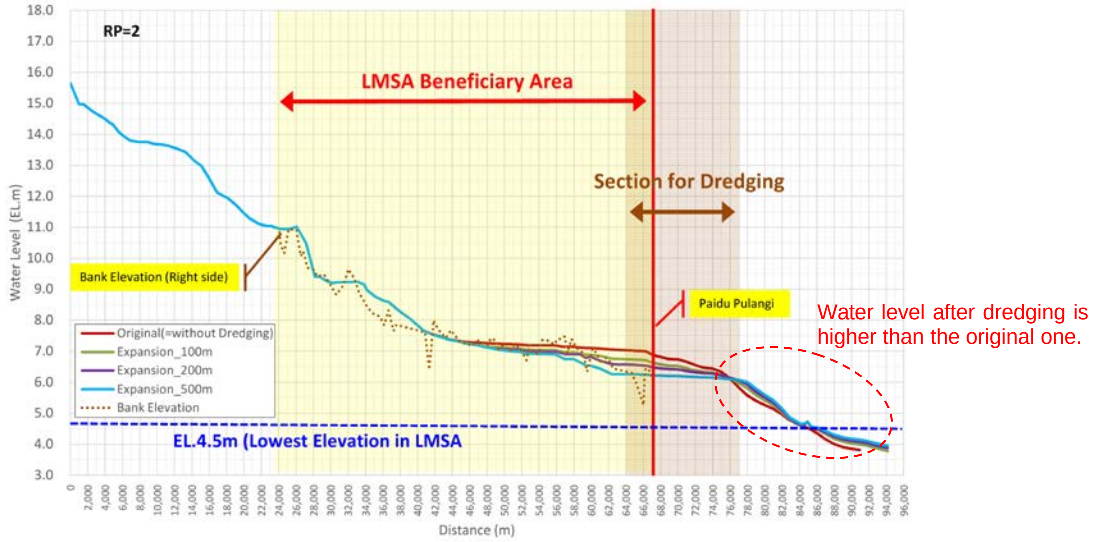
3.8.2 Simulation Result

Figure 3.8.2 illustrates the longitudinal profile of the maximum flood water level of the Pulangi river and Table 3.8.2 shows the maximum flood water level at Paidu Pulangi. The maximum flood water level at Paidu Pulangi in case of the partial dredging is lower than the original one (equal to the without dredging) in all return period floods. However, since the maximum flood level is higher than EL.4.5m, which is the lowest elevation of the LMSA's beneficial area, flood damage in LMSA cannot be mitigated completely. On the other hand, maximum flood water level at the downstream areas of dredging section is higher than the original one.

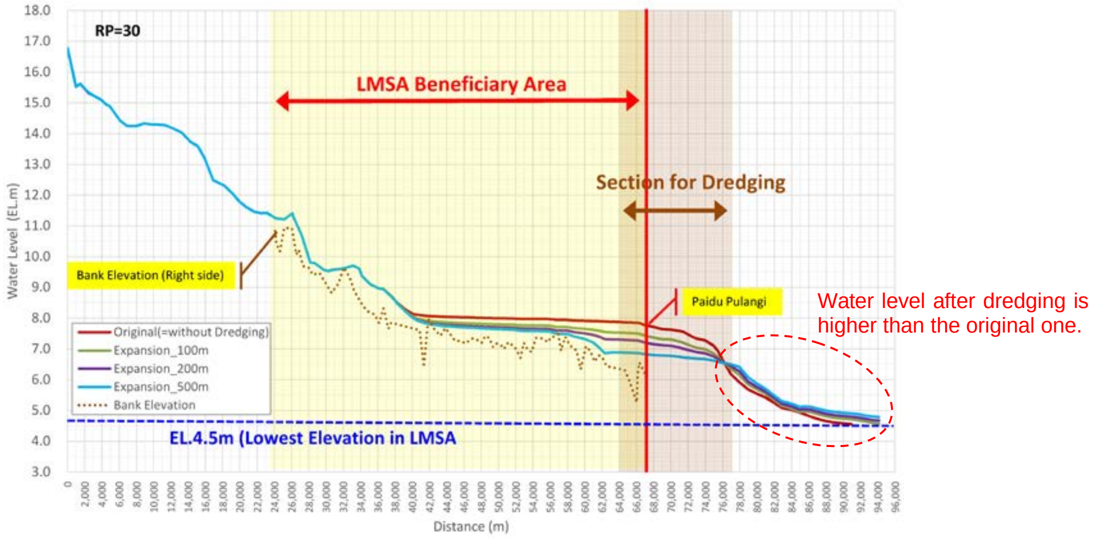
Table 3.8.2 Simulation Results (Maximum Water Level at Paidu Pulangi), Unit: EL. m

Return Period (year)	(1) Original (=without dredging)	(2) After Dredging					
		100m Expansion		200m Expansion		500m Expansion	
		Water Level	Difference from (1)	Water Level	Difference from (1)	Water Level	Difference from (1)
2	6.90	6.64	-0.26	6.49	-0.41	6.23	-0.67
30	7.78	7.44	-0.34	7.21	-0.57	6.83	-0.95
100	8.26	7.93	-0.34	7.69	-0.57	7.27	-1.00

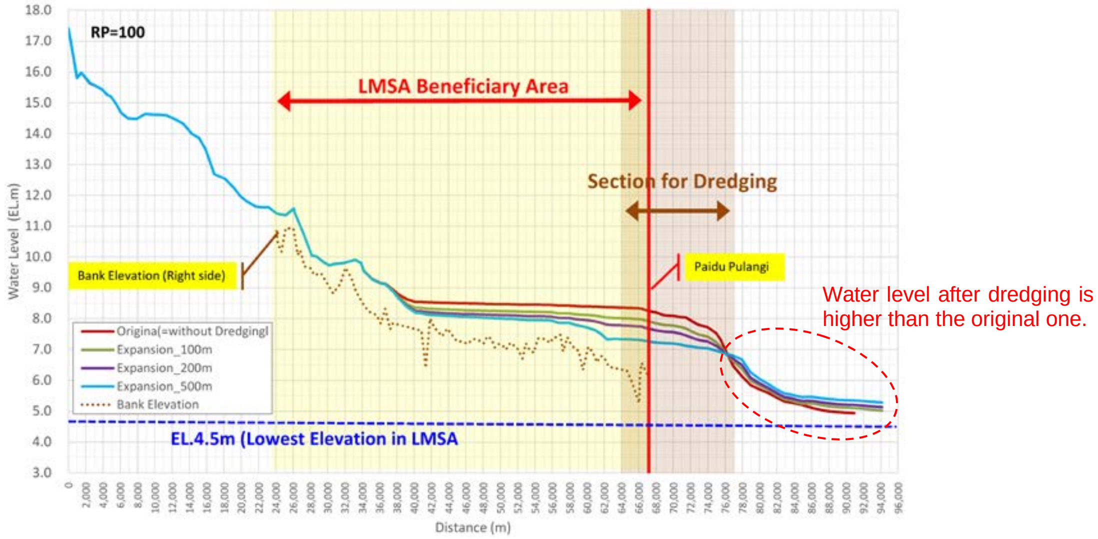
Source: JICA Survey Team



Return Period: 2-year



Return Period: 30-year



Return Period: 100-year

Figure 3.8.2 Longitudinal Profile of the Maximum Flood Water Level of the Pulangi River

Source: JICA Survey Team

Figure 3.8.3 illustrates the maximum inundation area and Table 3.8.3 shows the average water depth in the LMSA. According to the figure and table, maximum average water depth in LMSA becomes to 12 - 50cm lower than the original one (equivalent to without dredging). On the other hand, inundation area and flood water depth at the downstream area of dredging section are bigger than the original ones.

Table 3.8.3 Simulation Results (Average Water Depth in LMSA), Unit: m

Return Period (year)	(1) Original (=without dredging)	(2) After Dredging					
		100m Expansion		200m Expansion		500m Expansion	
		Water Depth	Difference from (1)	Water Depth	Difference from (1)	Water Depth	Difference from (1)
2	1.59	1.47	-0.12	1.42	-0.17	1.40	-0.19
30	2.30	2.08	-0.22	2.00	-0.30	1.91	-0.39
100	2.72	2.47	-0.25	2.36	-0.36	2.22	-0.50

Source: JICA Survey Team

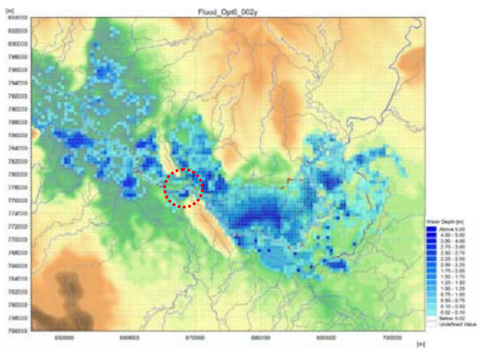
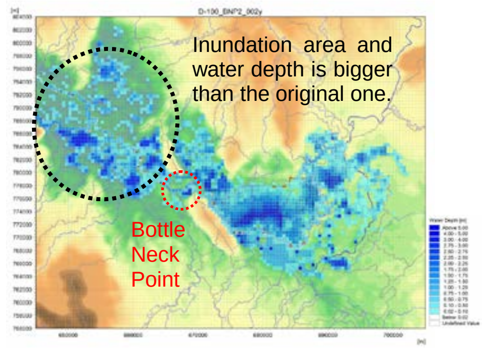
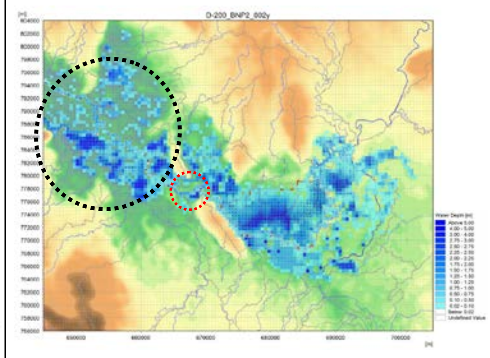
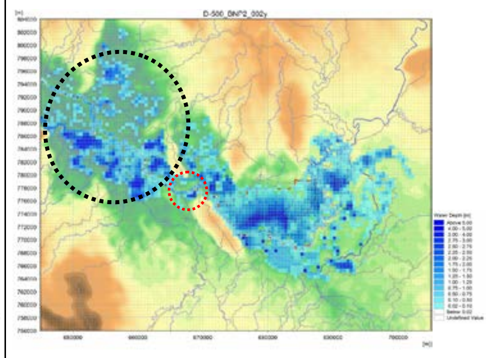
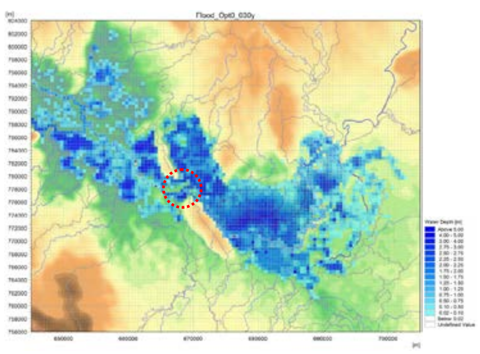
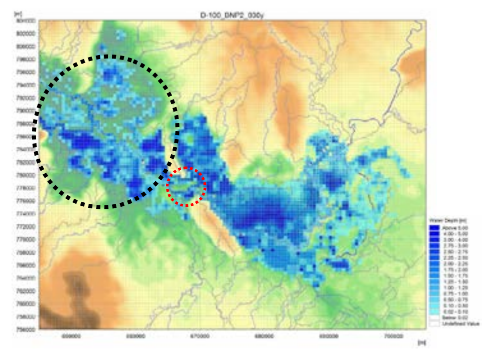
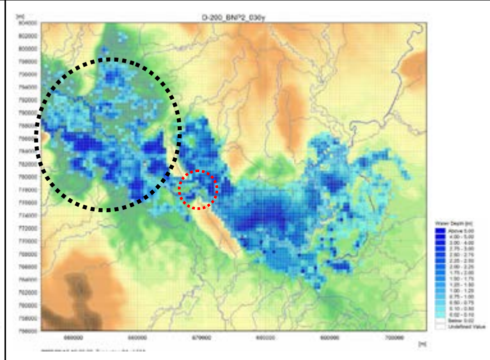
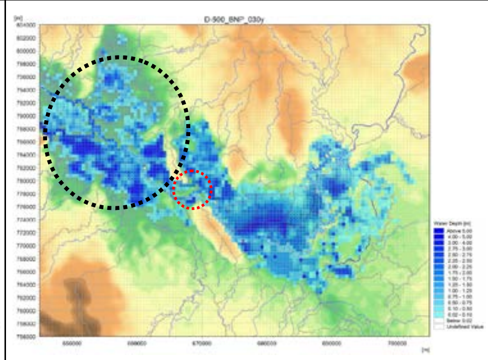
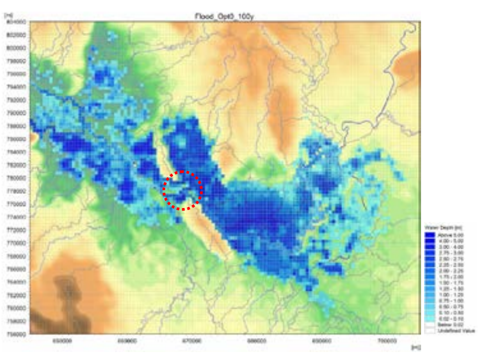
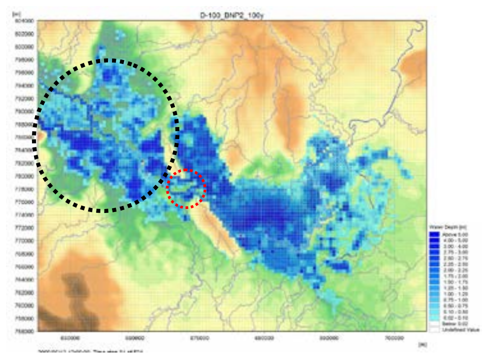
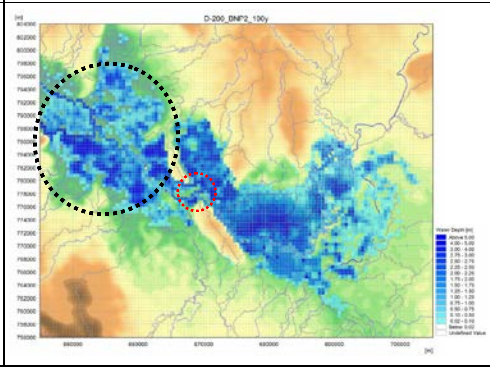
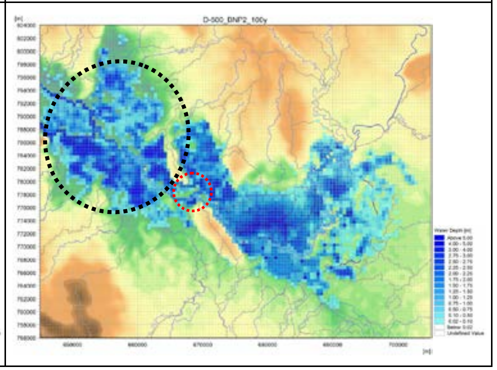
Return Period	Original (without Dredging)	100m Dredging Expansion	200m Dredging Expansion	500m Dredging Expansion
2 year				
30 year				
100 year				

Figure 3.8.3 Simulation Results (Maximum Inundation Area)

Source: JICA Survey Team

3.8.3 Preliminary Economic Evaluation

1) Planted Area increased by Partial Dredging

Based on the i) maximum flood water level at Paidu Pulangi (see Table 3.8.2), ii) decreased average water depth in LMSA by the partial dredging (see Table 3.8.3), and 3) H (elevation) and A (area) relation curve in LMSA utilized in "3.3.3 Inland Inundation Simulation by Simple Rainfall-Evaporation Model" (see Figure 3.8.4), planted area increased by partial dredging is estimated as shown in Table 3.8.4:

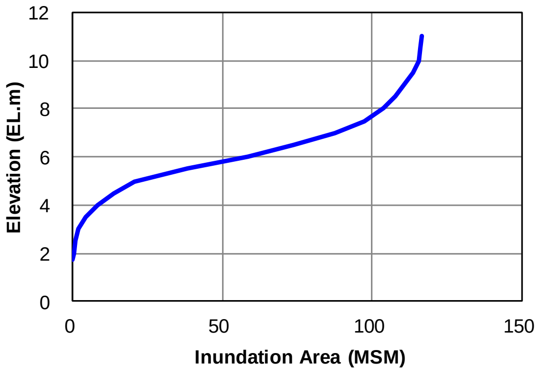


Figure 3.8.4 H-A Relation Curve in LMSA

Source: JICA Survey Team

Table 3.8.4 Planted Area to be Increased by Partial Dredging

Return Period (year)	Expansion Range (m)	(1) Maximum Flood Water Level at Paidu Pulangi (EL.m) (from Table 3.8.2)	(2) Decreased Maximum Average Water Depth in LMSA by dredging (m) (from Table 3.8.3)	(3) Maximum Average Water Depth in LMSA after Dredging (= (1) + (2)) (EL.m)	(4) Planted Area in LMSA with elevation (1) (km^2) (from Figure 3.8.4)	(5) Planted Area in LMSA with elevation (2) (km^2) (from Figure 3.8.4)	(6) Difference of Area from the original one (=increased area) (= (4) – (5)) (km^2)	(7) Area Increasing Ratio (= (6) / (5) x 100) (%)
2	Original	6.90	-	-	84.6	-	-	-
	100	-	-0.12	6.78	-	81.3	3.3	4.1
	200	-	-0.22	6.68	-	78.6	6.0	7.6
	500	-	-0.25	6.65	-	77.7	6.9	8.9
30	Original	7.78	-	-	100.9	-	-	-
	100	-	-0.17	7.61	-	98.7	2.2	2.2
	200	-	-0.30	7.48	-	96.9	4.0	4.1
	500	-	-0.36	7.42	-	95.7	5.2	5.4
100	Original	8.26	-	-	105.9	-	-	-
	100	-	-0.19	8.07	-	104.4	1.5	1.4
	200	-	-0.39	7.78	-	100.9	5.0	5.0
	500	-	-0.50	7.76	-	100.7	5.2	5.2

Source: JICA Survey Team

Expected planted area to be increased by partial dredging can be illustrated in Table 3.8.5 with designed planted area by case which is proposed in consideration with inundated area (see 4.3.2 Development Direction for Lower Malitubog Service Area in MMIP II). Note that in this survey the JICA Team proposes 2 cases for canal network development; namely, 1) Case-1 where the canals within LMSA are to be constructed only within limited area, almost free from flood as well as the inundation not more than 50cm depth, and 2) Case-2 where the irrigation canals are to be constructed as per the original design.

Table 3.8.5 Expected Planted Area Increased by Partial Dredging

Case	Return Period (year)	Expansion Range (m)	(1) Planned Planted Area in LMSA (Wet Season) (ha)	(2) Area Increasing Ratio (%) (from Table 3.8.5)	(3) Planted Area Increased by Partial Dredging (= (1) x (2)), (ha)
With Project Case-1	2	100	2,810	4.1	115
		200		7.6	214
		500		8.9	250
	30	100		2.2	62
		200		4.1	115
		500		5.4	152
	100	100		1.4	39
		200		5.0	141
		500		5.2	146
With Project Case-2	2	100	3,810	4.1	156
		200		7.6	290
		500		8.9	339
	30	100		2.2	84
		200		4.1	156
		500		5.4	206

Case	Return Period (year)	Expansion Range (m)	(1) Planned Planted Area in LMSA (Wet Season) (ha)	(2) Area Increasing Ratio (%) (from Table 3.8.5)	(3) Planted Area Increased by Partial Dredging (= (1) x (2)), (ha)
	100	100		1.4	53
		200		5.0	191
		500		5.2	198

Note: the planned planted area would vary, in essence, according to the return period of flood. However, in this simple estimation of the increased planted area by partial dreading, same planted area is applied in view of simplicity of the estimation.
Source: JICA Survey Team

2) Construction Cost of Partial Dredging

Required dredging volume, its construction cost (direct cost) and unit construction cost per ha to be increased by partial dredging are summarized in Table 3.8.6. At least [redacted] PhP/ha should be necessary and this value is much higher than [redacted] PhP/ha which was original development cost of MMIP II estimated based on the approved project cost. Additionally, cost in Table 3.8.6 is dredging cost only, and the cost for other work items such as dehydration, transportation of the dredged soils, land acquisition of disposal areas are not considered. In this case, construction cost becomes much higher than the value in the Table 3.8.6. Therefore the partial dredging works to mitigate flood damage to LMSA is judged not to be economically feasible.

Table 3.8.6 Construction Cost (Direct Cost) of the Dredging

With/ Without Project	Return Period (year)	Expansion Range (m)	(1) Required Dredging Volume (million m^3)	(2) Unit Cost (PhP)	(3) Construction Cost of Dredging (million PhP)	(4) Planted Area Increased by Partial Dredging (ha) (from Table 3.8.5)	(5) Construction Cost per ha (= (3) / (4)) (million PhP / ha)
With Project Case-1	2	100	11.9	[redacted]	[redacted]	115	[redacted]
		200	23.9		[redacted]	214	[redacted]
		500	59.7		[redacted]	250	[redacted]
	30	100	11.9		[redacted]	62	[redacted]
		200	23.9		[redacted]	115	[redacted]
		500	59.7		[redacted]	152	[redacted]
	100	100	11.9		[redacted]	39	[redacted]
		200	23.9		[redacted]	141	[redacted]
		500	59.7		[redacted]	146	[redacted]
With Project Case-2	2	100	11.9		[redacted]	156	[redacted]
		200	23.9		[redacted]	290	[redacted]
		500	59.7		[redacted]	339	[redacted]
	30	100	11.9		[redacted]	84	[redacted]
		200	23.9		[redacted]	156	[redacted]
		500	59.7		[redacted]	206	[redacted]
	100	100	11.9		[redacted]	53	[redacted]
		200	23.9		[redacted]	191	[redacted]
		500	59.7		[redacted]	198	[redacted]
Unit construction cost per 1 ha according to the NEDA Approved Budget							[redacted]

Note: the planned planted area would vary, in essence, according to the return period of flood. However, in this simple estimation of the increased planted area by partial dreading, same planted area is applied in view of simplicity of the estimation.
Source: JICA Survey Team

3.9 Flood Simulation with the Ambal-Simuay River and Rio Grande de Mindanao Flood Control Projects

DPWH has a project plan namely the “Ambal-Simuay River and Rio Grande de Mindanao Flood Control Projects”. This project aims to protect Cotabato city from flood with the following two measures:

1) Cutoff channel: This channel works to divert a part of flood water of the Ambal-Simuay River to the sea, whereby reducing flood water flowing over to the Cotabato city.

2) Diversion access road: This diversion access road works to store flood water from the Rio Grande de Mindanao River to in order to reduce flood water flowing into the Cotabato city.

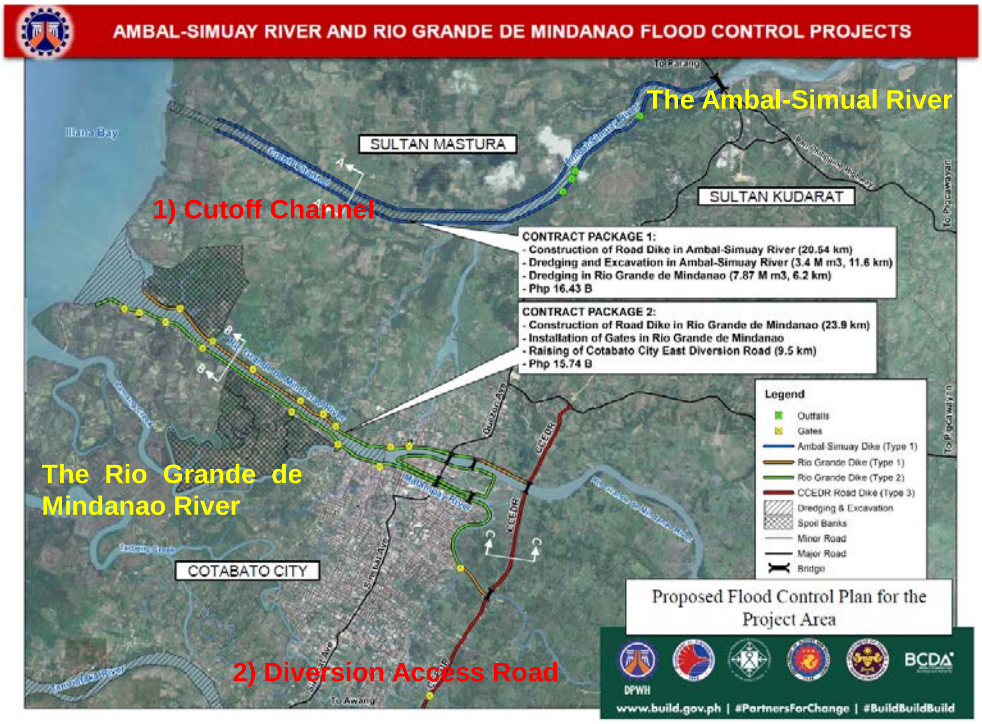
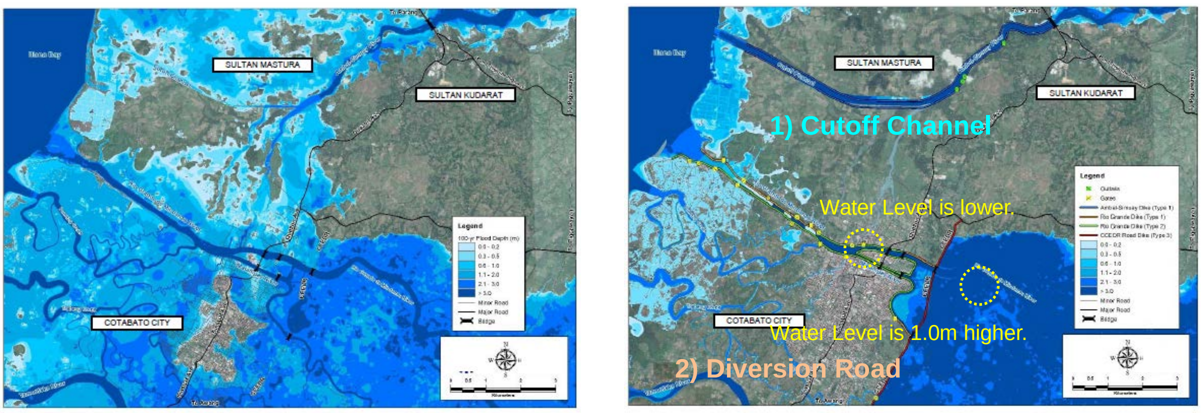


Figure 3.9.1 General Plan of the Ambal-Simuay River and Rio Grande de Mindanao Flood Control Projects

Source: DPWH presentation material

According to the results of flood simulation by DPWH, almost all the flood damage on the Cotabato city could be eliminated after implementation of this DPWH's project, composed of 1) cutoff channel which functions as flood diversion water-course, and 2) the embankment of diversion access road.

While it can be said that DPWH's project would act in the direction of reducing the flood water level in the Ria Grande de Mindanao near Cotabato city, it could raise the water level of Pulangi river due to the embankment of diversion access road to be constructed at the upstream of Cotabato city. Flood water level of the Rio Grande de Mindanao River at the downstream side of the diversion road will be lowered than the present ones. On the other hand, flood water level at the upstream side of the diversion road would be higher by 1.0m than that of the present condition according to the simulation by DPWH. Due to this situation, flood water level of the Pulangi River would be higher than that of current ones.



Present Condition After Implementation of the Project

Figure 3.9.2 Results of Flood Simulation under Present Condition and after Implementation of the DPWH's Project

Source: DPWH presentation material

Therefore, in order to assess the impact by the DPWH project on the water level of the Pulangi river, flood simulation after the implementation of this project is carried out in the following sections:

3.9.1 Specific Conditions for Flood Simulation with the Ambal-Simuay River and Rio Grande de Mindanao Flood Control Projects

1) Boundary Condition

As already discussed, flood water level at the upstream side of the diversion road would become 1.0m higher than the present condition's one. As it is difficult to reproduce the DPHW's simulation results, simulation model having adjusted boundary condition, which makes flood level at the diversion road point 1.0m higher than the present one, is to be employed.

2) Flood Protection Dike for LMSA

To compare the flood condition under present condition and after implementation of DPHW's project, a model without flood protection dike for LMSA is utilized.

3) Target Flood

100-year return period flood is selected as it is prescribed in the DPWH's standard as the target flood for design.

3.9.2 Simulation Result

Figure 3.9.3 illustrates the longitudinal profile of the maximum flood water level of the Pulangi river. Even water level at the diversion road point is 1.0m higher than that of the current condition, the maximum flood water level at Paidu Pulangi would be only 4.6cm (=8.310m – 8.264m) higher. Also Table 3.8.2 shows the average flood water depth in LMSA and in this case it is only 4.0cm higher that the current flood water level. Based on these results, the" Ambal-Simuay River and Rio Grande de Mindanao Flood Control Project" would work in the direction of raising up flood water level in and around LMSA, however its impact is very limited, only 4cm higher, whereby actual impact would not be recognized.

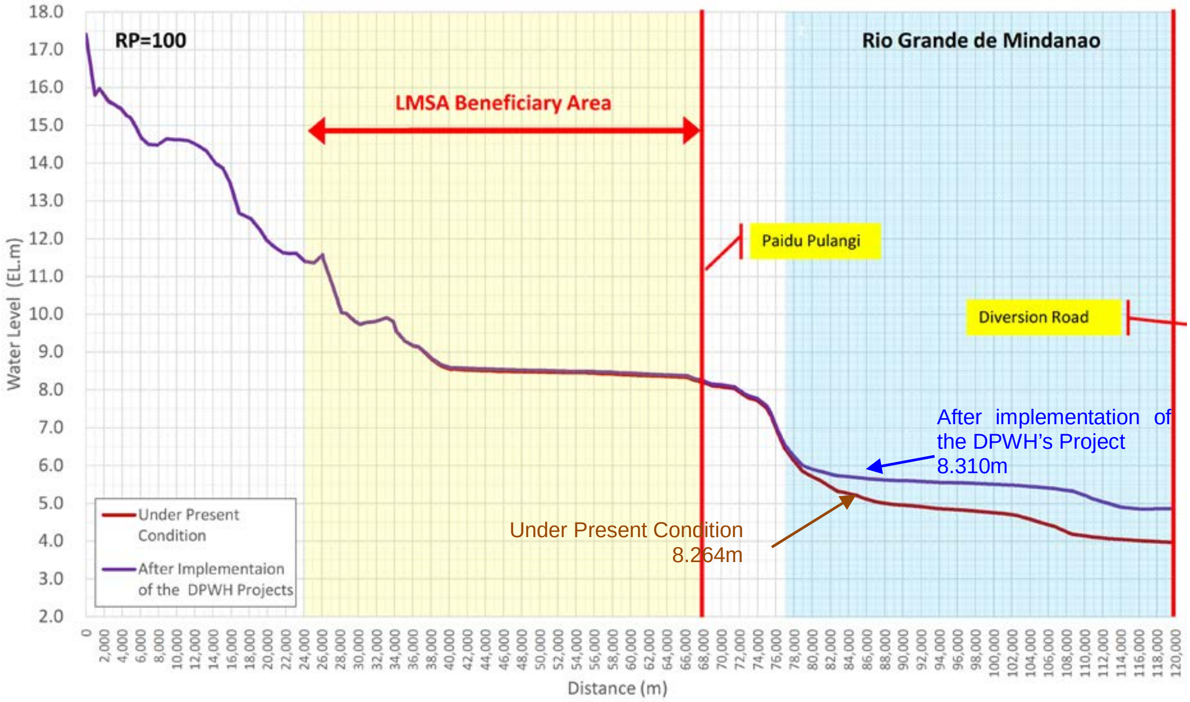


Figure 3.9.3 Longitudinal Profile of the Maximum Flood Water Level of the Pulangi River

Source: JICA Survey Team

Table 3.9.1 Simulation Results (Average Water Depth in LMSA)

Location	Average Water Depth (m)		Difference (= (2) - (1)) (m)
	(1) Under Present Condition	(2) After the DPWH's Projects	
LMSA	2.65	2.69	0.04
Liguasan Marsh	1.05	1.11	0.06

Source: JICA Survey Team

3.10 Conclusion of the Simulations

As conclusion, the results of the four simulations are summarized as below:

1) Impact on the Liguasan Marsh by the Dike Construction

- ✓ The dike would expand the inundation area by 19% to 34% and make the flood water level higher by 65cm to 81cm in the Liguasan Marsh.
- ✓ The required height of the dike shall be 50cm higher than the original NIA design. In this case, construction cost (direct cost) comes to [redacted] PHP ([redacted] JPY).
- ✓ Dike might act as the physical border dividing the vicinity area socially and environmentally.
- ✓ There are residents living along the right side of the Pulangi river and therefore resettlement of these residents will be required to construct the dike.

2) Impact on the LMSA by the Dike Construction

- ✓ The dike would have a significant impact on the beneficially area in LMSA, but dike will cause inland flood originating from rainfall within the LMSA.
- ✓ Even to eliminate the inland flood in the rainy season in case of 2-year return period, 30 sluices should be installed as drainage structures. In this case, construction cost (direct cost) including dike construction is estimated at [redacted] PHP ([redacted] JPY).
- ✓ Even if 30 sluices were installed, almost a half of the LMSA could be still inundated during the rainy-season cropping season due to inland flood. This is because that the water level on the Pulangi river remains higher than the inland water level in the LMSA throughout the rainy season. It is, therefore, difficult to drain the inland flood water to the Pulangi river. Further to mitigate the inland flood, a pumping station should be considered, which is not feasible economically as the drainage facilities.
- ✓ Such inundation originating in the rainfall would affect the commencement of the dry season cultivation as well. Even if 30 sluices were installed to mitigate the rainy season inland flooding, commencement of the land preparation for the dry-season cropping should be postponed by one month than the standard cropping timing, waiting for some time till when the land can be ready for the dry season cropping.

3) Impact on the LMSA and Liguasan Marsh by the Dredging

- ✓ Even to mitigate the damage to the LMSA by flood in case of the 2-year return period rainfall, 345 million cum dredging (expansion width becomes 500m) is required for whole stretch of the Pulangi river. In this case, construction cost (direct cost) is estimated as [redacted] PHP ([redacted] JPY). Since it is only for the dredging, the total cost including other work items such as dehydration, transportation of the dredged soil, land acquisition for disposal areas will be further increased.
- ✓ If the target return period is more than 2-year and/or when it is needed to think compensation for loss of the properties along the Tamontaka and the Rio Grande de Mindanao rivers to be included

as the protection target, dredging volume and construction cost become enormous. In addition, land acquisition and resettlement are required for dredging and for treating dredged mud, causing further increase in the cost.

- ✓ Adverse effects on the Liguasan marsh cannot be negligible because the flow depth becomes much smaller. This may cause dry out of the marsh to some extent, change of the ecosystem of the Pulangi river as well as Liguasan march, possibly affecting the fishing industry.

4) Impact on the LMSA by the Partial Dredging around the Bottle Neck Point

- ✓ The effect of the partial dredging to mitigate flood damage to LMSA is very limited.
- ✓ Partial dredging causes more serious flood damage at the downstream area of the dredging section/reach than the original one.
- ✓ As unit construction cost for the dredging ([redacted] PhP/ha) is much higher than [redacted] PhP/ha, which is the unit investment cost per beneficial area estimated based on the MMIP II NEDA approved project cost. Dredging works applied partially for the bottleneck point to mitigate the flood damage to LMSA cannot still be economically feasible.

5) Impact on the LMSA by the DPWH's Project namely Ambal-Simuay River and Rio Grande de Mindanao Flood Control Projects

- ✓ Cutoff channel would act to lower the flood water level of the Rio Grande de Mindanao River; however at the same time the embankment of diversion access road would act to raise up the water level of Pulangi river.
- ✓ Totally, average flood water level in LMSA would go up by this DPWH's project; however its impact is very limited as average flood water level within the LMSA would go only 4cm.