MEMORANDUM OF AGREEMENT

KNOWN ALL MEN BY THESE PRESENTS:

This **MEMORANDUM OF AGREEMENT (MOA)** entered into by and between the **DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES (DENR)** Regional Office IV-A with office address at DENR IV-A (CALABARZON) Compound, Brgy. Mayapa, Calamba City, Laguna represented by **GILBERT C. GONZALES, CESO III** in his capacity as Regional Executive Director **(RED)** hereinafter referred to as the "**FIRST PARTY**".

AND

BATANGAS STATE UNIVERSITY with office address at Rizal Avenue, Extension, Batangas, 4200 Batangas represented herein by **TIRSO A. RONQUILLO, Ph.D.** in his capacity as President herein referred to as "**SECOND PARTY**".

WITNESSETH

WHEREAS, under the Supreme Court decision with GR Nos 171947-48, dated December 19, 2008, the DENR is tasked to lead in the rehabilitation, clean up and preservation of Manila Bay, to restore and maintain its water SB level;

WHEREAS, the DENR, as the primary government agency responsible for the protection, conservation, management and rehabilitation of the environment and natural resources, DENR through Manila Bay Site Coordinating and Management Office (MBSCMO) is tasked to implement activities to rehabilitate and restore the rivers in the Province of Laguna;

WHEREAS, the DENR-Provincial Environment and Natural Resources Office (PENRO) Laguna identified Saran River, San Juan River and San Cristobal River as priority rivers for the rehabilitation activities under the Manila Bay Rehabilitation Project, hence, a Geographic Information System (GIS)-based river profiling of the above-mentioned rivers is necessary to further guide in the implementation of activities and to provide vital information that they can use as recommendation to the concerned Local Government Units (LGUs); and

WHEREAS, the **BATSTATEU** is a duly recognized state university that has a deep concern to protect, conserve and enhance the natural resources and environment and willing to become a partner of the DENR.

WHEREAS, BATSTATEU has the expertise, experience and capability to undertake the GIS mapping and characterization and DENR Reg. IVA wishes to engage the SUC's services for this purpose;

NOW THEREFORE, for the consideration of the above premises, the both **PARTIES** agree as follows:

A. OBLIGATIONS OF THE PARTIES

The **FIRST PARTY** shall perform the following activities for the GIS-based river profiling such as:

a. Provide/allocate funds in the amount of **SIX HUNDRED THOUSAND PESOS ONLY (₱600,000.00)** to cover the expenses of the material and labor cost for the GIS-based River Profiling within the stretch of Saran River in Los Banos, Laguna and San Juan River in Calamba City, Laguna and San Cristobal River covering the cities of Calamba, Cabuyao and Sta. Rosa in Laguna per attached in the approved Work Program;

b. Designate an MBSCMO Laguna personnel that will supervise and monitor the work of the SECOND PARTY;

c. Accept the accomplishment of the SECOND PARTY after validation/inspection of the completed works/outputs by its Inspection and Acceptance Committee; and

d. Pay the SECOND PARTY based on the terms of payment provided below.

The **SECOND PARTY** shall perform the following activities for the GIS-based river profiling such as:

a. Provide/undertake the labor component in the GIS-based River Profiling of Saran River, San Juan River and San Cristobal River in Province of Laguna in accordance with the approved Work Program hereto attached and marked as Annex "A" which form an integral part of this contract;

b. Specifically, they shall undertake the following activities:
   1. Mobilization;
   2. Coordination with necessary organizations and LGUs;
   3. Data Collection; and
   4. Data Processing

c. Submit its Accomplishment Report and Billing Statement to DENR for payment in accordance with the terms of payment prescribed below.

B. TERMS OF PAYMENT

The activity rendered by the SECOND PARTY shall be paid in the following schedule:

Budgetary Requirement	Expected Output	Duration
40% of the total amount	- Geophysical location - Topography/Geo-morphological features - Geology - Validated Land-use Maps - Hydrologic data of the watershed - Visualized hydrologic features of the watershed - Initial accomplishment report	60 days after the issuance of the Notice to Proceed (NTP)
55% of the total amount	- Solid waste generation/report information of barangays and municipalities within the catchment - Solid waste management of barangays and municipalities within the catchment - Wastewater generation and management of barangays and municipalities within the catchment - ISF Maps - Political boundaries of the watershed - Report about the population estimates within the catchments - Report about the economic activities and priorities of cities and municipalities within the catchments - Thematic Maps	90 days after the submission of initial accomplishment report
5% of the total amount	Final Terminal Report	Upon completion of the project and acceptance of the final

		terminal report of the project

This contract is subject to the withholding of government tax based on gross amount billed. Any excess amount or activities over the approved Work Program and Approved Budget of the contract shall be for the account of the "SECOND PARTY".

C. CONTRACT DURATION

The work herein contracted shall commence upon the issuance of the Notice to Proceed (NTP) and shall be completed within the next one hundred eighty (180) working days.

A. LIMITATION AND LIABILITY

Both parties shall not hold each other liable for any damages/losses to their persons or property caused by a THIRD PARTY in the course of the project. However, should the damages occur due to the negligence of the party, then said damages will be charged to the account of the party at fault after proper determination. Provided further, that any damages/losses to persons or property of a THIRD PARTY due to the negligence of either party to this agreement during the course of the project will be charged to the account of the party at fault after proper determination. Provided finally, that damages/losses caused by a THIRD PARTY, by omission or negligence should be charged against such THIRD PARTY.

B. Amendments

Any amendment to this Agreement shall be effected only on the basis of written mutual consent by the parties.

C. Effectivity

This agreement shall take effect upon signing and shall remain in full force and in effect for a period of one (1) year unless otherwise revoked, revised, or amended upon express mutual agreement by all parties hereto.

IN WITNESS WHEREOF, the parties have hereunto set their hand this ____________ at DENR, Los Baños, Laguna.

DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES (DENR)

GILBERT C. GONZALES, CESO III
Regional Executive Director/First Party

BATANGAS STATE UNIVERSITY (BatStateU)

TIRSO A. RONQUILLO, Ph.D.
President/Second Party

Certified Fund Availability:

MELANIE C. GARCIA
Accountant III

WITNESSES

RONILO L. SALAC
PENR Officer, Laguna

ROMEL U. BRIONES, Ph.D.
Director for Research/Project Leader

REPUBLIC OF THE PHILIPPINES)
CITY OF CALAMBA) S.S.

ACKNOWLEDGEMENT

BEFORE ME, a Notary Public for and in ________, on this ___ day of ________ 2020 appeared the following persons with their respective Community Tax Certificates (CTC) number, dates and places of issuances stated across their names:

NAME	CTC NO.	DATE ISSUED	PLACE ISSUED
Gilbert C. Gonzales	135-026-049		
Tirso A. Ronquillo	633-420-000		

are known to me and the same persons who executed the foregoing instrument and acknowledged to me that the same is their free and voluntary act and deed, as well as those of the offices they represent.

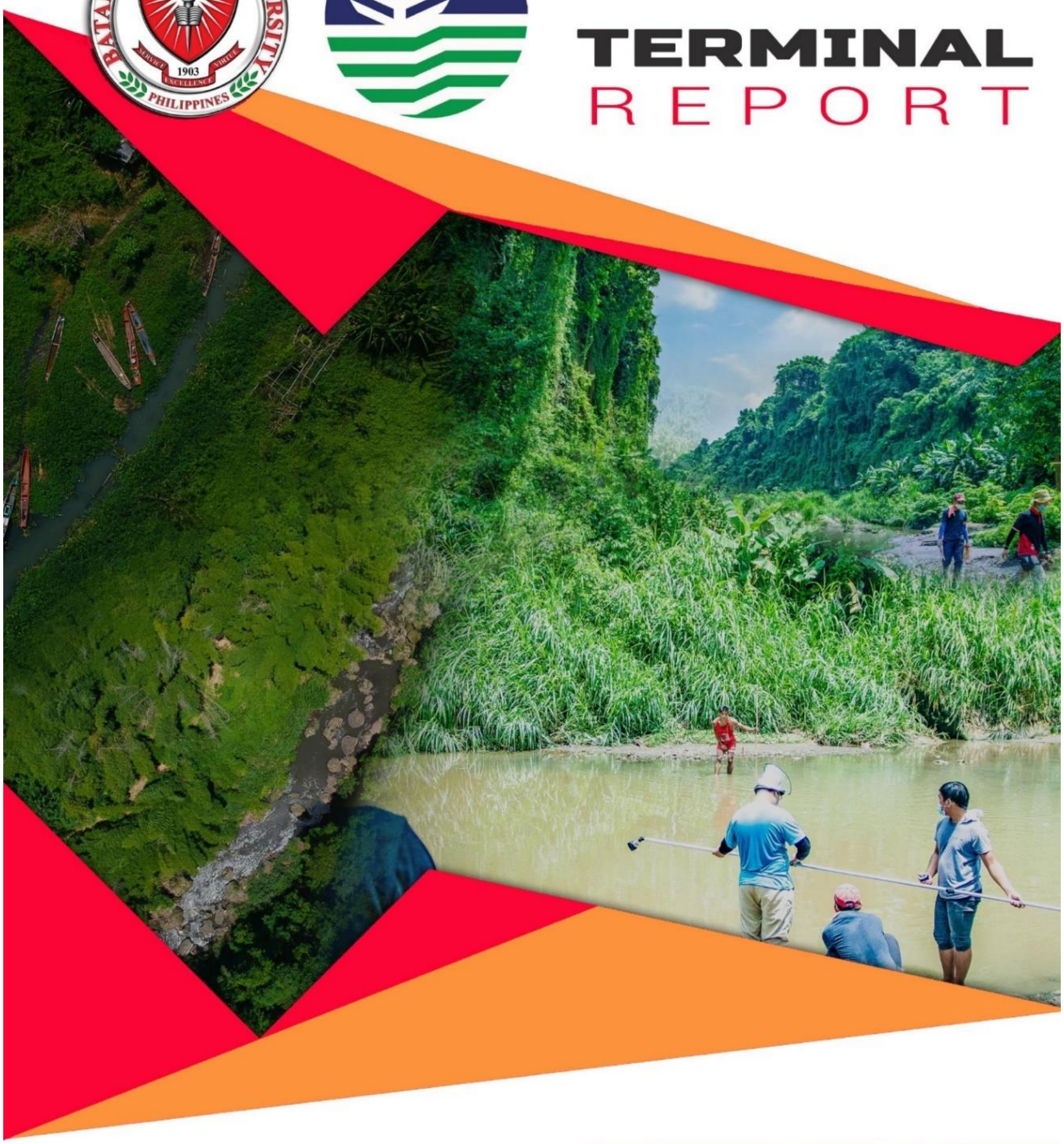
This instrument, consisting of four (4) pages, including this page on which this Acknowledgement is written, refers to the agreement between the DENR and the Batangas State University and has been signed by the parties and their witnesses on each and every thereof.

IN WITNESS WHEREOF, I hereby affixed my signature and notarial seal on the date and in place above written.

Doc. No. 6
Page No. 7
Book No. I
Series of 2020

EDGARDO T. LOPEZ
Notary Public
Roll No. 34482
IBP Lifetime No. 02504
PTR No. ________
MCLE Compliance No. VI-________ 2022
My Commission Expires 31, Dec. ________

TERMINAL REPORT



GIS-based River Profiling

of Saran River, San Juan River, and San Cristobal River in the Province of Laguna

Leading Innovations Transforming Lives

Manila Bay Site Coordinating Management Office Laguna (MBSCMO)
Provincial Environment and Natural Resources Office (PENRO), Laguna Philippines
Department of Environment and Natural Resources (DENR)

Preferred citation:

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TABLE OF CONTENTS

	Page
List of Tables	**iii**
List of Figures	**ix**
Executive Summary	**xix**
I. Introduction	**1**
A. Background	1
B. Map of River System	4
C. Objectives	8
II. River Profile	**8**
A. Physical Characteristics of the River	8
1. Geomorphological Features	9
2. Climate	21
3. Land Classification	28
4. Geology	31
6. Water Quality	40
7. Flora and Fauna	55
B. Major Tributaries within the River System	68
C. Covered City/Municipality Profile	86
1. Population and Land Area of the Barangays in the Municipality Covered in the River System	86
2. Land Use Classification	96
4. Solid Waste Generation	102
5. Wastewater Generation	109
6. Informal Settlers Families (ISFs) along the rivers	111

7. Piggeries and Poultries 117

8. Wastewater Pipes and Canals from Households directly draining to the River 119

9. Non-Point Pollution Sources (NPS) along the River System 123

III. Attachments 138

1. Geo-tagged Photos 138

2. Maps 151

IV. References 172

LIST OF TABLES

Table 1. Slope of San Juan River in Laguna Province 12

Table 2. Slope of San Cristobal River in Laguna Province 12

Table 3. Slope of Saran River in Laguna Province 13

Table 4. Elevational distribution of San Juan River catchment within Laguna Province 13

Table 5. Elevational distribution in San Cristobal River catchment within Laguna Province 14

Table 6. Elevational distribution in Saran River catchment within Laguna Province 14

Table 7. Land cover classification of catchment of San Juan River within Calamba City, Laguna. 28

Table 8. Land classes within the catchment of San Cristobal River in Laguna province. 29

Table 9. Land classes within the catchment of Saran River in Laguna province. 29

Table 10. Geological formations within the catchment of San Juan River of Laguna province. 32

Table 11. Geological formations within the catchment of San Cristobal River of Laguna province. 33

Table 12. Geological formations within the catchment of Saran River of Laguna province. 34

Table 13. Soil series within catchment of San Juan River in Laguna Province. 36

Table 14. Soil series within the catchment of San Cristobal River in Laguna Province. . 38

Table 15. Soil series within the catchment of Saran River in Laguna Province. 39

Table 16. Concentrations of fecal coliform and total coliform in Saran River of Laguna Province. 52

Table 17. Concentrations of fecal coliform and total coliform in San Cristobal River of Laguna Province. 53

Table 18. Concentrations of fecal coliform and total coliform in San Juan River of Laguna Province. 53

Table 19. Concentrations of selected heavy metals in San Juan River of Laguna Province. 54

Table 20. Concentrations of selected heavy metals in San Cristobal River of Laguna Province. 54

Table 21. Concentrations of selected heavy metals in Saran River of Laguna Province. 55

Table 22. Tree species composition along the stream of Brgy. Milagrosa, upstream of San Juan River within Calamba City, Laguna. 57

Table 23. Tree species composition along the stream of Brgy. Parian, midstream of San Juan River within Calamba City, Laguna. 58

Table 24. Tree species composition along the upstream of San Juan River within Calamba City, Laguna. 58

Table 25. Three composition in Brgy. Diezmos, Cabuyao (upstream). 60

Table 27. Tree species composition in Brgy.Looc Calamba (downstream). 61

Table 28. Three compositions in the sampling plot in Brgy. Timugan, upstream of Saran River in Los Banos Laguna 61

Table 29. Three compositions in the sampling plot in Brgy. Malinta, midstream of Saran River in Los Banos Laguna. 63

Table 30. Three compositions in the sampling plot in Brgy. Anos, downstream of Saran River in Los Banos Laguna. 64

Table 31. Encountered faunal species along San Juan River within Calamba City, Laguna province. 66

Table 32. Encountered faunal species within San Cristobal River................................. 67

Table 33. Faual species encountered along Saran River in Los Baños, Laguna.............. 67

Table 34. Area in hectare of sub-basin/tributary of San Juan River within the 31 barangays of Calamba City, Laguna. 68

Table 35. Area in hectare of sub-basin/tributary of San Cristobal River within the five (5) barangays of Cabuyao Laguna... 71

Table 37. Area of sub-basin/tributary of San Cristobal River within the additional 13 barangays of Calamba City, Laguna. 78

Table 38. Area of sub-basin/tributary of San Cristobal River within the two (2) barangays of Sta. Rosa City, Laguna.. 83

Table 40. Population of the 30 barangays of Calamba City, Laguna within the catchment of San Juan River... 86

Table 41. Political boundary within the Catchment of San Juan Watershed in Laguna Province.. 89

Table 42. Population of the five (5) barangays of Cabuyao, Laguna covered by San Cristobal River. 92

Table 43. Population of the twenty-six (26) barangays of Calamba City, Laguna covered by San Cristobal River. 93

Table 44. Population of the two barangays of Sta. Rosa City, Laguna covered by San Cristobal River. 94

Table 45. Political boundary within the catchment of San Cristobal Watershed in Laguna Province 94

Table 46. Population of the four (4) barangays of Los Baños, Laguna covered by Saran River. 95

Table 47. Political boundary within the catchment of Saran Watershed in Laguna Province 96

Table 48. Land Cover within the catchment of San Juan Watershed in Calamba City, Laguna Province. 98

Table 49. Land Cover within the entire catchment of San Cristobal Watershed in Laguna Province. 99

Table 50. Land use/ Land cover within the catchment of Saran River in Los Baños, Laguna based on 2015 classification of NAMRIA. 100

Table 51. Distribution of built-up areas in the localities within the San Juan River in Laguna Province. 101

Table 52. Distribution of built-up areas in the tree localities within the San Cristobal River in Laguna Province. 102

Table 54. Estimated solid-waste generation of the population within the thirty (30) barangays of Calamba City, Laguna within the catchment of San Juan river.103

Table 55. Estimated solid-waste generation of the population within the five (5) barangays of Cabuyao, Laguna within the catchment of San Cristobal river. 104

Table 56. Estimated solid-waste generation of the population within the twenty-six (26) barangays of Calamba City, Laguna within the catchment of San Cristobal river. 104

Table 57. Estimated solid-waste generation of the population within the two (2) barangays of Sta. Rosa City, Laguna within the catchment of San Cristobal river. 105

Table 58. Estimated solid-waste generation of the population within the catchment of Saran River in Los Baños, Laguna. 107

Table 59. Estimated solid-waste generation of the population within the two (2) barangays within the catchment of Saran River in Los Baños, Laguna 108

Table 60. Estimated waste-water generation of the population within the 30 barangays of Calamba City, Laguna within the catchment of San Juan River. 110

Table 62. Informal Settler Families (ISF) along the riverbank of San Juan River in the seventeen (17) Barangays of Calamba City, Laguna. 112

Table 63. Status of piggeries along San Cristobal River based on the survey of DENR Laguna. 117

Table 64. Status of piggeries along Saran River based on the survey of DENR Laguna. 119

Table 65. Waste-water disposal status of ISFs along San Cristobal River based on the survey of DENR Laguna. 120

Table 66. Waste-water disposal status of ISFs along Saran River based on the survey of DENR Laguna. 122

Table 68. Estimated organic nitrogen yield of different land uses within the 31 barangays of Calamba City, Laguna. 126

Table 69. Estimated organic phosphorus yield of different land uses within the 31 barangays of Calamba City, Laguna. 127

Table 70. Estimated sediment yield of sub-basins in the five (5) barangays of Cabuyao Laguna based on landuse, topography, soil, and precipitation. 129

Table 73. Estimated sediment yield of sub-basins in the two barangays of Sta. Rosa City based on landuse, topography, soil, and precipitation. 131

Table 74. Estimated organic nitrogen yield of sub-basins in the five (5) barangays of Sta. Rosa City based on landuse, topography, soil, and precipitation. 131

Table 75. Estimated organic nitrogen yield of sub-basins in the twenty-six (26) of Calamba City based on landuse, topography, soil, and precipitation. 132

Table 77. Estimated organic ntirogen yield of sub-basins in the two barangays of Sta. Rosa City based on landuse, topography, soil, and precipitation. 133

Table 78. Estimated organic phosphorus yield of sub-basins in the five (5) barangays of Cabuyao based on landuse, topography, soil, and precipitation. 133

Table 79. Estimated organic phosphorus yield of sub-basins in the twenty-six (26) barangays of Calamba City, Laguna based on landuse, topography, soil, and precipitation. 134

Table 81. Estimated organic phosphorus yield of sub-basins in the two (2) barangays of Sta. Rosa City based on landuse, topography, soil, and precipitation. 135

Table 82. Estimated sediment yield in the four (4) barangays of Los Baños, Laguna based on landuse, topography, soil, and precipitation. 136

Table 83. Estimated organic nitrogen yield of sub-basins in the the four (4) barangays of Los Baños, Laguna based on landuse, topography, soil, and precipitation. ...136

Table 84. Estimated organic phosphorus yield of sub-basins in the four (4) barangays of Los Baños, Laguna based on landuse, topography, soil, and precipitation. ...137

LIST OF FIGURES

Figure 1 . Catchment boundary of San Juan River within Laguna Province. 5

Figure 2. Catchment boundary of San Cristobal River within Laguna Province. 6

Figure 3. Catchment boundary of Saran River within Los Baños, Laguna Province........ 7

Figure 4. Slope map of San Juan Catchment within Laguna Province........................... 11

Figure 5. Slope map of San Cristobal Catchment within Laguna Province.................... 11

Figure 6. Slope map of Saran Catchment within Laguna Province................................ 12

Figure 7. Elevation map of the San Juan watershed in Laguna Province. 15

Figure 8. Elevation map of the San Cristobal watershed in Laguna Province. 16

Figure 9. Elevation map of the Saran watershed in Laguna Province. 16

Figure 10. Cross-section profile of the main channel of in the upstream of San Juan River of Laguna province. 17

Figure 11. Cross-section profile of the main channel in the midstream of San Juan River of Laguna province. 18

Figure 12. Cross-section profile of the main channel in the upstream of San Cristobal River of Laguna province. 18

Figure 13. Cross-section profile of the main channel of in the midstream of San Cristobal River of Laguna province. 19

Figure 14. Cross-section profile of the main channel in the upstream of Saran River of Laguna province. 19

Figure 15. Cross-section profile of the main channel in the midstream of Saran River of Laguna province. 20

Figure 16. Cross-section profile of the main channel in the downstream of Saran River of Laguna province. 20

Figure 17. Climate map of San Juan Catchment within Laguna Province...................... 22

Figure 18. Climate map of San Cristobal Catchment within Laguna Province............... 22

Figure 19. Climate map of Saran Catchment within Laguna Province 23

Figure 20. Annual precipitation patterns in Calamba City from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020)*............................... 23

Figure 21. Annual temperature patterns in Calamba City from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020)*............................... 24

Figure 22. Annual windspeed patterns in Calamba City from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020)*............................... 24

Figure 23. Annual precipitation patterns within the catchment of San Cristobal River in Laguna province from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020).* 25

Figure 24. Annual temperature patterns within the catchment of San Cristobal River in Laguna province from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020).* 25

Figure 25. Annual windspeed patterns within the catchment of San Cristobal River in Laguna province from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020).* 26

Figure 26. Annual precipitation patterns within the catchment of Saran River in Laguna province from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020).*... 26

Figure 27. Annual temperature patterns within the catchment of Saran River in Laguna province from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020)*. 27

Figure 28. Annual windspeed patterns within the catchment of Saran River in Laguna province from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020)*. 27

Figure 29. Land cover map of San Juan Catchment within Laguna Province. 30

Figure 30. Land cover map of San Cristobal Catchment within Laguna Province. 30

Figure 31. Land cover map of Saran Catchment within Laguna Province. 31

Figure 32. Geological map of San Juan Catchment within Laguna Province 32

Figure 33. Geological map of San Cristobal Catchment within Laguna Province 33

Figure 34. Geological map of Saran Catchment within Laguna Province 34

Figure 35. Soil series map of San Juan Catchment in Laguna Province 36

Figure 36. Soil series map of San Cristobal Catchment in Laguna Province 37

Figure 37. Soil series map of Saran Catchment in Laguna Province. 38

Figure 38. Sampling stations for water quality and biodiversity asssessment and monitoring in San Juan River, Saran River and Saran River of Laguna Province *(Google Earth 2020)*. 40

Figure 39. Levels of dissolved oxygen (DO) along the mainstream of San Juan River in Laguna province from Sept 2019 to March 2020. 41

Figure 40. Levels of dissolved oxygen (DO) along the mainstream of San Cristobal River in Laguna province from Feb 2019 to Apr 2020. 42

Figure 41. Levels of dissolved oxygen (DO) along the mainstream of Saran River in Laguna province from Feb 2019 to Apr 2020. 43

Figure 42. Levels of biochemical oxygen demand (BOD) along the mainstream of San Juan River in Laguna province from Sept 2019 to March 2020. 44

Figure 43. Levels of biochemical oxygen demand (BOD) along the mainstream of San Cristobal River in Laguna province from Feb 2019 to Apr 2020. 44

Figure 44. Levels of biochemical oxygen demand (BOD) along the mainstream of Saran River in Laguna province from Feb 2019 to Apr 2020. 45

Figure 45. Levels of pH along the mainstream of San Juan River in Laguna province from Sept 2019 to March 2020. 46

Figure 46. Levels of pH along the mainstream of San Cristobal River in Laguna province from Feb 2019 to Apr 2020. 46

Figure 47. Levels of pH along the mainstream of Saran River in Laguna province from Feb 2019 to Apr 2020. 47

Figure 48. Levels of nitrate along the mainstream of San Juan River in Laguna province from Sept 2019 to March 2020. 48

Figure 49. Levels of nitrate along the mainstream of San Cristobal River in Laguna province from Feb 2019 to Apr 2020. 48

Figure 50. Levels of nitrate along the mainstream of Saran River in Laguna province from Feb 2019 to Apr 2020. 49

Figure 51. Levels of phosphate along the mainstream of San Juan River in Laguna province from Sept 2019 to March 2020. 50

Figure 52. Levels of phosphate along the mainstream of San Cristobal River in Laguna province from Feb 2019 to Apr 2020. 51

Figure 54. Sampling stations for water quality and biodiversity assessment and monitoring in San Juan River, San Cristobal River, and Saran River of Laguna Province. 56

Figure 55. Dominant tree species ecountered on the sampling stations along San Juan River of Calamba City, Laguna........ 57

Figure 56. Percentage of dominant tree species ecountered on the sampling stations along San Cristobal River of Calamba City, Laguna. 59

Figure 57. Map of major tributaries/ sub-basins of San Juan River wihtin Laguna Province. 70

Figure 58. Major tributaries of San Cristobal River are overlaid to each corresponding subwatershed. 71

Figure 59. Major tributaries of Saran River are overlaid to each corresponding subwatershed. 85

Figure 60. Population distribution in the different villages (barangays) within San Juan River of Laguna province. 88

Figure 61. Political Boundary distribution within San Juan Watershed in Laguna Province. 90

Figure 62. Spatial distribution of 2015 population within the catchment of San Cristobal River in Laguna province. 91

Figure 63. The 2015 population and the estimated wastewater and solid waste generation. 92

Figure 64. The 2015 land cover map of San Juan Catchment within Laguna Province... 97

Figure 65. The 2015 land cover map of San Cristobal Catchment within Laguna Province. 99

Figure 66. The 2015 land cover map of Saran Catchment within Laguna Province. 100

Figure 67. Distribution of volume of collected solid-waste from five (5) barangays during the river clean-up spearheaded by DENR Laguna....................................106

Figure 68. Distribution of volume of collected solid-waste from selected stream segment during the river clean-up spearheaded by DENR Laguna. 106

Figure 69. Distribution of volume of collected solid-waste from two (2) barangays during the river clean-up spearheaded by DENR Laguna....................................107

Figure 70. Distribution of volume of collected solid-waste from selected stream segment during the river clean-up spearheaded by DENR Laguna. 108

Figure 71. Distribution of volume of collected solid-waste from selected stream segment during the river clean-up spearheaded by DENR Laguna. 109

Figure 73. Distribution of informal settler families (ISF) in different villages (barangays) along San Juan River..113

Figure 74. Distribution of informal settler families (ISF) along the riverbank of San Cristobal River in the five (5) barangays of Cabuyao Laguna covered by San Cristobal River..114

Figure 75. Distribution of informal settler families (ISF) along the riverbank of San Cristobal River in the twenty-six (26) barangays of Calamaba City, Laguna covered by San Cristobal River. 115

Figure 76. Distribution of informal settler families (ISF) along the riverbank of Saran River in Los Baños Laguna..116

Figure 77. ISF Maps along Saran River in Los Baños, Laguna. 116

Figure 80. Propotion of ISF population with the septic tank along San Cristobal River. 121

Figure 81. Propotion of ISF population in terms of solid-waste segregation along San Cristobal River..122

Figure 85. Hydrologic survey in the monitoring station of the upstream of San Juan River wtihin Calamba City, Laguna. 138

Figure 86. Capture aerial image of structure along the midstream of San Juan River in Brgy. Parian, Calamba City, Laguna. 138

Figure 87. Riparian vegetation along the upstream of San Juan River located in Brgy. Milagrosa, Calamba City, Laguna...139

Figure 88. Fresh water turtle encountered during biodiversity survey along the stream of San Juan River at Brgy. San Juan, Calamba City, Laguna.........................139

Figure 89. Load of silt created an island along the downstream of San Juan River at Brgy. San Juan, Calamba City, Laguna. 140

Figure 90. Informal settlers in midstream of San Juan River in Brgy. Parian, Calamba City, Laguna. 140

Figure 91. Domestic water waste from informal settlers in San Juan River midstream at Brgy. Parian, Calamba City, Laguna..141

Figure 92. Vegetation in San Juan River midstream at Brgy. Parian, Calamba City......142

Figure 93. Measuring streamflow depth and velocity in the upstream of Diezmo, Cabuyao, Laguna. 142

Figure 94. Plant diversity along the upstream of San Cristobal River in Barangay Diezmo, Cabuyao Laguna. 143

Figure 95. Water flow in the upstream of San Cristobal River in Brgy. Diezmo, Cabuyao, Laguna. 143

Figure 96. Measuring the stream depth and velocity in the midstream at San Cristobal River. 144

Figure 97. Drone shot of Informal Settler Families (ISFs) along the midstream of San Cristobal River 144

Figure 98. Measuring of cross-sectional area and streamflow in the upstream of Saran River. 145

Figure 99. Vegetation cover along the upstream of Saran River in Brgy. Timugan, Los Baños, Laguna. 145

Figure 100. Turbid water flow in Saran River at Brgy. Malinta, Los Baños, Laguna. ...146

Figure 101. Settlers along midstream of Saran River in Brgy. Malinta, Los Baños, Laguna. 147

Figure 102. Domestic waste draining along the midstream of Saran River in Brgy. Anos, Los Baños, Laguna. 148

Figure 103. Measuring the stream flow depth and velocity along the midstream of Saran River in Brgy. Anos, Los Baños, Laguna. 149

Figure 104. Screened debris of solid waste in the midstream of Saran River and turbid water flow at Brgy. Anos, Los Baños, Laguna..149

Figure 105. Aerial photo of ISFs along the downstream of Saran River in Brgy. Malinta, Los Baños, Laguna. 150

Figure 106. ISF Maps along San Juan River in Laguna Province................................155

Figure 107. Sediment yield map within catchment of San Juan River in Laguna Province. 151

Figure 108. Rate of organic nitrogen yield was transported with sediment into the reach during the time step...152

Figure 109. Rate of organic Phosphorus yield transported with sediment into the reach during the time step..153

Figure 110. Rate of NO3 in surface runoff (kg N/ha) with San Juan River catchment in Laguna Province. 154

Figure 111. ISF distribution along the San Cristobal River in Cabuyao Laguna. 156

Figure 112. ISF distribution along the San Cristobal River in Calamba City, Laguna. ..157

Figure 113. ISF distribution along the San Cristobal River in Sta. Rosa City, Laguna. .157

Figure 114. Spatial variation of average annual sediment yield in the catchment of San Cristobal River in Cabuyao, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover. 158

Figure 115. Spatial variation of average annual sediment yield in the catchment of San Cristobal River in Calamba City, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover. 160

Figure 116. Spatial variation of average annual sediment yield in the catchment of San Cristobal River in Sta. Rosa City, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover 161

Figure 117. Spatial variation of average annual organic nitrogen in the catchment of San Cristobal River in Cabuyao, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover. 162

Figure 118. Spatial variation of average annual organic nitrogen in the catchment of San Cristobal River in Calamba City, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover 163

Figure 119. Spatial variation of average annual organic nitrogen in the catchment of San Cristobal River in Sta. Rosa City, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover. 164

Figure 120. Spatial variation of average annual organic phosphorus in the catchment of San Cristobal River in Cabuyao, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover. 165

Figure 121. Spatial variation of average annual organic phosphorus in the catchment of San Cristobal River in Calamba City, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover 166

Figure 122. Spatial variation of average annual organic phosphorus in the catchment of San Cristobal River in Sta. Rosa City, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover 167

Figure 123. Spatial variation of average annual sediment yield in the catchment of Saran River in Los Baños, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover. 168

Figure 124. Spatial variation of average annual organic nitrogen yield in the catchment of Saran River in Los Baños, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover. 169

Figure 125. Spatial variation of average annual organic nitrogen yield carried through surface runoff in the catchment of Saran River in Los Baños, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover..........................170

Figure 126. Spatial variation of average annual organic phosphorus yield in the catchment of Saran River in Los Baños Laguna based on the 2010-2019 precipitation patterns and 2015 landcover. 171

EXECUTIVE SUMMARY

Watershed characterization is one of the most important and tedious activities in sound watershed management. It covers the physical, biological, and socio-economic components of the watershed including vulnerabilities and development issues within the watershed. The data and information generated from this activity are crucial to guide management decisions to attain a balance between development activities and conservation initiatives. Computer-based tools and techniques such as geographic information systems (GIS) and watershed models have revolutionized watershed characterization today. This report contains the results of the GIS-based watershed characterization of San Juan River, San Cristobal River, and Saran River in Laguna Province under the jurisdiction of the Provincial Environmental and Natural Resources Office (PENRO) of Laguna. San Juan and San Cristobal rivers are two of the largest contributing rivers to Laguna lake with boundaries traversing provinces of Laguna and Batangas with a total catchment area of 19,590 hectares and 12,617 hectares respectively. Saran River on the other hand is an important small watershed of Los Baños, Laguna with a catchment area of 245 hectares. The land-uses on the three watersheds are mainly devoted to lowland cultivation, annual crop, and built-up areas. Commercial centers and industrial parks are also present in San Juan and San Cristobal. The total estimated population is 250,320 for San Juan in 2020 while 353,870 and 8,324 for San Cristobal and Saran based on the 2015 census. Of this, a total of 4,313 families are informal settlers living along the mainstream and tributaries. Solid waste generation with the catchment is estimated at 93 tons/per day for San Juan, 132 tons/per day for San Cristobal, and 3 tons/per day for Saran while wastewater generation is 14 million liters, 19 million liters, and 466,139 liters per day respectively. Downstream areas are the most populated and congested for the three watersheds. Water quality is relatively poor with most of the parameters falls below class C and class D, particularly in the midstream and downstream areas. Sediment, nitrate, and phosphate leaching are higher in urbanized and industrialized midstream and downstream areas. With this situation, the determination and conservation of critical source areas are necessary to protect groundwater sources. Holistic programs for ISF which include relocation from the river easement and riparian areas are one of the most important and needed actions. The

establishment of monitoring programs for important watershed parameters like water quality, biodiversity, and land-use changes are important to the sustainable management of the river. Implementable strategies for solid-waste management for each LGUs are necessary to reduce problems with solid waste. Landuse and development plans of the entire San Juan Watershed including catchment within Batangas Province should be done holistically. Hence, the establishment of a management council can be a good start.

I. INTRODUCTION

Healthy watersheds indicate a balance between environmental conservation and economic development. A healthy watershed can provide sustainable ecosystem services such as nutrient cycling, carbon storage, erosion control, biodiversity, soil formation and protection, wildlife habitat, water storage, water infiltration, flood control, food, and recreation, and reduce the effects of climate change and other natural disasters. Management of watershed requires consideration of all components of the landscape. At the beginning of 2019, DENR officially started the Manila Bay Rehabilitation Program dubbed as the *"Battle as the for Manila Bay"* with the main objective of bringing the iconic bay back to life. The program has three components which are clean-up and water quality improvement, rehabilitation and resettlement, and education and sustainment. Manila bay covers eight (8) provinces with four (4) coastal and four (4) non-coastal. Seventeen (17) principal river systems are draining to the bay with a total drainage area of 1,994 square kilometers or 199,400 hectares. The largest contributing catchment is the Laguna Lake River Basin which drains to Manila Bay via Pasig river.

The Laguna Lake River Basin is the largest part of the Pasig-Laguna River Basin which drains to Manila Bay. It has a total area of 4,108.74 square kilometers encompassing areas of Metropolitan Manila, Rizal, Laguna, Quezon, Cavite, and Batangas. San Juan River watershed is one of the 17 identified critical watersheds draining to Laguna Lake. Geographic Information Systems (GIS) and Remote Sensing (RS) technologies were used to analyze and visualize most of the physical characteristics of this watershed. It is hoped that this report will be a useful basis for the rehabilitation of Manila Bay by managing these contributing watersheds.

A. Background

This characterization is part of the Manila Bay Rehabilitation Program spearheaded by the Department of Environment and Natural Resources (DENR). Significant efforts have been made to clean the coastal and downstream areas of the bay. These efforts include coastal and waterway clean-up, sewer inspection, and repairs, provision of sanitation facilities to informal settler families (ISFs), intensification of solid waste management among others. However, a holistic approach is necessary to achieve greater success. This can be done by managing the midstream and upstream environment of the watershed. This is because wastewater and pollutants that go with streamflow can emanate from this region. Failure to recognize and address this issue contributes to the failure of any rehabilitation program.

Laguna Lake Basin and its tributaries are one of the major watershed systems that are draining to Manila bay discharging storm waters, domestic, industrial, urban, and agricultural run-offs. Three (3) of the major tributaries that drain to Laguna lake are the Saran River in Los Baños, San Cristobal River, and San Juan River in Calamba City. These three rivers are vital contributors that flow to the lake and significantly influence the water quality and lake dynamics which in turn affect Manila bay. Information on the physical, biological, and socio-economic components of these watersheds is vital for their proper management and key for the success of any efforts to rehabilitate downstream environments. Several studies on these watersheds have been made, however, detailed watershed characterization has not been done yet.

Data availability is the main challenge in any watershed characterization. Continuous and accurate monitoring data on key watershed parameters are scarce especially for developing countries like the Philippines. A more recent challenge is the restrictions on social mobility due to COVID 19 pandemic. For this project, the face-to-face interview and on-site survey on the congested areas particularly for ISFs along the stream banks have become restricted and pose a high risk for contamination and further spread of the virus. Therefore, strategies and methodology were adjusted and modified to ensure the achievement of the objectives. This provides the learning insight that plans for watershed characterization should be flexible enough to cope up with sudden environmental and societal changes. The methods and procedures used to gather and analyze the selected parameters are briefly described as follows.

Geomorphological characteristics are derived from the digital elevation model (DEM) from NAMRIA using geographic information system (GIS) tools. Climate map and weather data are mainly from PAGASA, however, monthly averages from international weather debasing and forecasting networks were also considered to supply missing data. Land cover and land use classification were based on 2015 land cover maps generated by the NAMRIA. Soil type and soil map are from the digital soil map by the Bureau of Soil and Water Management (BSWM) of the Department of Agriculture (DA). Three sampling stations were established to represent the downstream, midstream, and upstream conditions. Water quality parameters were selected and analyzed following the guidelines prescribed by the DENR Administrative Order No. 08 series of 2016. Data from the monthly monitoring by PENRO and CENRO was integrated into the separate sampling conducted under this characterization. A survey on flora was conducted by establishing plots along the riparian zone while a faunal survey was done through the catch and trap method in selected points along the river. Estimates of the population within the catchment based on the latest population per village/barangay correlated with the percentage of the area of each village within the catchment. Data on solid waste generation and wastewater generation were solicited from the respective local government units usually at the municipal or city level. Data mining from the web was also done to extract the location of the major industries within the catchment. Built-up areas were extracted from the latest land cover maps provided by the national mapping bureau (NAMRIA).

Non-point source pollution is estimated through modeling and not well validated. These estimates must be used with precaution since the value is not actual but relative. Nevertheless, this gives a picture of the spatial distribution of pollution sources and points us to areas that need more attention. Mapping the ISFs is one of the most challenging tasks of this characterization. Since many of the activities to conduct the actual ground survey are restricted due to the existing pandemic, various methods were employed such as satellite image analysis, image and video capture using drones, and data sources from the LGUs with ground validation. Due to scale and required resources to map out the illegal structure within the restricted riparian areas, ISF maps were generated mostly for the urban and built-up areas. Similarly, data gathering and mapping of piggeries and poultry were done using combinations of approaches which include data mining, data accession from LGUs, and droning. As much as possible all parameters selected to characterize the physical, biological, and socio-economic components of the watershed were visualized using thematic maps. For parameters with missing geographic information, tables and statistics were provided to reflect the condition of the watershed for those parameters. It is hoped that the result characterization will be the basis for strategic wastewater management to control point and non-point source pollution generated from various sources within the watershed. Since some of the information that will be gathered and generated are baselines, future monitoring efforts will also benefit from these projects.

B. Map of River System

The topography and geomorphology of a river system directly dictate its hydrological processes. The catchment area dictates the amount of flow since it is proportional to the quantity of rainfall that the watershed is receiving. All water received from precipitation is channeled to the stream network and will eventually go to larger water bodies such as lakes or oceans. Flow in the stream is controlled by surface flow, subsurface flow, and groundwater flow. Stream network on the other hand influences the time of flow.

a. San Juan River

The entire watershed of San Juan River has a total area of 19,590 hectares and a boundary length of 142 km that traverses provincial boundaries of Batangas, Cavite, and Laguna (Figure 1). The catchment shape is elongated narrowing downstream towards the main outlet. This type of shape generally exhibits a more gradual peak flow since precipitation that falls within the catchment will not converge at the main channel and outlet at the same time (Figure 1).

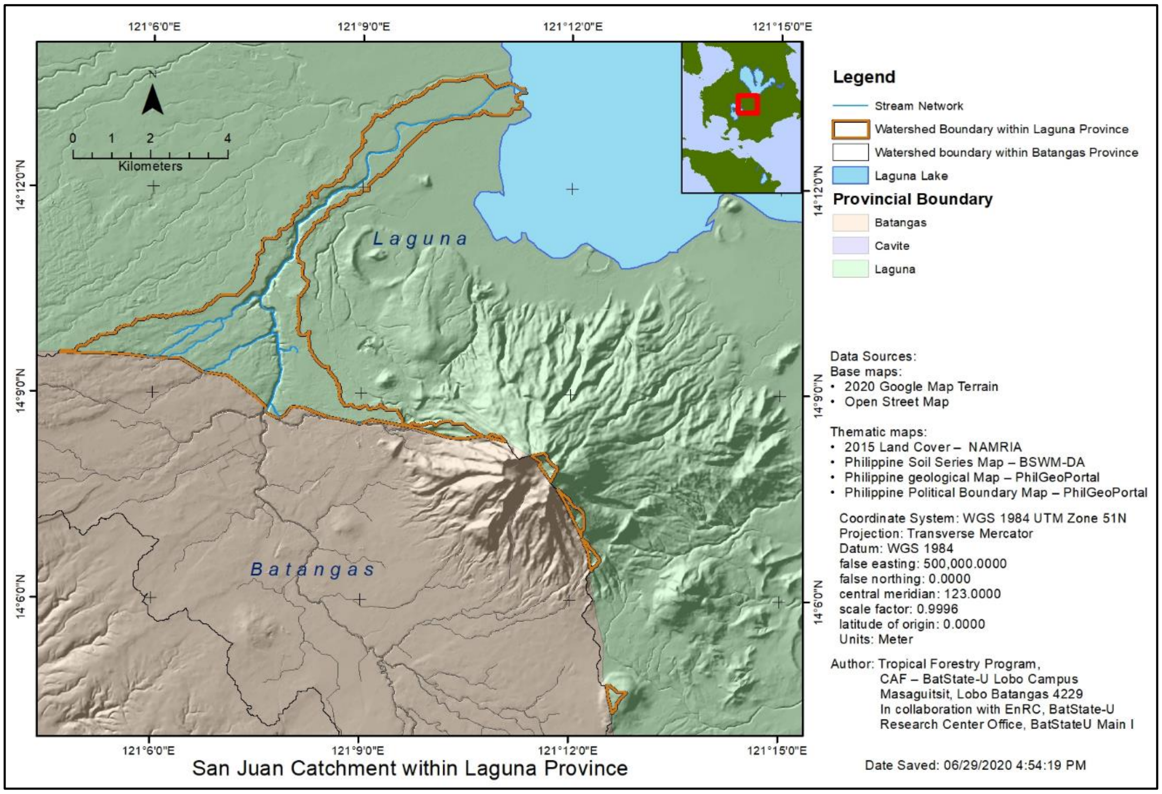

Figure 1 . Catchment boundary of San Juan River within Laguna Province.

The catchment of the San Juan River that is within the Laguna province has an area of 2,067 hectares. This is the downstream area of the greater San Juan River with midstream and headwaters located within Batangas Province. The total stream length within Laguna province is 26.8 km. This includes the main channel and all tributaries within Laguna. The Main channel traverses Calamba City and with only two (2) main tributaries. The main outlet draining along the coast of Laguna lake at 121.188456 E and 14.223488 N.

b. San Cristobal River

The entire watershed of San Cristobal River has a total area of 12,617 hectares and a boundary length of 85.7 km that traverses provincial boundaries of Cavite and Laguna. The catchment shape is elongated narrowing downstream towards the main outlet (Figure 2).

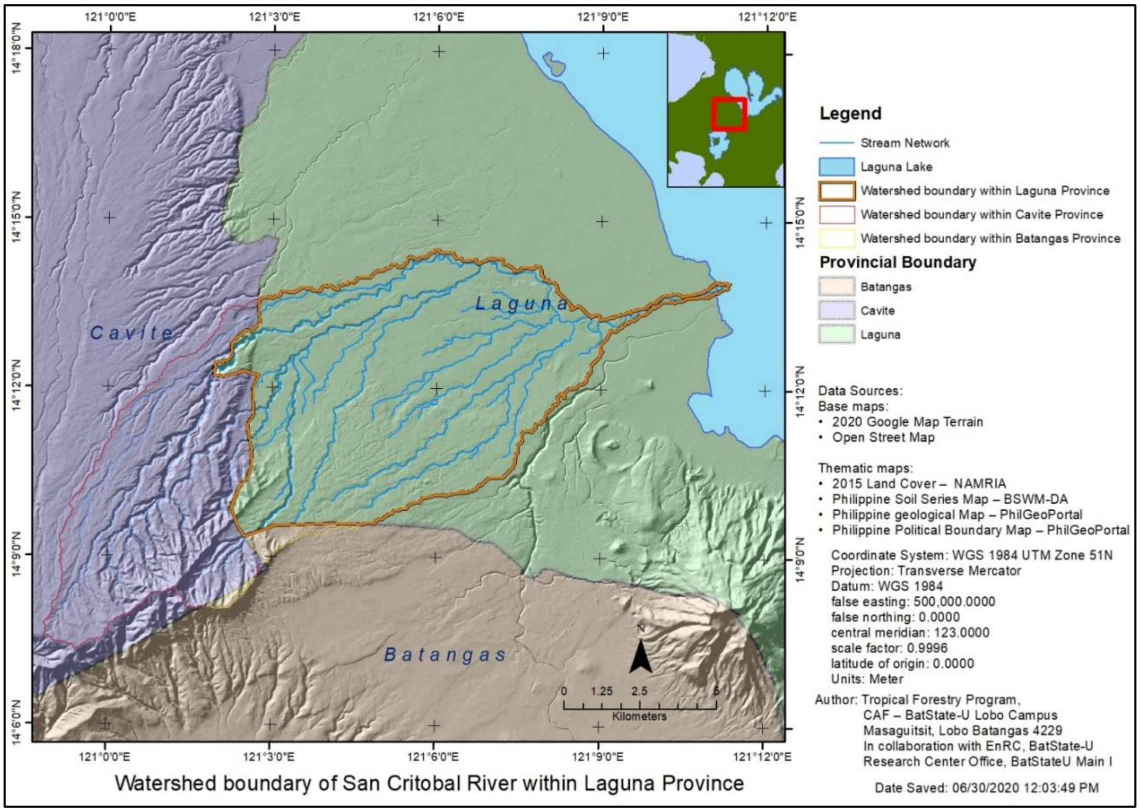

Figure 2. Catchment boundary of San Cristobal River within Laguna Province.

This type of shape generally exhibits a more gradual peak flow since precipitation that falls within the catchment will not converge at the main channel and outlet at the same time. The catchment of San Cristobal River that is within the Laguna province has an area of 8,022 hectares. These areas are the midstream and downstream part of the entire San Cristobal River.

The total stream length of the San Cristobal River within Laguna province is 13.66 km. This includes the main channel and all tributaries within Laguna. The main channel traverses the municipality of Cabuyao, Santa Rosa City, and Calamba City while the main outlet draining along the coast of Laguna lake at 121.189400 E and 14.231498 N.

c. Saran River

The entire watershed of Saran River has a total area of 245.54 hectares and a boundary length of 13.55 km that traverses four barangays of Los Baños Laguna (Figure 3). Similarly, with the catchments of San Juan and San Cristobal, the shape of the catchment of Saran River is elongated with a narrow surface along the main channel in the downstream near the main outlet.

The total stream length of Saran River 6.81 km spread in the three (3) barangays of the Municipality of Los Baños. This includes the main channel and all tributaries within Los Baños, Laguna. The Main channel traverses barangay Anos and Malinta of Los Baños, Laguna. The main outlet draining along the coast of Laguna lake at 121.229441 E and 14.187434 N.

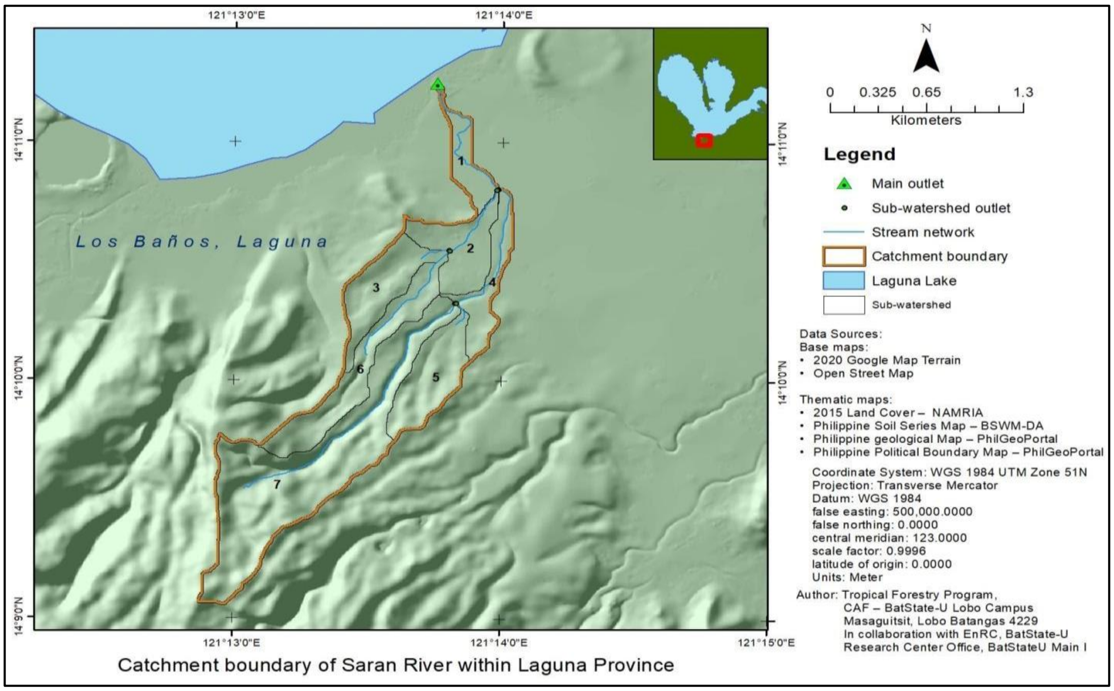

Figure 3. Catchment boundary of Saran River within Los Baños, Laguna Province.

C. Objectives

The extent and depth of watershed characterization depend on the target management objectives on which the results of the characterization will be used. This means that decisions on the amount and type of parameter and indicators to be measured and observed are heavily influenced by the set objectives. However, the cost and availability of resources are also equally important in deciding the extent and depth of the characterization.

The overall objective of this characterization is to provide information about the basic parameters and indices of three important rivers of the greater Laguna Lake Basin. Parameters can be grouped under biophysical and socioeconomic characteristics of the watershed. Biophysical characteristics include geomorphology, climate, land-use, geology, soil type and characteristics, water quality, and flora, and fauna. Socio-economic characteristics include solid waste and wastewater generation, poultry and piggeries, informal settlers families, and the extent of built-up areas. For the socio-economic aspect, implications to watershed health of important variables such as the human population, presence of informal settler families (ISF), livestock and poultry industries, and extent of built-up were an important component of this report. Quantitative analysis for some variables has been difficult due to scarcity or the complete absence of data of some important parameters. Hence, experience and studies from similar characterization were used as basis for wider analysis.

II. RIVER PROFILE

A. Physical Characteristics of the River

The physical characteristics of a watershed are the main driver of its hydrologic regime. Water quality and timing depend directly on the existing physical condition of the watershed. This section presents the selected parameter to describe the physical characteristics of each watershed.

1. Geomorphological Features

Water quality, quantity, and timing are directly influenced by geomorphological features of the watershed. Analysis of morphometric parameters is very important for watershed planning since it gives information about the basin characteristics including the slope, topography, runoff characteristics, etc. The majority of geomorphological characteristics of watersheds are input to modeling. Five parameters were chosen to briefly describe the geomorphological characteristics of the watershed.

Catchment area is the most important parameter for hydrologic characterization because this directly reflects the volume of water that the watershed can generate in a rainfall event. For quick flow estimation, the volume of water available for runoff may be assumed as a product of rainfall depth and drainage area. The Watershed area is one of the required inputs for all modeling activities. The catchment of the San Juan River that is within the Laguna province has an area of 2,067 hectares. This is the downstream area of the greater San Juan River with midstream and headwaters located within Batangas Province. On the other hand, the catchment of the San Cristobal River has an area of 8,022 hectares. These areas are the midstream and downstream of the entire San Cristobal River with upstream located within Cavite Province. The catchment of the Saran River that is within the Los Baños Laguna province has an area of 245.54 hectares.

Watershed length (L) is defined as the distance measured along the main channel from the watershed outlet to the basin divide. Length increases as the drainage increase and is important in hydrologic computation particularly in the travel time of water through a watershed. The watershed length of San Juan catchment within the Laguna province is 13.2 km, originating from the main outlet up to the arbitrary upstream located between the provincial boundaries of Laguna and Batangas. The watershed length of San Cristobal catchment within the Laguna province is 13.66 km, originating from the main outlet up to the arbitrary upstream located between the provincial boundaries of Laguna and Cavite. The watershed length of Saran catchment is 5.15 km, originating from the main outlet up to the arbitrary upstream located in Brgy. Timugan, Los Baños, Laguna.

Watershed shape reflects the way that runoff will aggregate at the outlet. For example, a circular-shaped watershed would results in runoff from various parts of the watershed reaching the outlet at the same time. The shape of the catchment of the three rivers is elongated narrowing downstream towards the main outlet. This type of shape generally exhibits a more gradual peak flow since precipitation that falls within the catchment will not converge at the main channel and outlet at the same time.

The slope angle (gradient) of the watershed reflects the rate of change of elevation concerning distance along the principal flow path. This is an important factor in calculating the momentum of runoff and flood magnitudes. For San Juan River, the catchment is segmented into three (3) slope types. The largest area has slope of 0 -18 with 84.09 % (1735.43 ha) followed by 18-50 slope with 10.34% (213.32 ha) while 50% above has the smallest area with 5.57 % (115.01 ha) (Figure 4). This indicates the majority of the catchment has relatively flat terrain which exhibits slower runoff velocity.

For San Cristobal river, the largest area has slope of 0 -18 with 91.80 % (7,361.74 ha) followed by 18-50 slope with 6.52% (523.09 ha) while 50% above has the smallest area with 1.67 % (134.28 ha) (Figure 5). This indicates the majority of the catchment has relatively flat terrain which exhibits slower runoff velocity.

Similarly, the largest area of Saran River also falls under slope of 0 -18 with 58 % (143.98 ha) . This is followed by 18-50 slope with 36.84% (90.20 ha) while 50% above slope has the smallest area with 4.37 % (10.70 ha)(Figure 6). Slower runoff velocity is also produced on this topography.

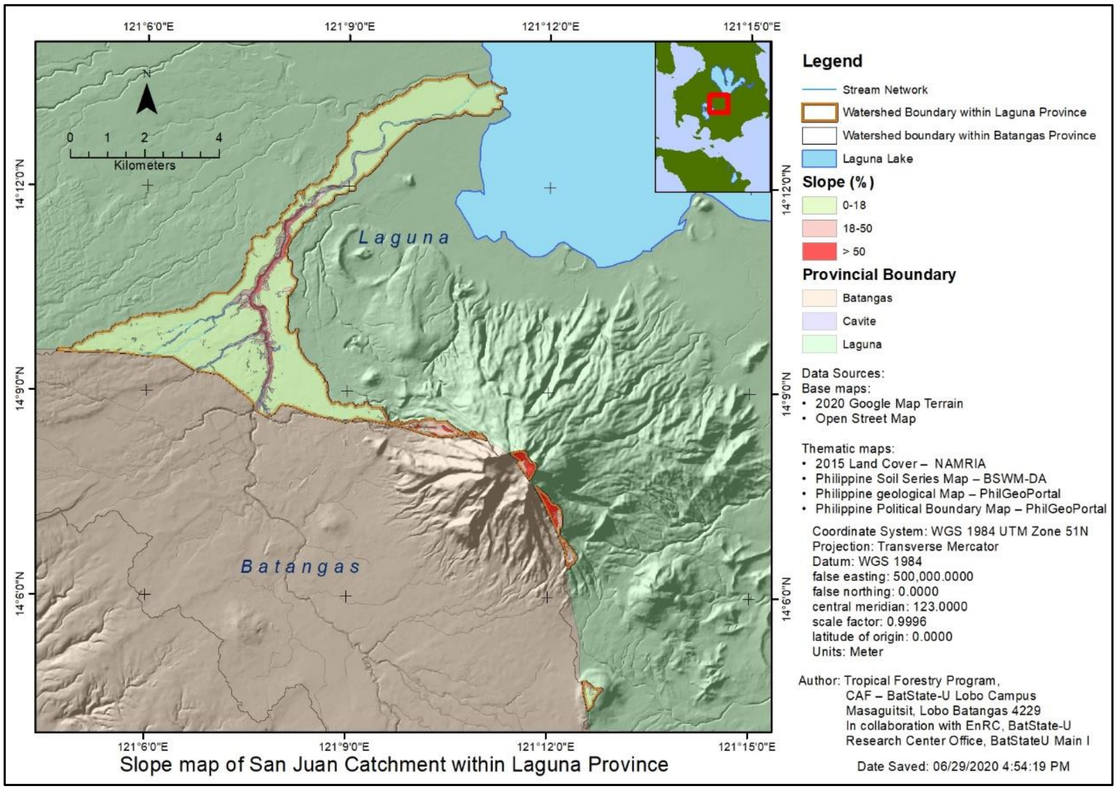

Figure 4. Slope map of San Juan Catchment within Laguna Province

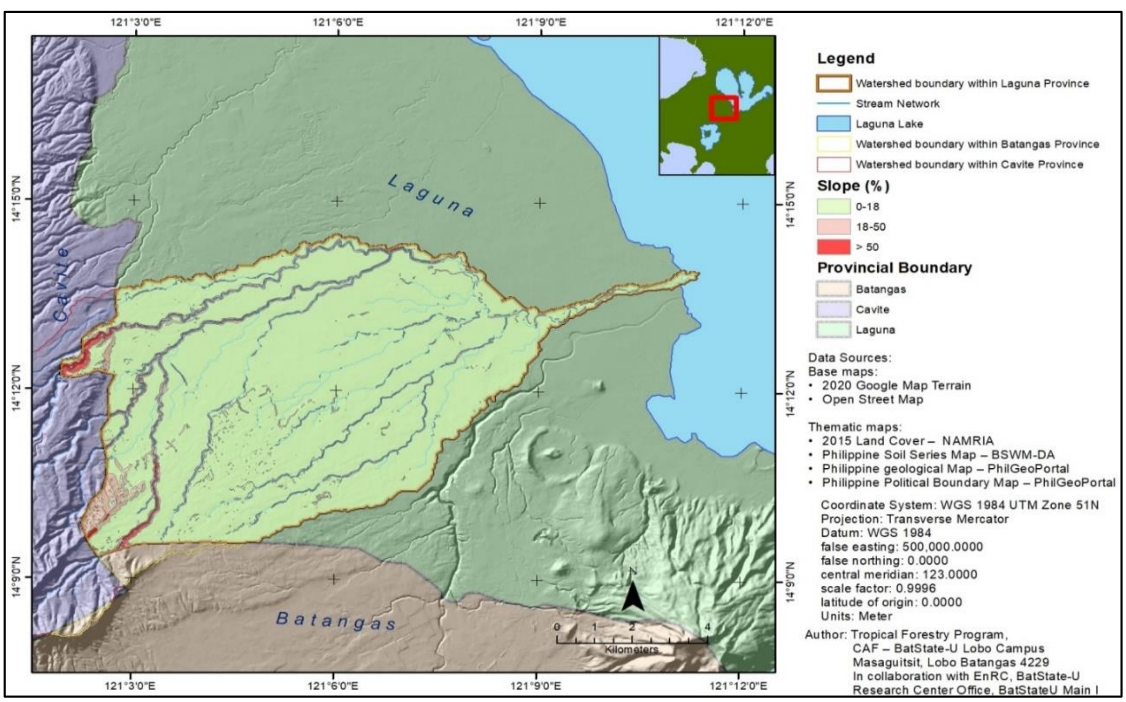

Figure 5. Slope map of San Cristobal Catchment within Laguna Province

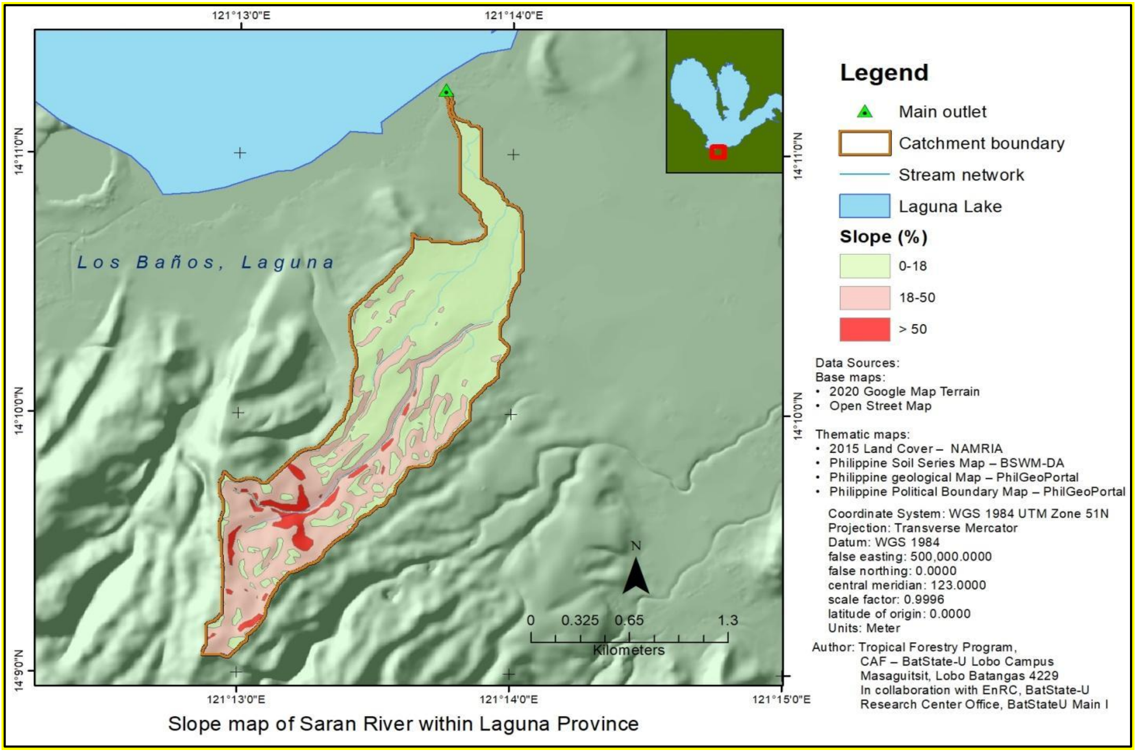

Figure 6. Slope map of Saran Catchment within Laguna Province

Table 1. Slope of San Juan River in Laguna Province

Slope (%)	Area	Percent (%)
0-18	1,735.43	84.09
18-50	213.32	10.34
Above 50	115.01	5.57
TOTAL	2,063.75	100.00

Table 2. Slope of San Cristobal River in Laguna Province

Slope (%)	Area	Percent (%)
0-18	7,361.74	91.80
18-50	523.09	6.52

Above 50	134.28	1.67
TOTAL	8,019	100.00

Table 3. Slope of Saran River in Laguna Province

Slope (%)	Area	Percent (%)
0-18	143.98	58.80
18-50	90.20	36.84
Above 50	10.70	4.37
TOTAL	244.88	100.00

For San Juan River, the catchment was divided into four (4) elevation ranges (Figure 7). Areas lower than 200 m elevation has the largest area with 92.27% followed by areas within 200-500 m. asl with 5.51 % (113.61 ha). There is only 4.4 ha with an elevation higher than 1000 meters above sea level. For San Cristobal river, the catchment was divided into two (2) elevation ranges. Areas lower than 200 m elevation has the largest area with 85.90% (6,888.27 ha) while by areas within 200-500 m. asl with 14.10 % (1,130.84 ha). For Saran River, the catchment was divided into two (2) elevation ranges. Areas lower than 200 m elevation have the largest area with 79.88 % followed by areas within 200-500 m. asl with 20.12 % (49.28 ha).

Table 4. Elevational distribution of San Juan River catchment within Laguna Province

Elevation (m.asl)	Area	Percent (%)
< 200	1904.20	92.27
200-500	113.61	5.51
500-1000	41.46	2.01

>1000	4.40	0.21
TOTAL	2,063.68	100.00

Table 5. Elevational distribution in San Cristobal River catchment within Laguna Province

Elevation (m.asl)	Area	Percent (%)
< 200	6,888.27	85.90
200 - 500	1,130.84	14.10
TOTAL	8,019.10	100.00

Table 6. Elevational distribution in Saran River catchment within Laguna Province

Elevation (m.asl)	**Area**	**Percent (%)**
< 200	195.58	79.88
200 - 500	49.28	20.12
TOTAL	**244.86**	**100.00**

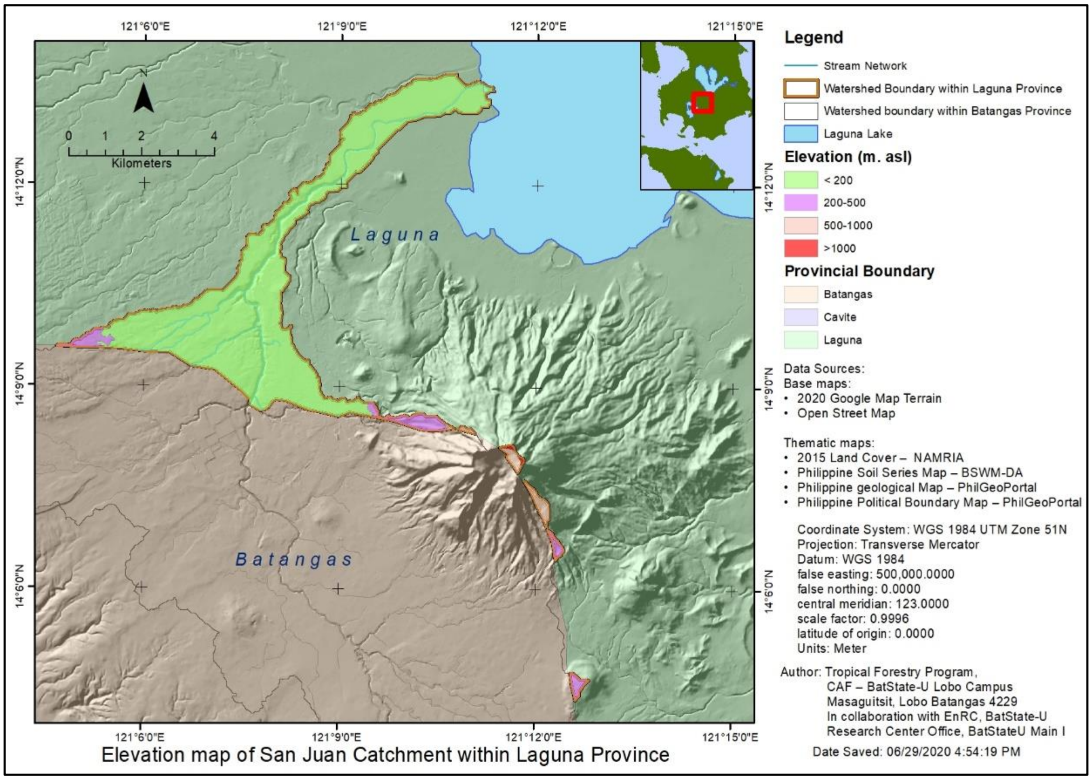

Figure 7. Elevation map of the San Juan watershed in Laguna Province.

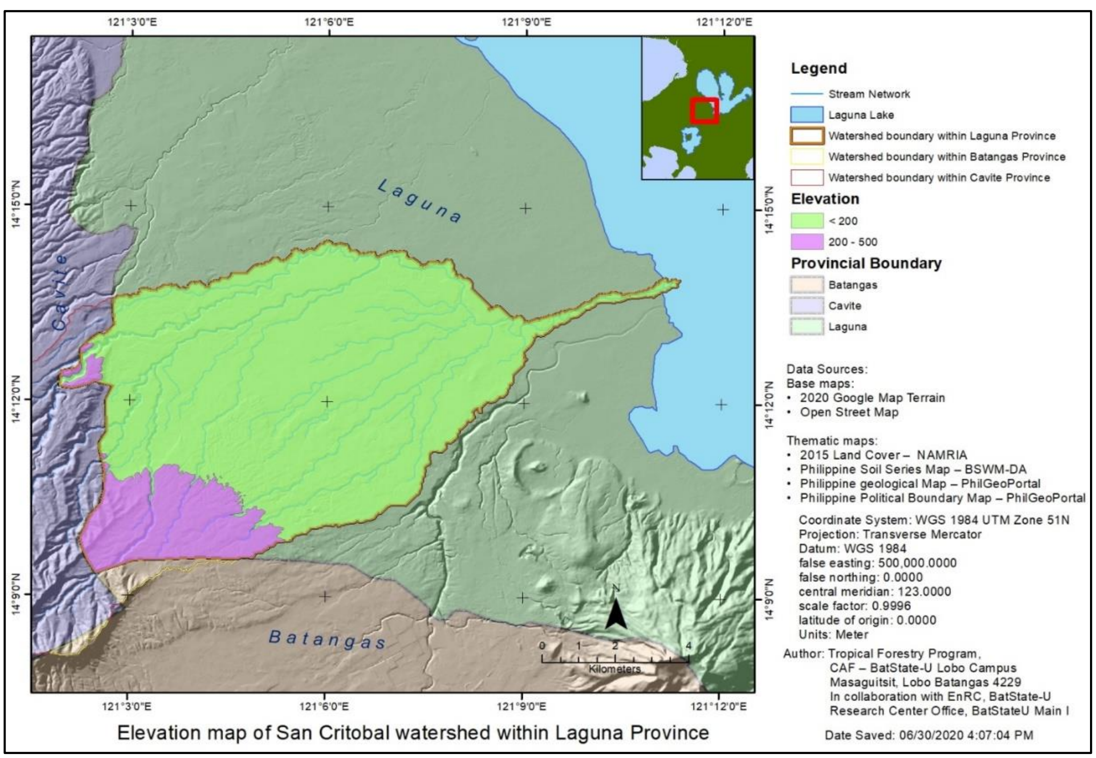

Figure 8. Elevation map of the San Cristobal watershed in Laguna Province.

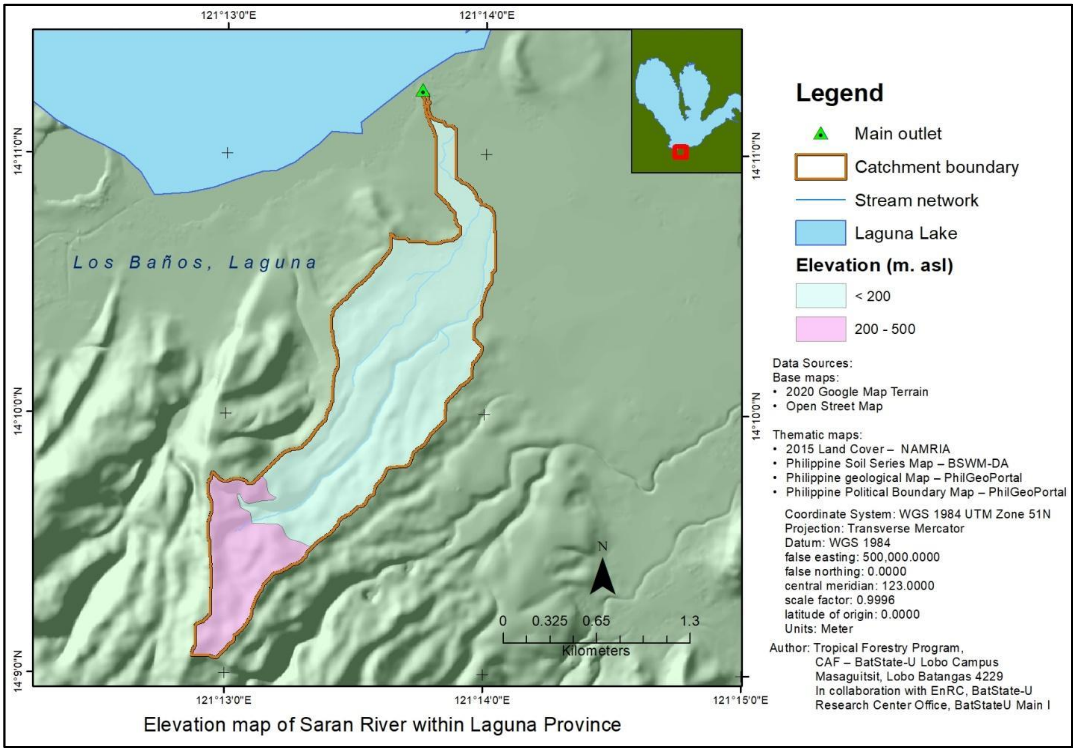

Figure 9. Elevation map of the Saran watershed in Laguna Province.

River discharge or streamflow is the volume of water flowing at a certain point along the channel per unit time. Measurement and monitoring of streamflow are important to estimate the amount of point source and non-point source pollutants being discharged by the river. It impacts water quality and living organisms in the stream. Large and swiftly flowing streams can receive pollution loads and have little effect while small streams have less capacity to dilute and degrade wastes.

The cross-sectional area of the San Juan River in Laguna province is 1.29 m^2 and 2.1 m^2 in the upstream and midstream respectively (Figure 10 & Figure 11). The streamflow rate for the same location was recorded at 0.36 m^3/s and 1.3 m/s^3 respectively. Downstream measurement near the main outlet recorded no streamflow velocity since it already part of the intertidal zone between the river and the lake.

San Cristobal River has wider channel cross sectional area than San Juan River 3.28 m^2 and 1.76 m^2 in the upstream and midstream respectively (Figure 12&Figure 13). The streamflow was measured in the same locations and recorded at 0.68 m^3/s and 0.14 m/s^3 respectively. Similarly, there is no flow measurement done in downstream near the main outlet which is part of the intertidal zone between the river and the lake.

Lastly, the cross-sectional area of Saran River in Laguna province 0.12 m^2, 0.17 $m^{2,}$ and 0.57 m^2 in the upstream, midstream, and downstream respectively (Figure 4,5 & Figure 6). Being the smallest river understudy the streamflow rate for the same location was recorded at 0.36 m^3/s and 1.3 m/s^3 respectively.

The monitoring stations for streamflow are the same as for water quality monitoring stations established by CENRO Los Banos. Open channel profiler was used to directly measure the channel profile and flow velocity.

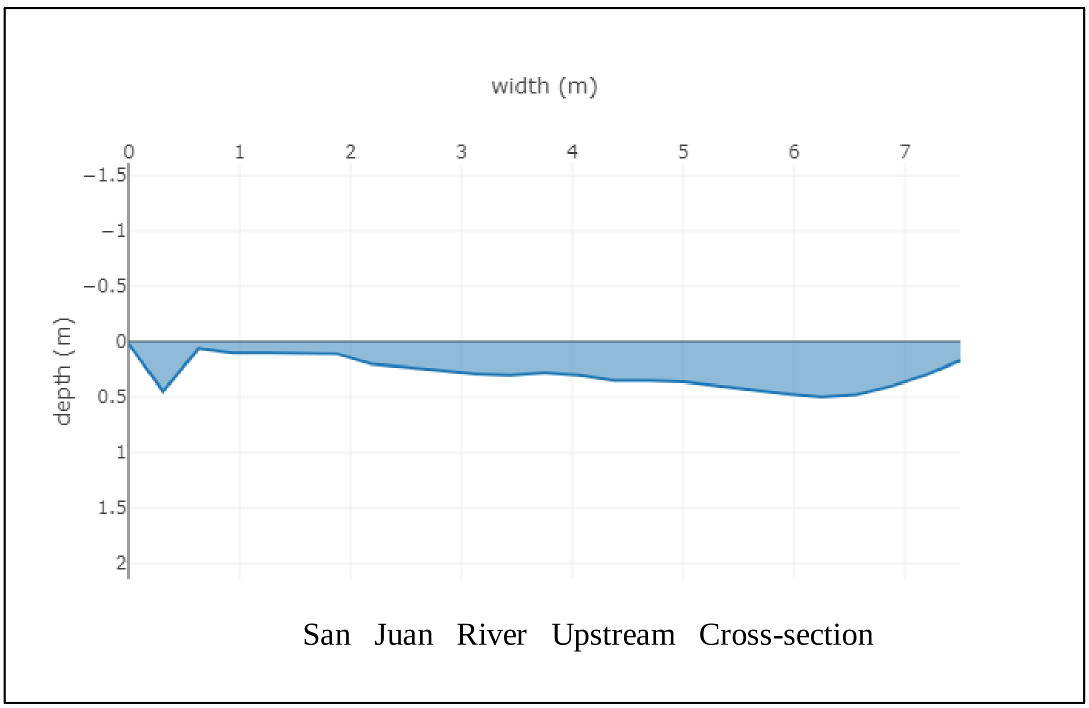

Figure 10. Cross-section profile of the main channel of in the upstream of San Juan River of Laguna province.

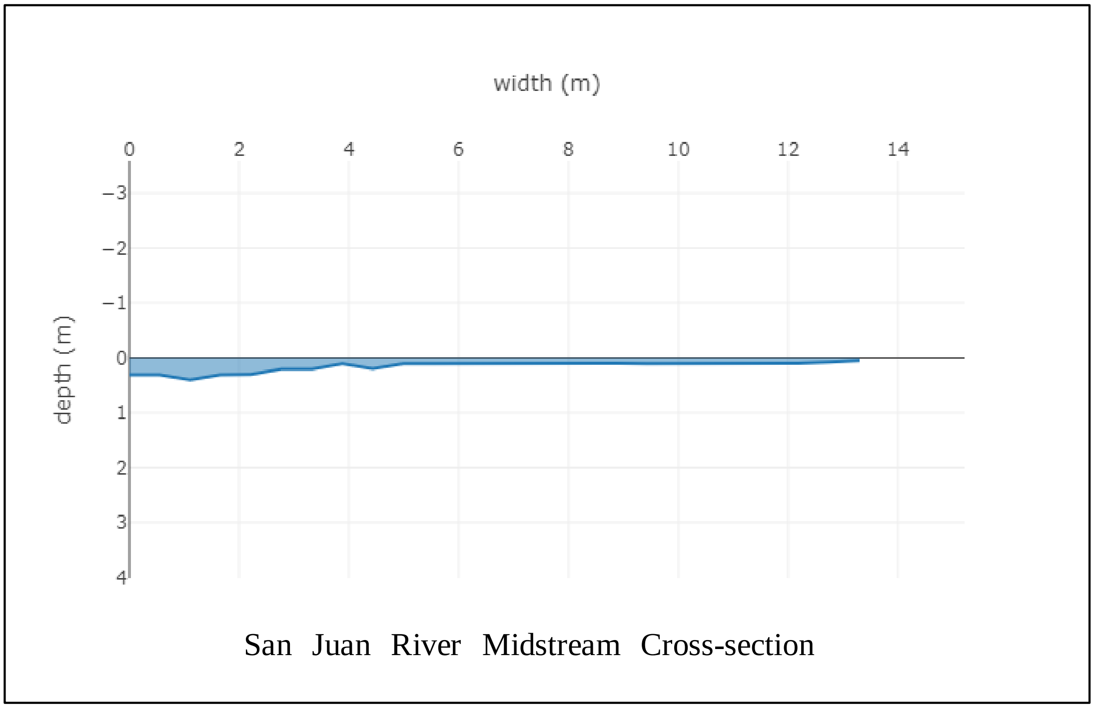

Figure 11. Cross-section profile of the main channel in the midstream of San Juan River of Laguna province.

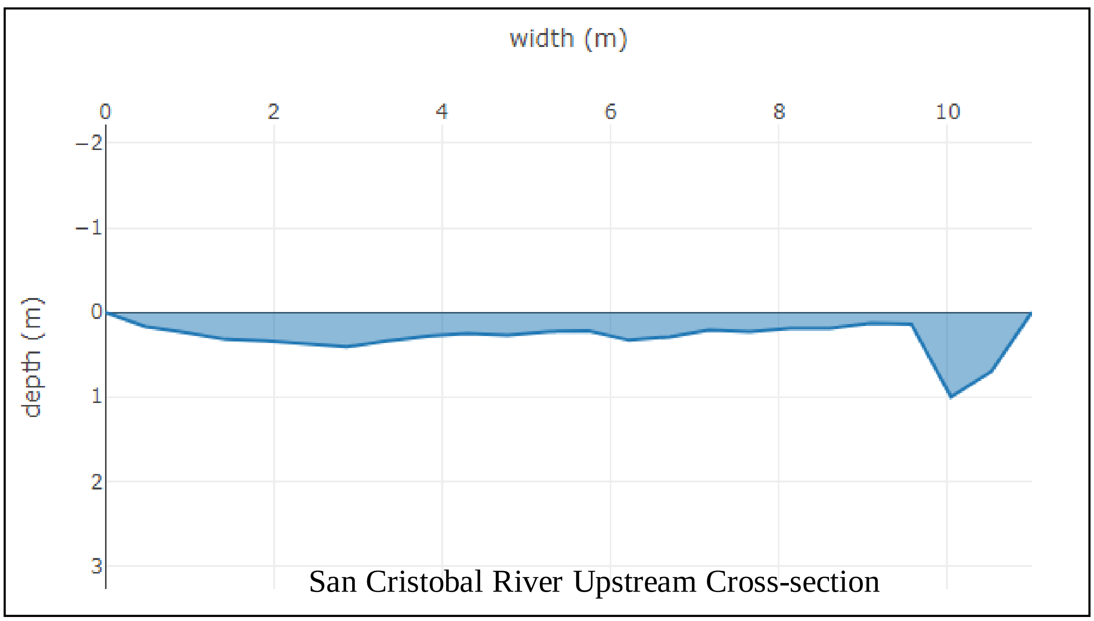

Figure 12. Cross-section profile of the main channel in the upstream of San Cristobal River of Laguna province.

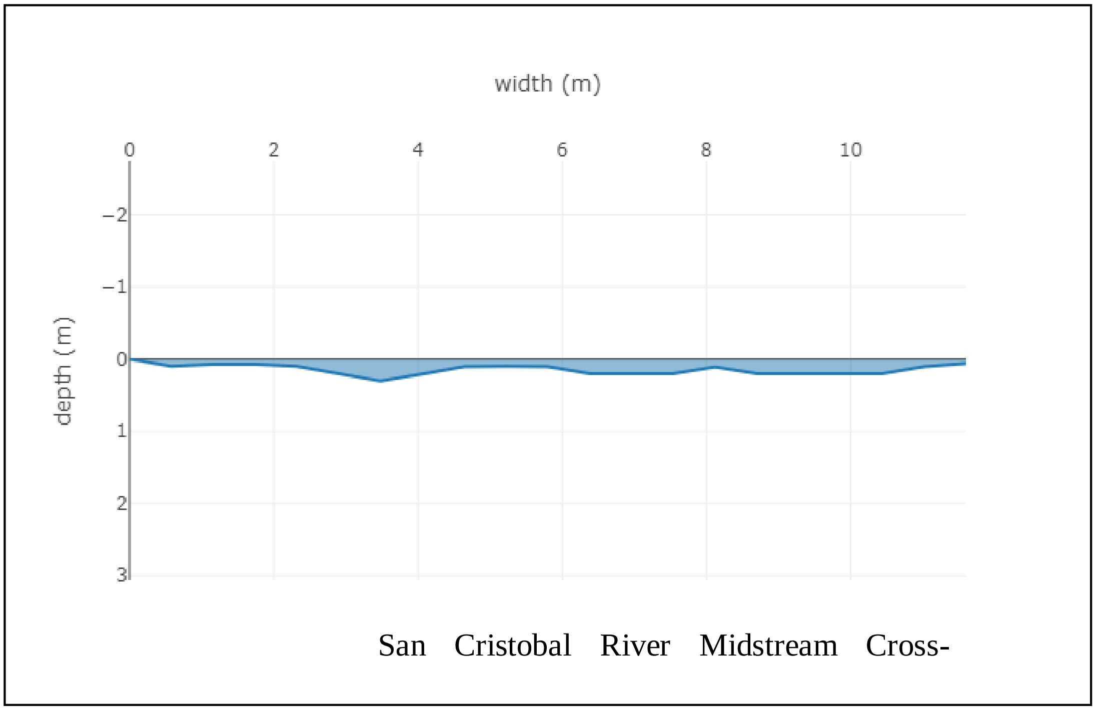

Figure 13. Cross-section profile of the main channel of in the midstream of San Cristobal River of Laguna province.

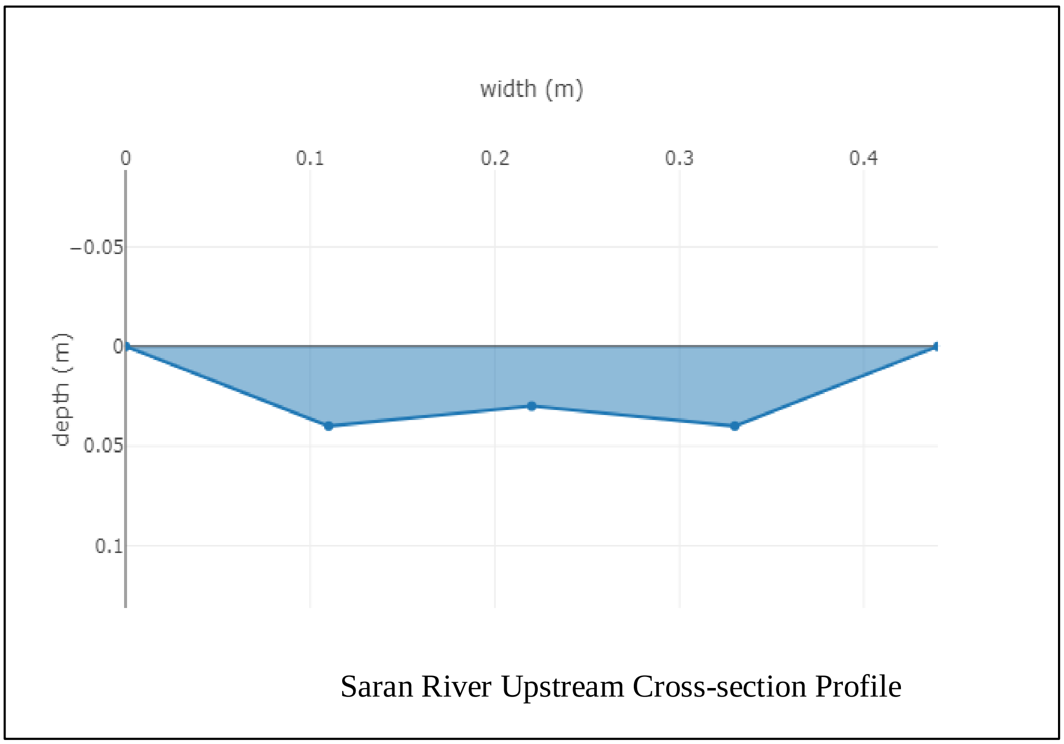

Figure 14. Cross-section profile of the main channel in the upstream of Saran River of Laguna province.

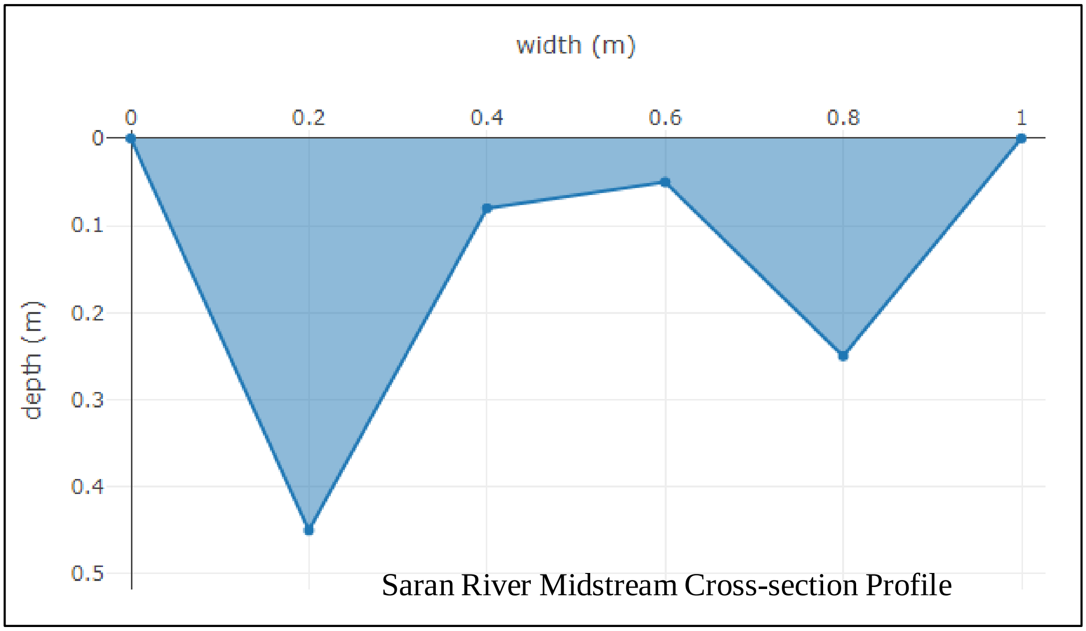

Figure 15. Cross-section profile of the main channel in the midstream of Saran River of Laguna province.

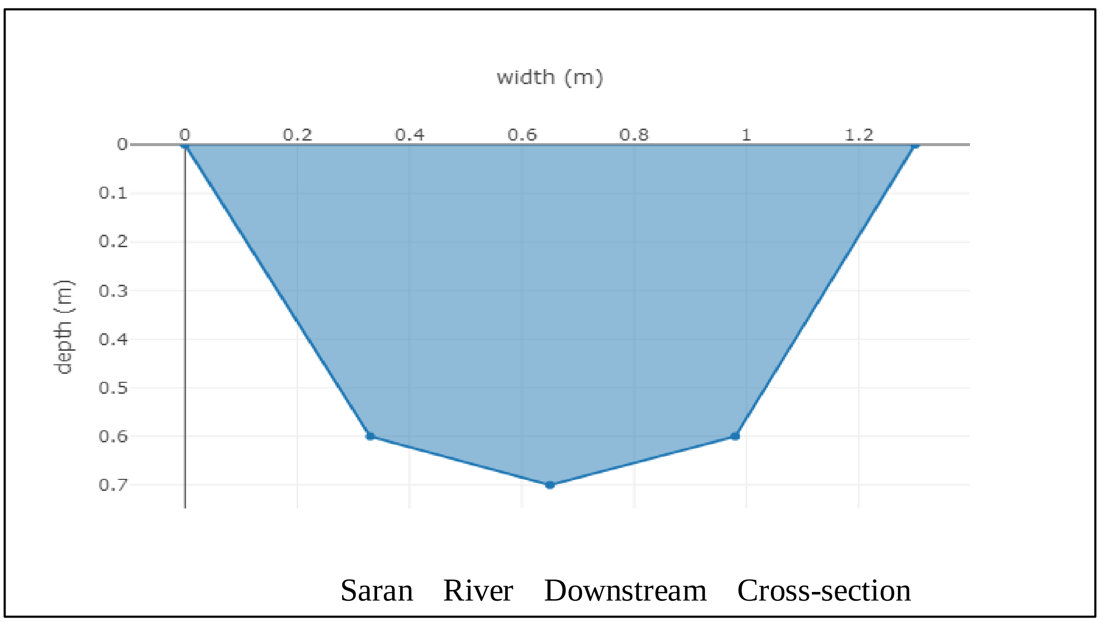

Figure 16. Cross-section profile of the main channel in the downstream of Saran River of Laguna province.

2. Climate

Climate is usually defined as the long-term average of weather conditions, typically averaged over a long period (at least 30 years). There are four climatic types in the Philippines based on the distribution of rainfall. Climatic type I have two pronounced seasons, dry from November to April and wet during the rest of the year. Climatic type II has no dry season with a pronounced rainfall from November to January. Climatic type III are areas with seasons that are not very pronounced, relatively dry from November to April, and wet during the rest of the year. Lastly, climatic type IV with rainfall is more or evenly distributed throughout the year.

Meteorological variables are selected to characterize the prevailing climate. Precipitation, temperature, humidity, atmospheric pressure, and wind are the most common measured and monitored variables. Precipitation is by far the most important factor controlling streamflow and runoff in the watershed. Most hydrologic characteristics are influenced by precipitation. Temperature, humidity, and wind influence the rate of evaporation and evapotranspiration. These two factors are directly related to changes in temperature. Temperature also affects both the chemical and biological characteristics of surface water. Particularly, dissolved oxygen, photosynthesis of aquatic plants, and metabolic rates of aquatic organisms are among the important factors that are affected by changes in temperature.

The catchments of the three rivers in the province fall in climatic type I with two pronounced seasons, dry from November to April and wet during the rest of the year (Figure 17).

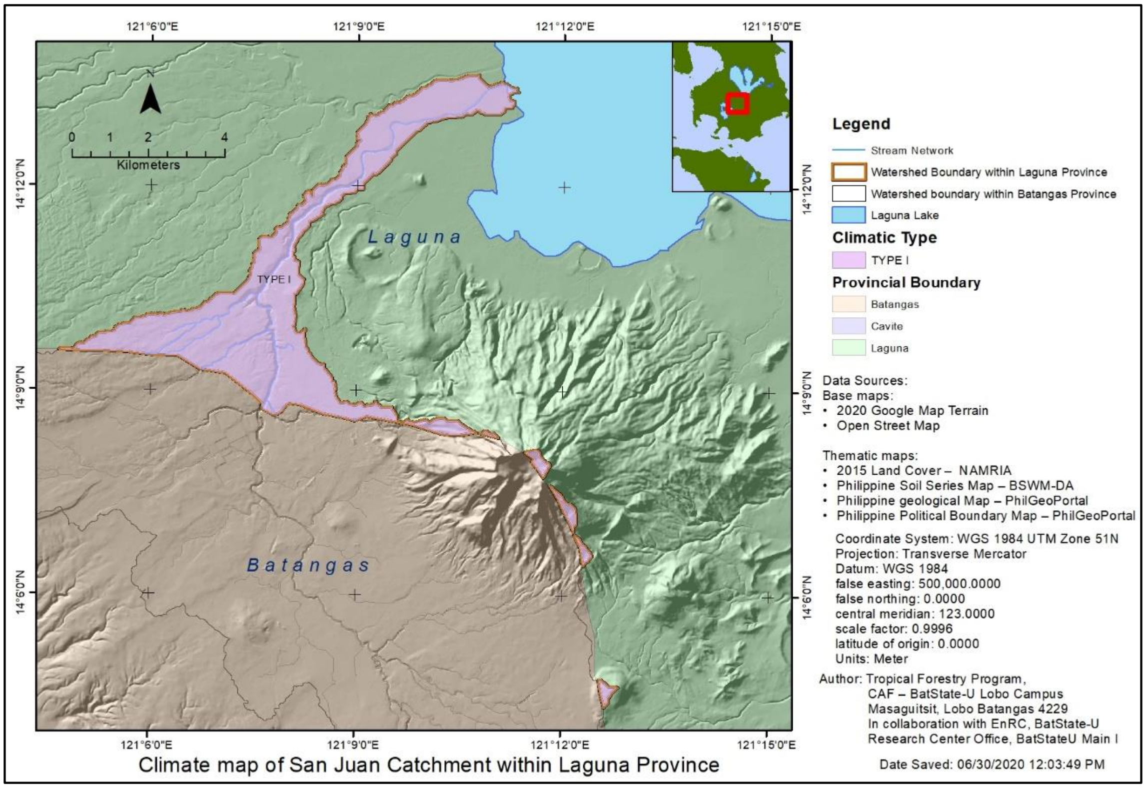

Figure 17. Climate map of San Juan Catchment within Laguna Province

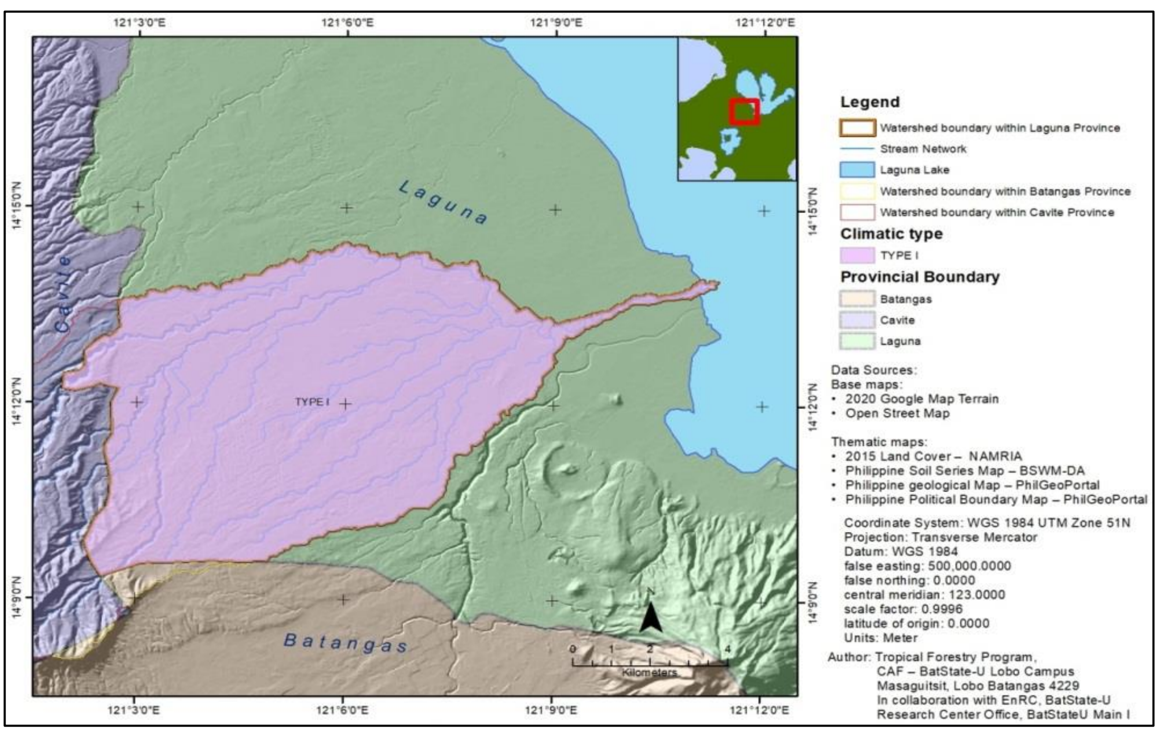

Figure 18. Climate map of San Cristobal Catchment within Laguna Province

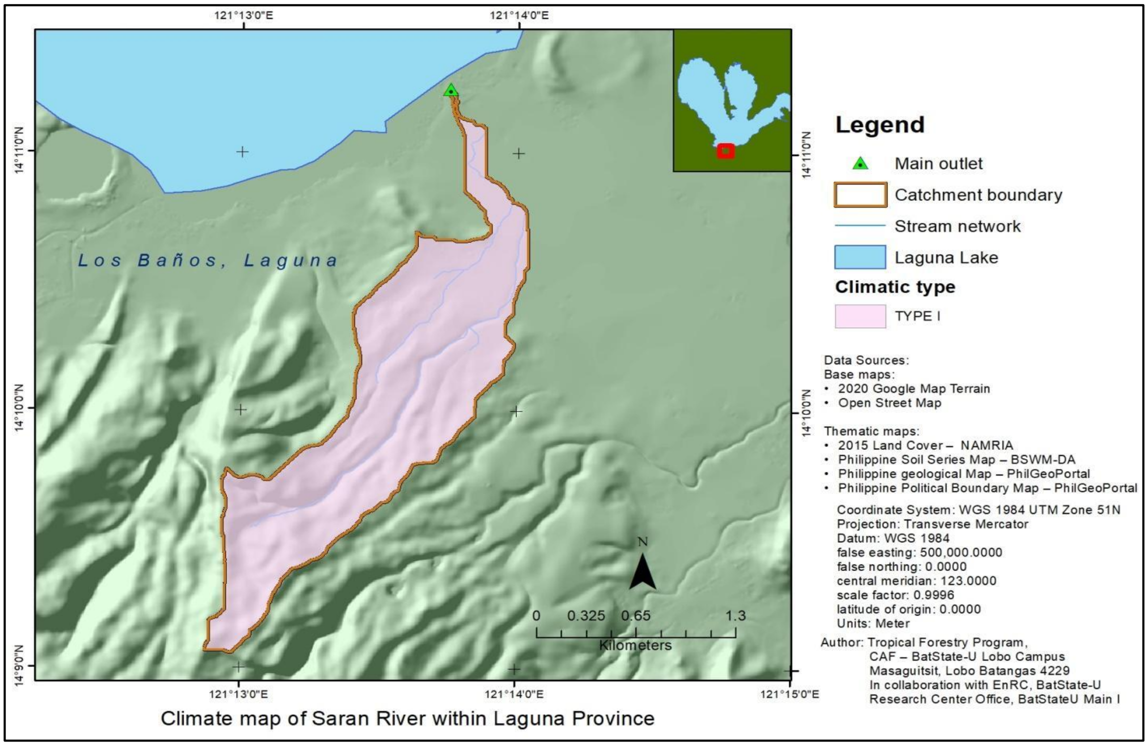

Figure 19. Climate map of Saran Catchment within Laguna Province

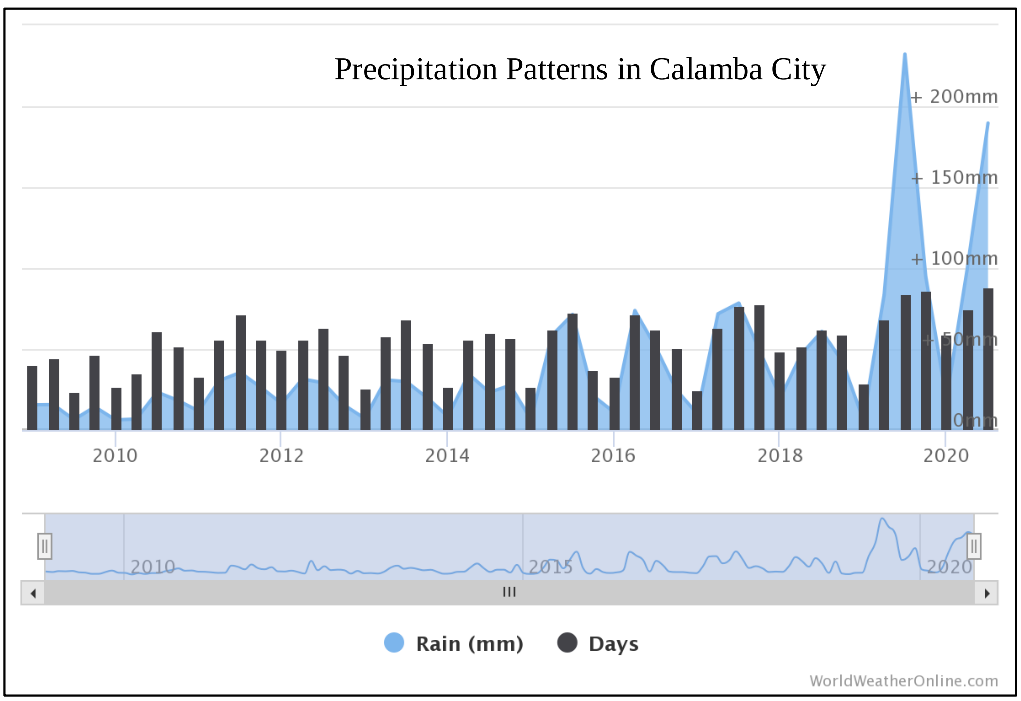

Figure 20. Annual precipitation patterns in Calamba City from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020).*

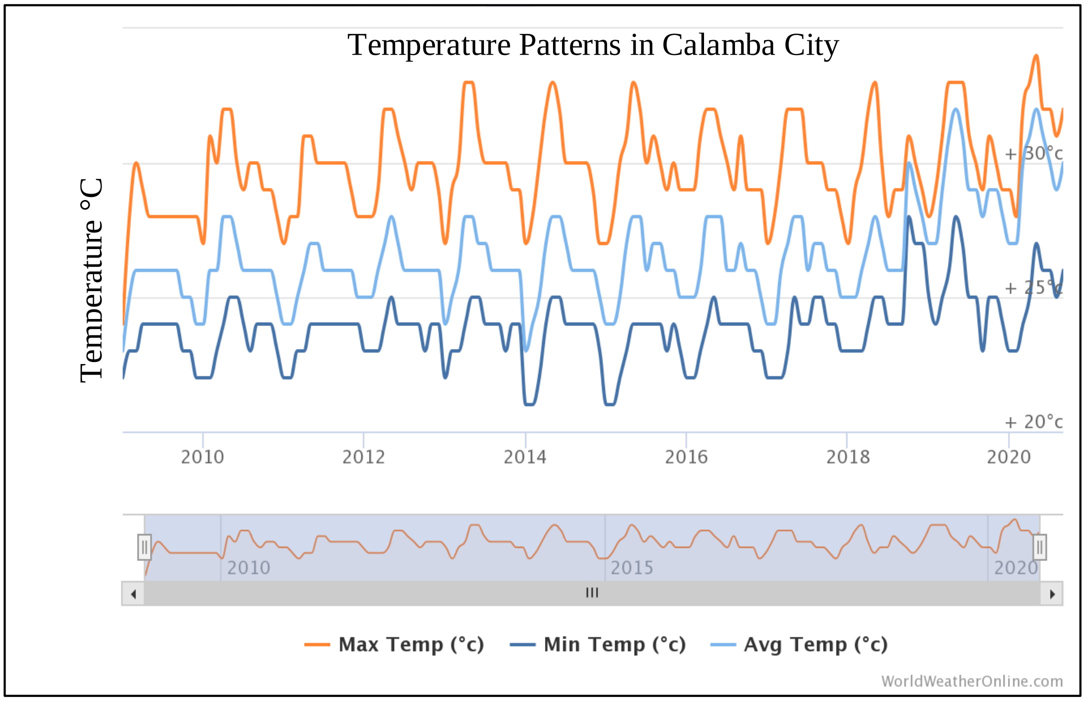

Figure 21. Annual temperature patterns in Calamba City from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020).*

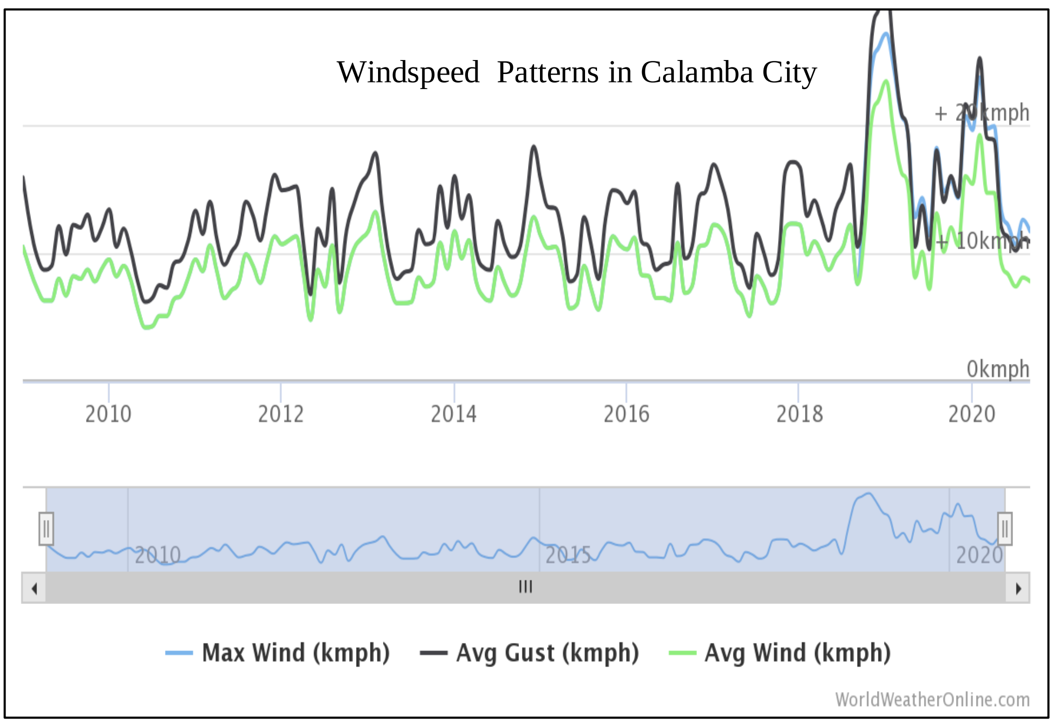

Figure 22. Annual windspeed patterns in Calamba City from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020).*

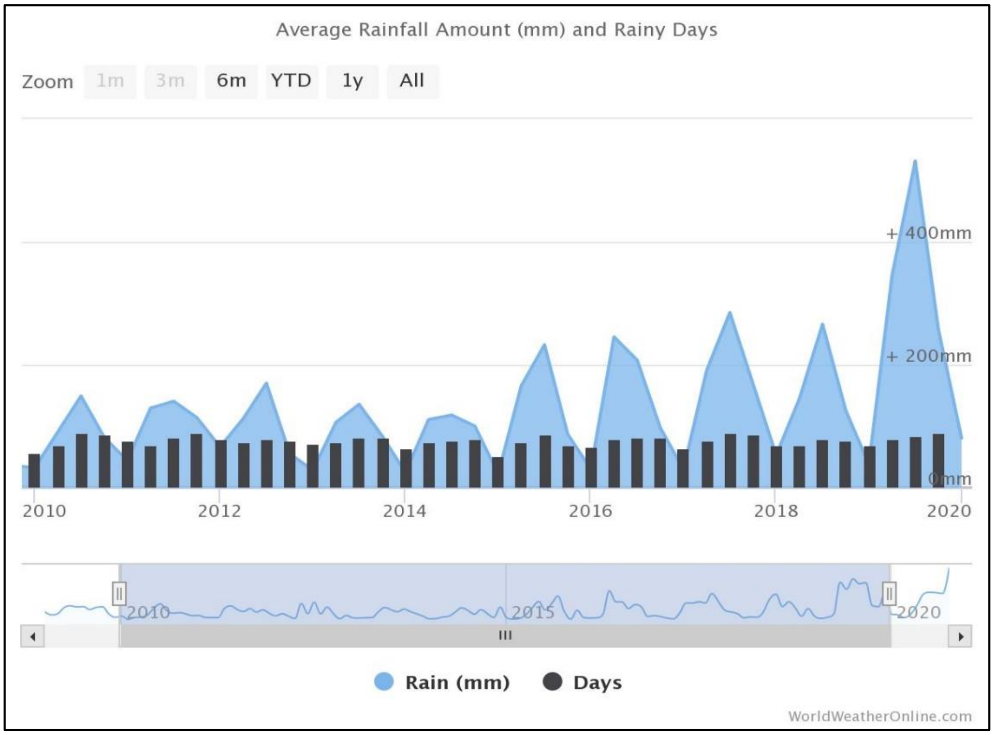

Figure 23. Annual precipitation patterns within the catchment of San Cristobal River in Laguna province from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020)*.

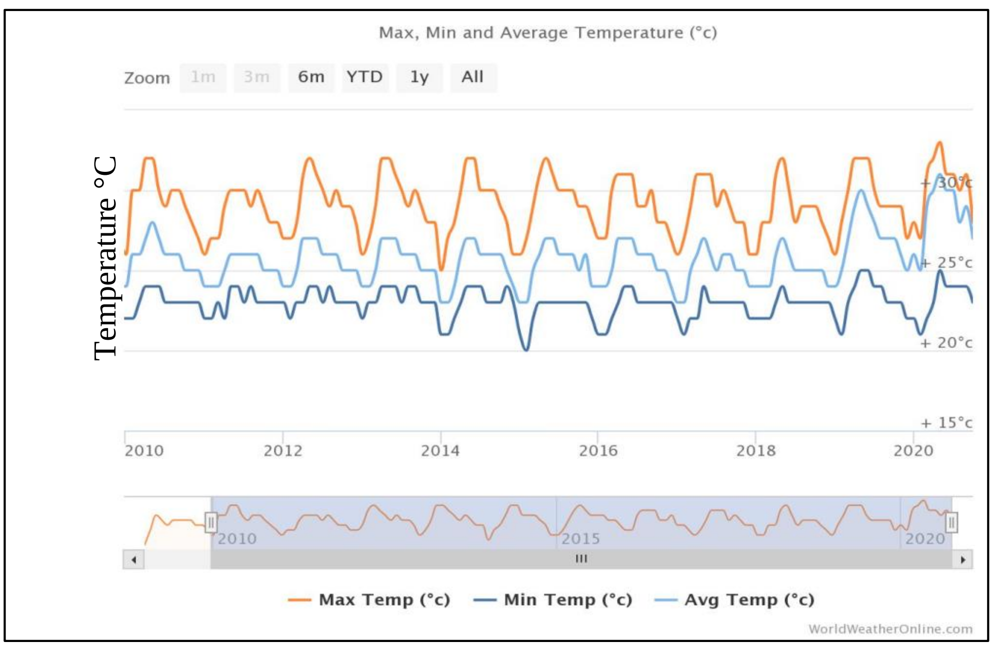

Figure 24. Annual temperature patterns within the catchment of San Cristobal River in Laguna province from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020)*.

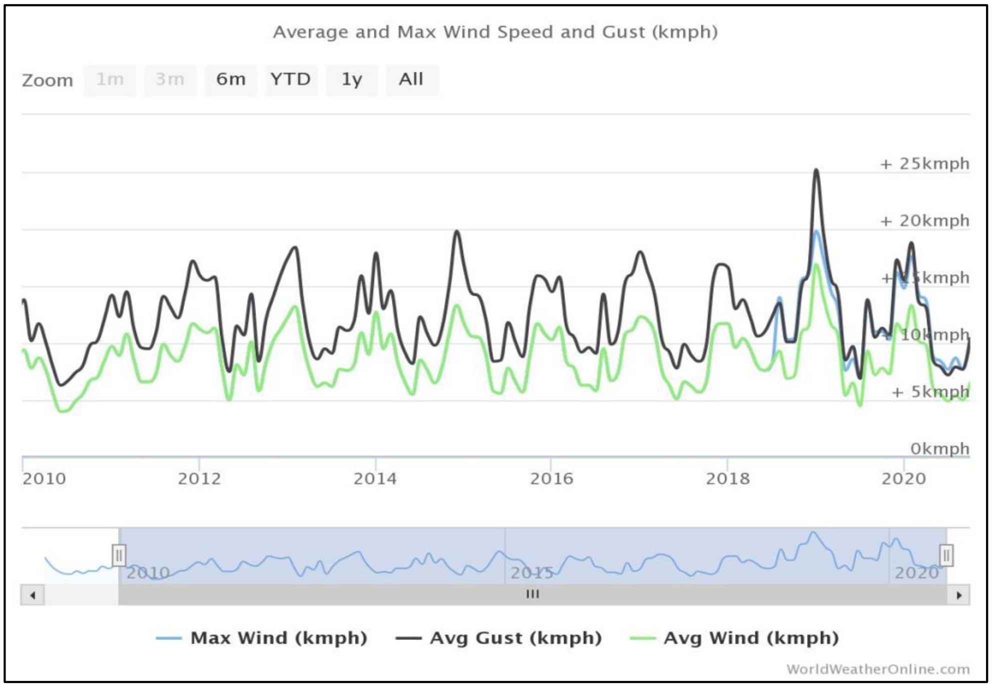

Figure 25. Annual windspeed patterns within the catchment of San Cristobal River in Laguna province from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020)*.

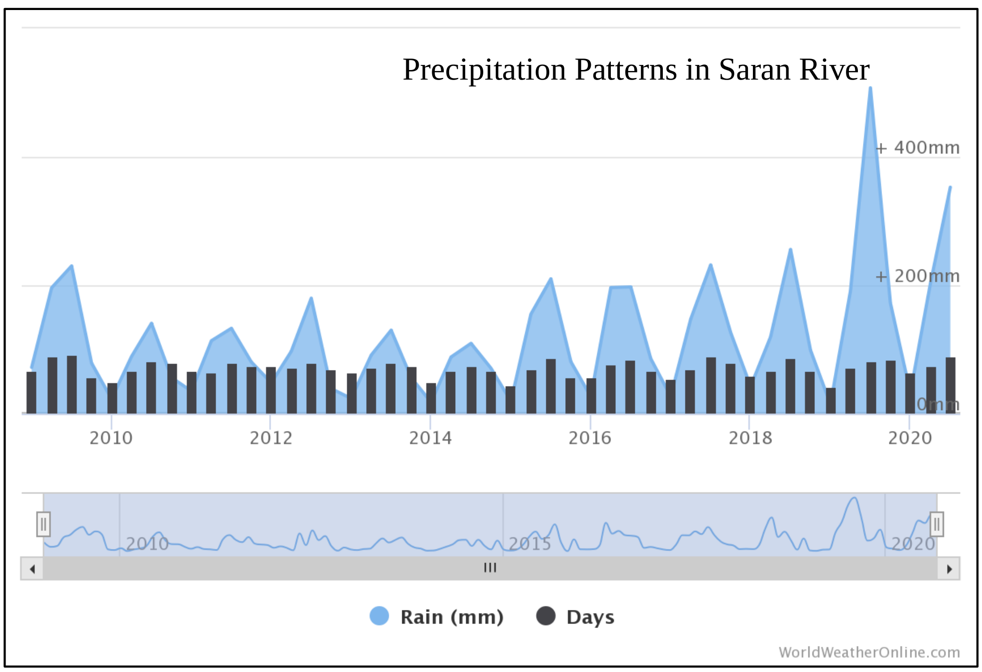

Figure 26. Annual precipitation patterns within the catchment of Saran River in Laguna province from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020)*.

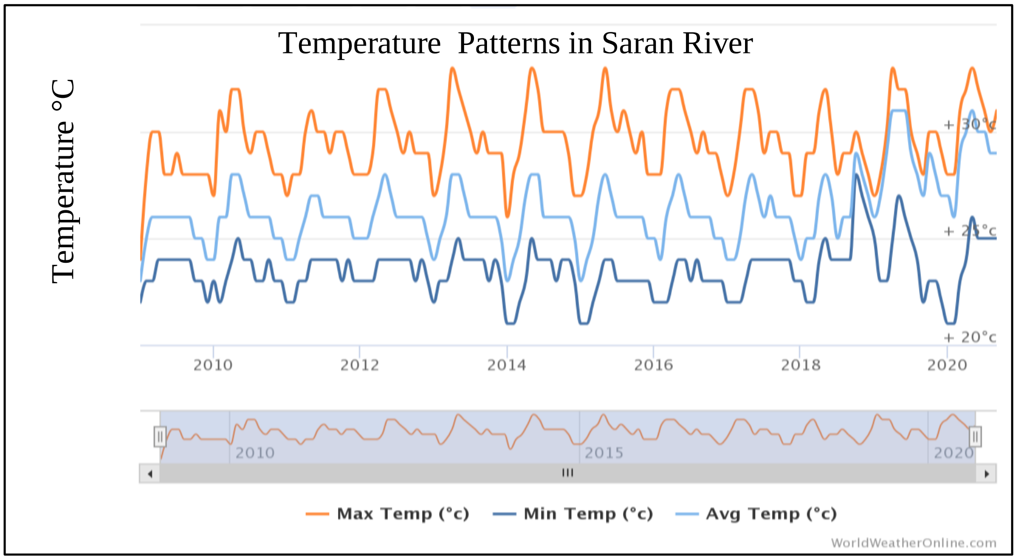

Figure 27. Annual temperature patterns within the catchment of Saran River in Laguna province from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020)*.

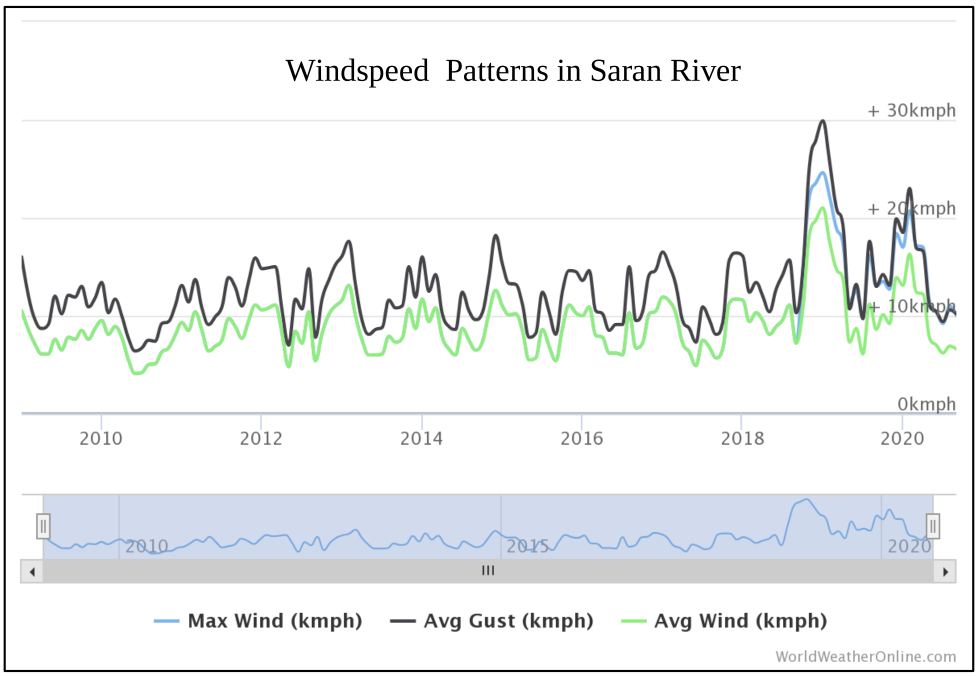

Figure 28. Annual windspeed patterns within the catchment of Saran River in Laguna province from 2010 to 2020 *(WorldweatherOnline.com: date accessed, Sept 2020)*.

3. Land Classification

Land use within a watershed has a major effect on water quality, hydrology, and ecology. Non-point source pollution such as sediment and nutrients from runoff from agriculture and built-up environment can adversely affect water quality. Vegetation removal during landscape development reduces the watershed's ability to absorb nutrients and trap nutrients. On the other hand, agricultural intensification, increasing urbanization, and economic development increase urban and suburban runoff which contaminate surface and groundwater.

Land cover in a watershed is classified through processing and analysis of aerial photographs and satellite imageries. Categories and classifications are used as the basis for classification. Table 7 shows the distribution of land cover types within the catchment of San Juan River within Calamba City. The area has three land cover types based on the classification based on the 2015 land cover map published by NAMRIA. Other land, cultivated, annual crop is the largest with 85% (1,678 ha). This is followed by other land, built-up area with 14% or 271 ha. The smallest land cover is open forest, broadleaved with approximately 1% or 7 ha.

Table 7. Land cover classification of catchment of San Juan River within Calamba City, Laguna.

Land Cover	Sum of Area (ha)	%
Open forest, broadleaved	17	1%
Other land, built-up area	271	14%
Other land, cultivated, annual crop	1,678	85%
Grand Total	1,966	100%

The land classification of San Cristobal River within the Province of Laguna is compose of six (6) land types. Land with cultivated annual crop has the largest composition with 77.26% (6,197.46 ha) followed by built-up area with 14.45% (1,182.89 ha.) and the smallest area is land cultivated with perennial crops.

Table 8. Land classes within the catchment of San Cristobal River in Laguna province.

Land Classification	Area (ha)	Percentage
Other lands, natural, barren land	26.18	0.33
Other lands, cultivated, annual crop	6197.46	77.26
Other lands, built-up area	1182.89	14.75
Other wooded land, shrubs	606.79	7.56
Other lands, cultivated, perennial crop	8.39	0.10
Inland water	0.02	0.00
Total	8021.73	100.00

Lastl, Saran River within the Province of Laguna is composed of three (3) land types with cultivated annual crop the largest are of 81.15% (6,197.46 ha). This is followed by built-up area 14.45% (1,182.89 ha.) while the smallest area is land cultivated with perennial crops.

Table 9. Land classes within the catchment of Saran River in Laguna province.

Land classification	Sum of Area (ha)	%
Open forest, broadleaved	42.01	17.11%
Other land, built-up area	4.25	1.73%
Other land, cultivated, annual crop	199.19	81.15%
Grand Total	245.45	100.00%

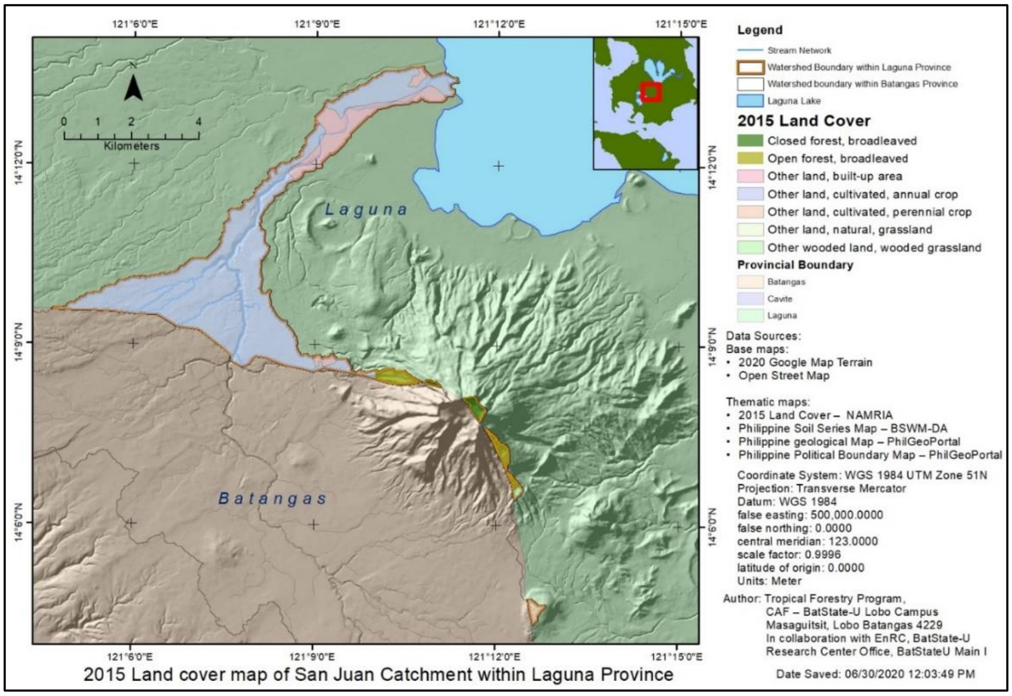

Figure 29. Land cover map of San Juan Catchment within Laguna Province.

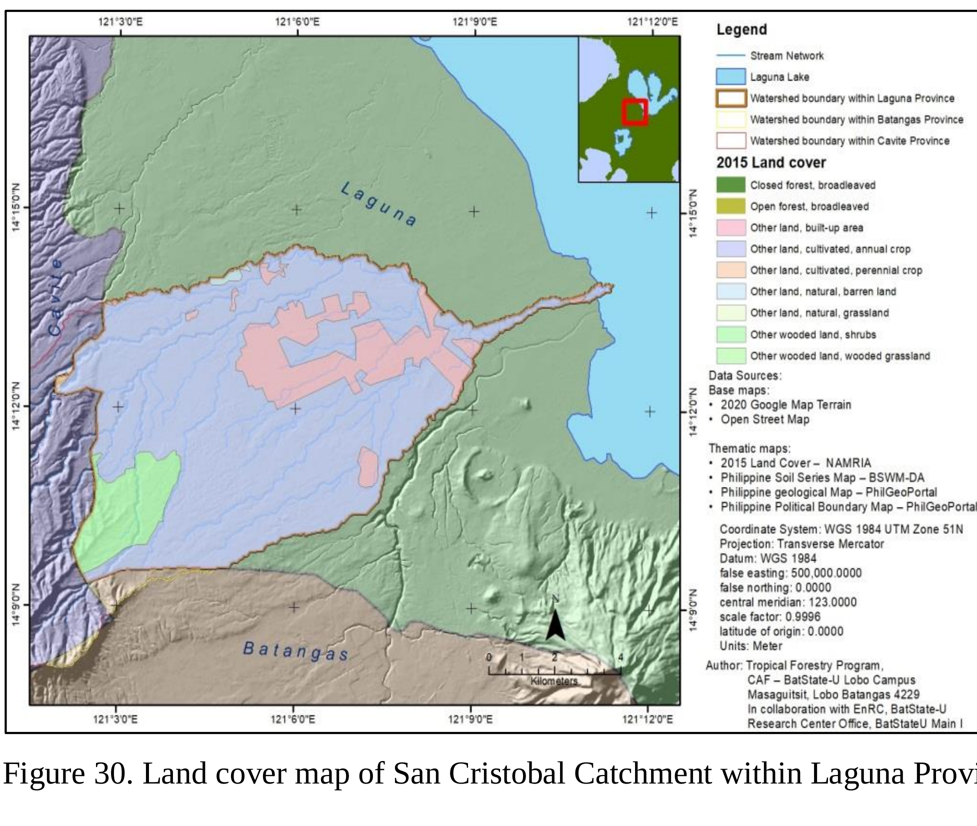

Figure 30. Land cover map of San Cristobal Catchment within Laguna Province.

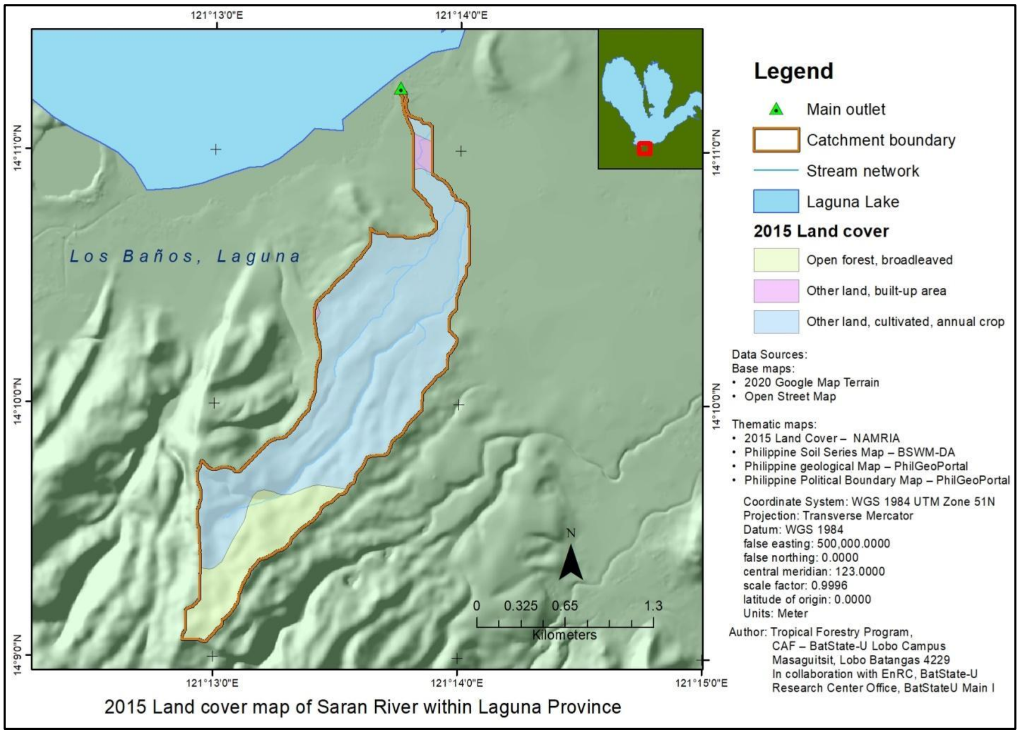

Figure 31. Land cover map of Saran Catchment within Laguna Province.

4. Geology

Geological formation plays an important role in the characteristics of sediment dynamics of a watershed. Bedrock formations and the soil materials produced from them influence the water quality, biological productivity and aquatic life of the stream. The particles' physical and chemical properties of sediments flowing out of the watershed is directly influenced by the parent materials overlaying the land of the watershed. It also influences topography, direction of water flow, shape of the drainage basin, stream bed materials and biological productivity. For example, karst areas have geology of limestone or dolomite which have openings where water has dissolved the rock along cracks and between layers. These routes funnel water much faster to the water table thereby increasing the risks of groundwater contamination.

Parent materials also determine the maximum depth of stream channels and control and lateral and sideways movement of the stream. For this characterization, the generalized geological map was used as the basis for determining the geology of the watershed. This map was culled from the USGS geological maps and was obtained from Philippine Geoportal.

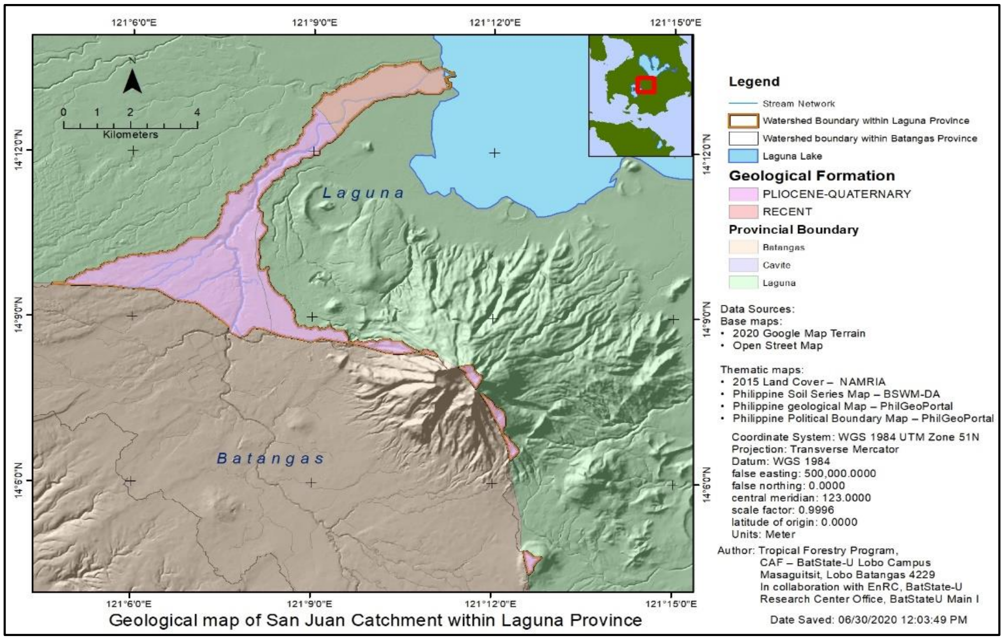

Figure 32. Geological map of San Juan Catchment within Laguna Province

The catchment of San Juan River within the Province of Laguna is compose of two types geological formation (Figure 32). Pliocene quaternary has the largest formation with an average of 81.1 % (1,673.58 ha) while the recent alluvial formation with 18.62 % (384.16 ha).

Table 10. Geological formations within the catchment of San Juan River of Laguna province.

Formation	Area (ha)	Percent (%)
PLIOCENE-QUATERNARY	1673.57	81.1
LAKE	5.94	0.29
RECENT	384.16	18.62
TOTAL	2,063.67	100

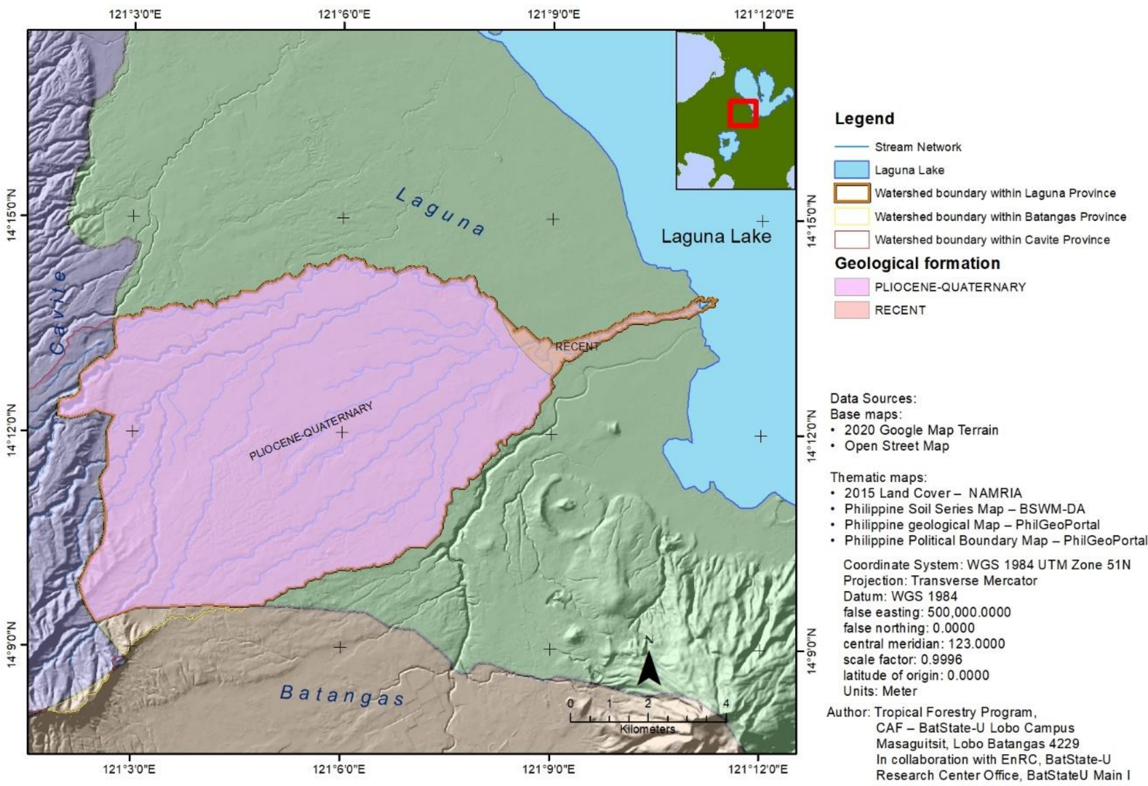

Figure 33. Geological map of San Cristobal Catchment within Laguna Province

There are two types of geological formations for San Cristobal River (Table 11). Pliocene quaternary has the largest formation with 97.81 % (7,837.21 ha) while the recent alluvial formation with 2.19 % (175.23 ha).

Table 11. Geological formations within the catchment of San Cristobal River of Laguna province.

Formation	Area (ha)	Percent (%)
PLIOCENE-QUATERNARY	7,837.21	97.81
LAKE	0.39	11.90
RECENT	175.23	2.19
TOTAL	**8,012.82**	**100**

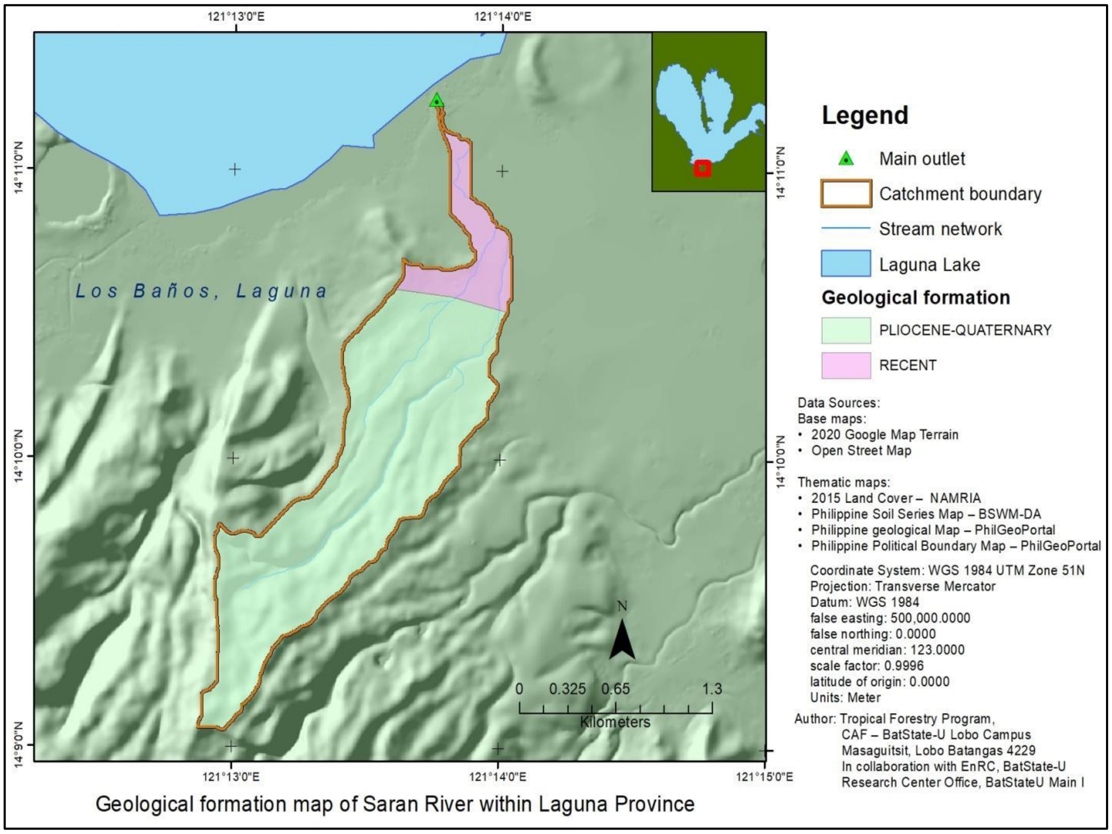

Figure 34. Geological map of Saran Catchment within Laguna Province

Lasty, Saran is aslo composed of two types of geological formations with pliocene quaternary has the largest formation with 86.75% (212.70 ha) while the recent alluvial formation with only 13.23% (32.44 ha).

Table 12. Geological formations within the catchment of Saran River of Laguna province.

Formation	Area (ha)	Percent (%)
PLIOCENE-QUATERNARY	212.70	86.75
RECENT	32.44	13.23
TOTAL	**245.18**	**100**

5. Soil Type and Characteristics

Soil is a collective term which refer to the unconsolidated mineral matter on the surface of the earth. Soil type and characteristics play an important role in the biomass generation of the catchment. Water quality can be influenced by soil chemical properties. Soil with high organic matters tends to form aggregates that encourage soil crumbling and enhance soil infiltration rate. Fertile soil supports vegetation growth and encourages the accumulation of soil organic matter which helps stabilize the water cycle of the watershed.

In a natural condition, there is a balance between inputs and the export of soil matter. This balance depends on the vegetation cover, topography, geology, and local climate. However, surface alteration to give way to agriculture and development increases soil export in the form of accelerated erosion. Accelerated erosion can reduce soil quality and cause downstream deposition. The latter decreases the channel capacity which causes flooding, erosion, and destruction of habitats.

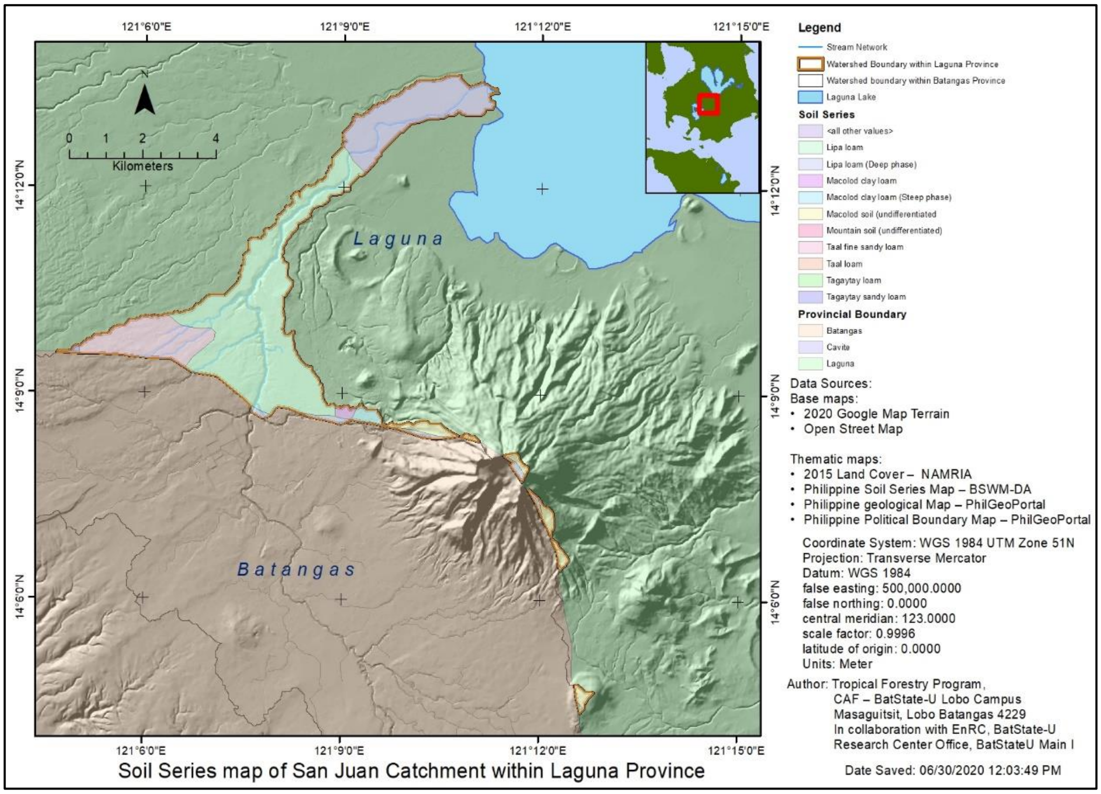

Figure 35. Soil series map of San Juan Catchment in Laguna Province

The catchment of San Juan River within the Province of Laguna is composed of 8 soil series based on the map of the Bureau of Soil and Water Management (BSWM) (Figure 35). Lipa loam has the largest distribution with 56.60.86% (1,168.12 ha) followed by Quingua silt loam with 20.37% (420.39 ha). Tagaytay sandy loam has the lowest area with only 0.24% (4.98 ha).

Table 13. Soil series within catchment of San Juan River in Laguna Province.

Soil Description	Topography	Soil Series	Area (ha)	Percent (%)
Lipa loam	Uplands	Lipa	1,168.12	56.60
Lipa loam (Deep phase)	Uplands	Lipa	47.62	2.31
Macolod clay loam	Highlands	Macolod	15.10	0.73

Macolod clay loam (Steep phase)	Highlands	Macolod	26.87	1.30
Macolod soil (undifferentiated	Highlands	Macolod	89.09	4.32
Quingua silt loam	Lowlands	Quingua	420.39	20.37
Taal fine sandy loam	Highlands	Taal	291.50	14.13
Tagaytay sandy loam	Highlands	Tagaytay	4.98	0.24
Total			**2,063.67**	**100.00**

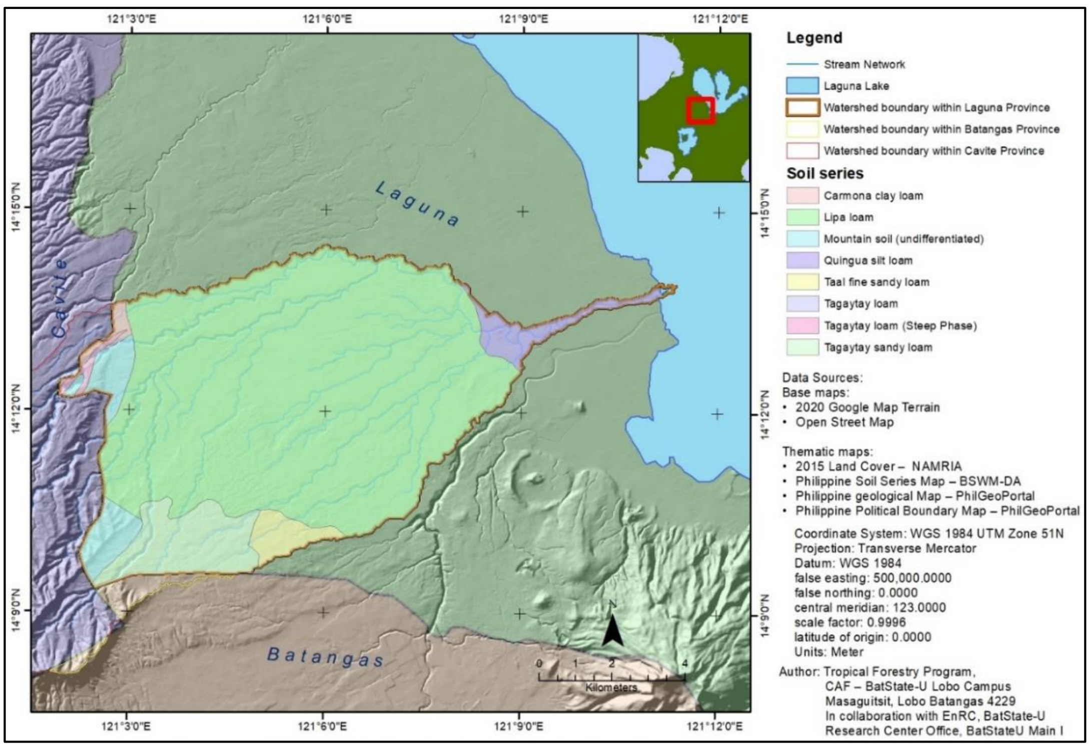

Figure 36. Soil series map of San Cristobal Catchment in Laguna Province

There are eight (8) soil types within the catchment of San Cristobal River within the Province of Laguna. Among these, Lipa loam is the largest distribution with 80.40%

(6,442.18 ha) followed by Tagaytay sandy loam with 8% (641.40 ha). Tagaytay loam has the lowest area with only 0.02% (1.55 ha).

Table 14. Soil series within the catchment of San Cristobal River in Laguna Province.

Soil Description	Topography	Soil Series	Area (ha)	Percent (%)
Carmona clay loam	Uplands	Carmona	55.57	0.69
Lipa loam	Uplands	Lipa	6442.18	80.40
Mountain soil (undifferentiated)	Highlands	Mountain soil	389.32	4.86
Quingua silt loam	Lowlands	Quingua	241.32	3.01
Taal fine sandy loam	Highlands	Taal	196.22	2.45
Tagaytay loam	Highlands	Tagaytay	1.55	0.02
Tagaytay loam (Steep Phase)	Highlands	Tagaytay	45.27	0.56
Tagaytay sandy loam	Highlands	Tagaytay	641.40	8.00
TOTAL			**8,012.82**	**100.00**

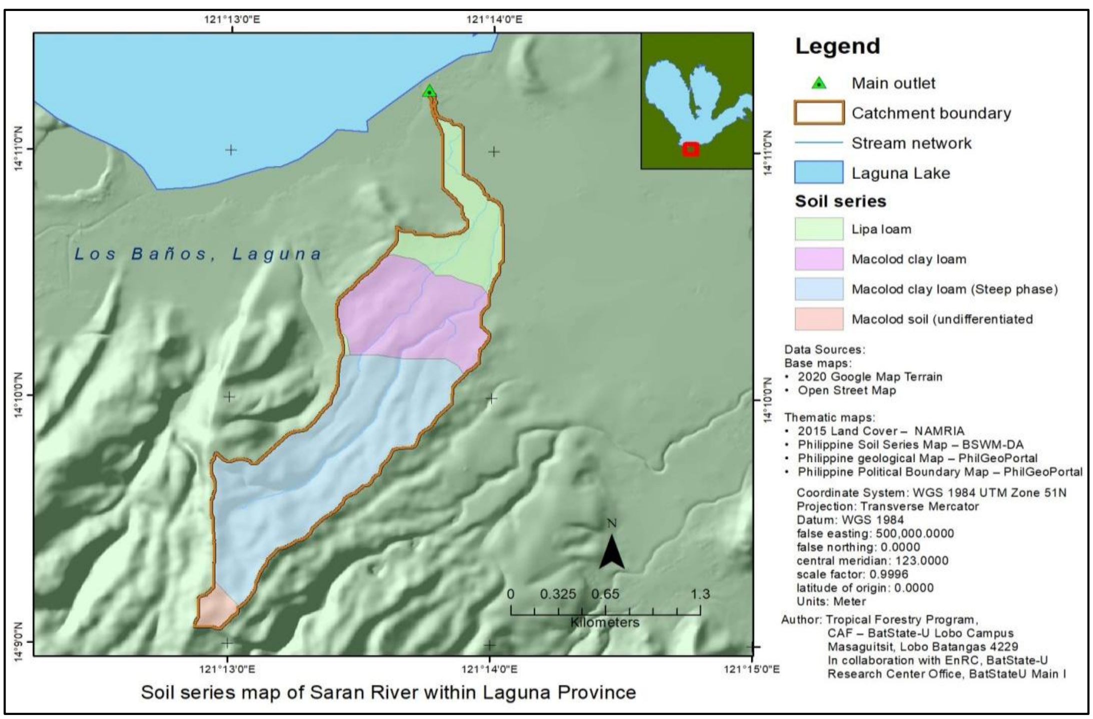

Figure 37. Soil series map of Saran Catchment in Laguna Province.

Lastly, the catchment of Saran River has also eight (8) soil series based on the map of the Bureau of Soil and Water Management (BSWM). Macolod clay loam (Steep phase has the largest distribution with 54.98% (134.81 ha) followed by Macolod clay loam with 26.11% (64.02 ha). Macolod (undifferentiated) has the lowest distribution with only 2.63% (6.45 ha).

Macolod clay loam (steep phase) the type of clay that is metahalloysite and /or kaolinite with poor to very poor crystallinity and is mainly metahalloysite. The Clay loam is a soil mixture that contains more clay than other types of rocks or minerals. A loam is a soil mixture that is named for the type of soil that is present in the greatest amount. The particles of clay are very small, which is one of its most important characteristics. For this reason, loams that contain a great deal of clay tend to be heavy, because they are so dense. While this soil type can be difficult to work with, it was also proved to be a very good growing medium. The density of clay is the cause of the two biggest drawbacks of clay loam.

Table 15. Soil series within the catchment of Saran River in Laguna Province.

Soil Description	**Topography**	**Soil Series**	**Area (ha)**	**Percent (%)**
Lipa loam	Uplands	Lipa	39.90	16.27
Macolod clay loam	Highlands	Macolod	64.02	26.11
Macolod clay loam (Steep phase	Highlands	Macolod	134.81	54.98
Macolod soil (undifferentiated	Highlands	Macolod	6.45	2.63
TOTAL			**2,063.67**	**100.00**

When clay is very wet, it swells to retain water, which makes it difficult to work with. Over time, this poor drainage can also stunt plant growth. Dry clay shrinks but stays packed, forming dense clouds and cracking the soil surface, These drawbacks can be lessened by adding organic matter over time.

6. Water Quality

Water quality is one of the most significant indicators in determining the health of the watershed. It is considered as the primary indicator of the condition of the natural environment and economic activities with the catchment. Hence, regular monitoring of water quality in sufficient monitoring stations along the stream network is very important to track the condition of the watershed and to pinpoint sources of pollution. The quality of water that flows along the stream network is influence by various factors. Among these are the land-use within the entire catchment, presence of vegetation especially along riparian areas, presence of wastewater generating industries, extent, and intensity of agricultural activities, presence of informal settlers and condition of wastewater, and septage disposal, and geology and soil characteristics of the area.

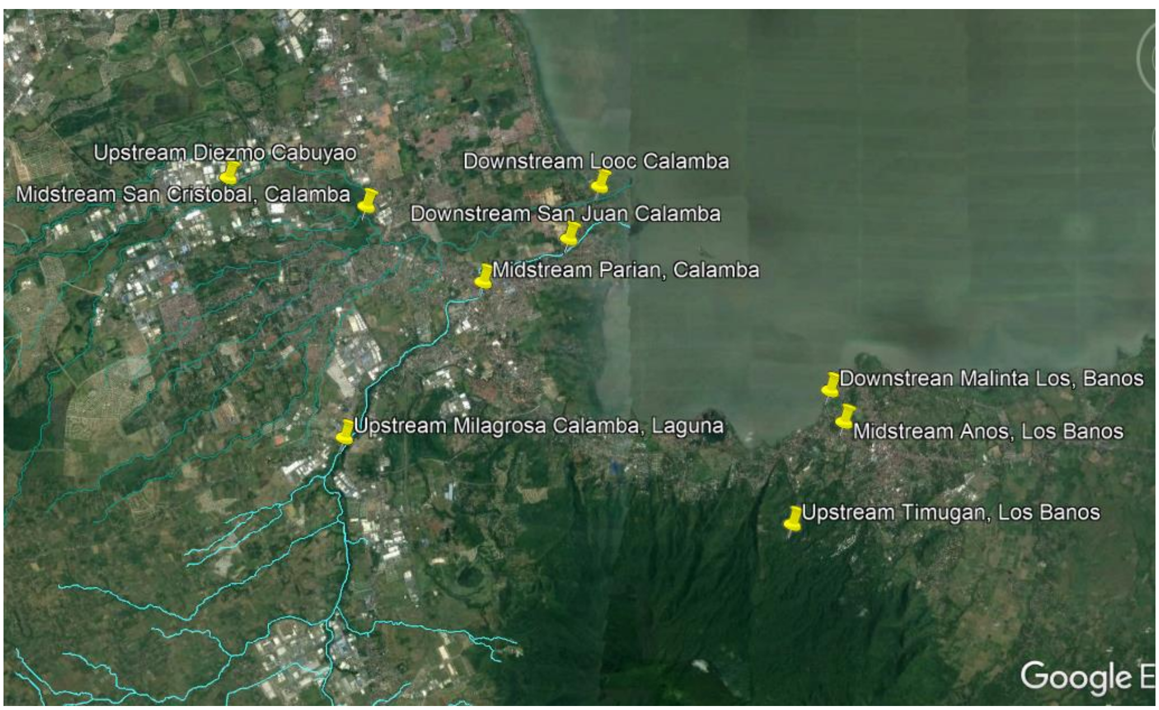

Figure 38. Sampling stations for water quality and biodiversity asssessment and monitoring in San Juan River, Saran River and Saran River of Laguna Province *(Google Earth 2020)*.

Water quality can be established through a measure of several parameters which can be categorized into biological, physical, and chemical properties. DENR Administrative Order No. 2016-08 provides guidelines for the classification of water bodies in the country and sets the general effluent standards (GES). It also identifies the primary parameters for evaluating water quality which includes biochemical oxygen demand (BOD), chlorine, color, dissolved oxygen (DO), fecal coliform, nitrate, pH, phosphate, temperature, and total suspended solids (TSS).

For the San Juan River within Laguna province, three (3) stations were monitored to represent the downstream, midstream, and upstream water quality conditions. Based on the water quality sampling and testing conducted by the PENRO Los Baños, the dissolved oxygen level falls below the class B and class C for surface water based on DAO 2016-08 with 67% of the measurement below 5mg/L (Figure 39). The downstream water quality has the most deteriorated with all (100%) of the measurement below class B AND C. Both midstream and upstream are also not in good condition when it comes to DO levels with 75% of the measurement falls below class B and C.

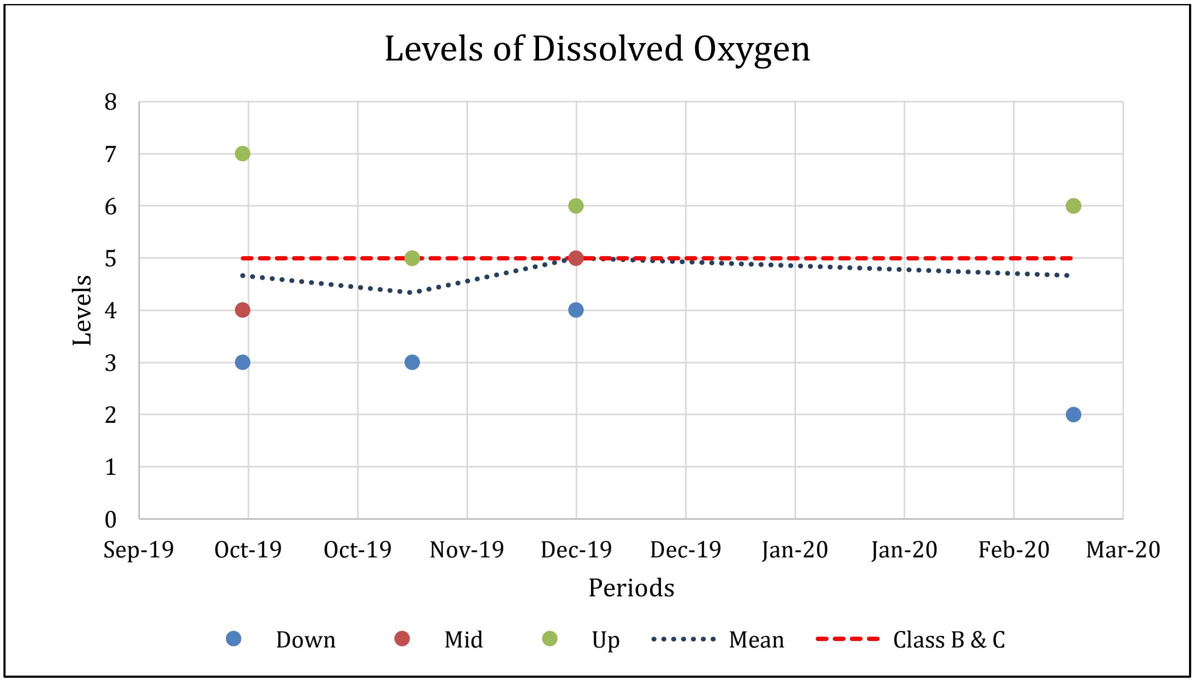

Figure 39. Levels of dissolved oxygen (DO) along the mainstream of San Juan River in Laguna province from Sept 2019 to March 2020.

For San Cristobal River the dissolved oxygen level falls below the class B and class C for surface water based on DAO 2016-08 with all (100%) of the measurement below 5mg/L (Figure 39) for all monitoring stations (downstream, midstream, and upstream).

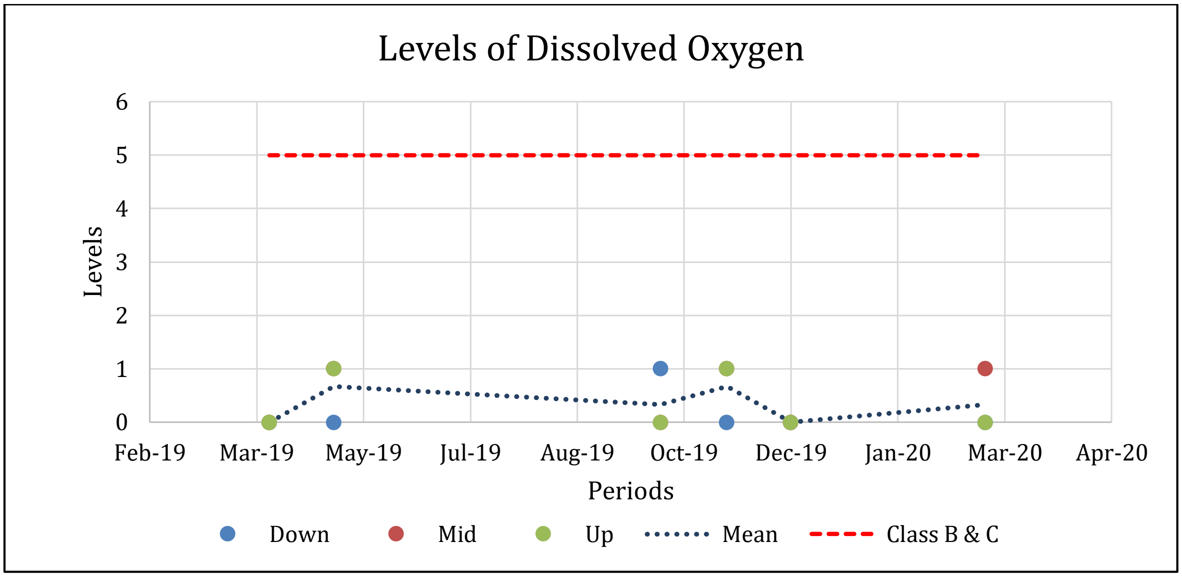

Figure 40. Levels of dissolved oxygen (DO) along the mainstream of San Cristobal River in Laguna province from Feb 2019 to Apr 2020.

The dissolved oxygen levels in most of the sampling stations of Saran River are below the class B and class C standard based on DAO 2016-08 with 67% of the measurement below 5mg/L (Figure 39). Downstream has the lowest quality with 100% of all measurements below class C. Upstream has the best quality in terms of DO with only 14% of measurements fall below class C.

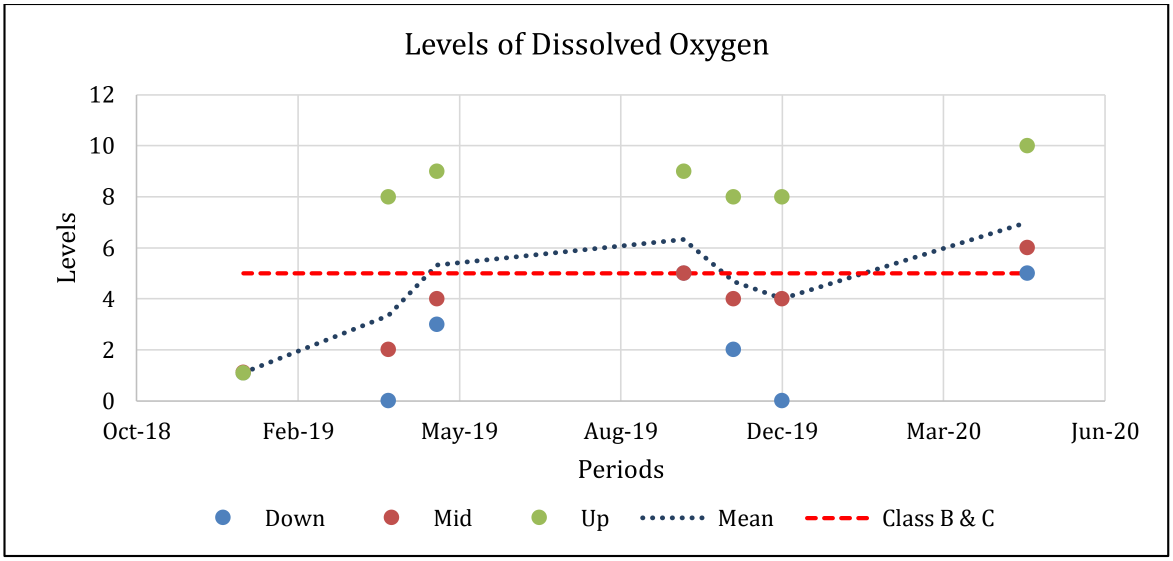

Figure 41. Levels of dissolved oxygen (DO) along the mainstream of Saran River in Laguna province from Feb 2019 to Apr 2020.

Dissolve oxygen refers to the level of non-compound oxygen available in the water. This is a very important indicator of water quality since dissolved oxygen is directly being used by aquatic organisms. Similar to other water quality parameters, too high or too low levels of DO can be harmful to aquatic organisms and can degrade water quality. DO is essential to most aquatic life. Fish, crustaceans, bacteria, and fungi use DO in the water during their respiration. Fish and crustaceans obtain oxygen for respiration through their gills, while plant life and phytoplankton require dissolved oxygen for respiration when there is no light for photosynthesis. Microbes such as bacteria and fungi also require dissolved oxygen. These organisms use DO to decompose organic material at the bottom of a body of water. Microbial decomposition is an important contributor to nutrient recycling. However, if there is an excess of decaying organic material (from dying algae and other organisms), in a body of water with infrequent or no turnover (also known as stratification), oxygen level can decrease at critical levels. Critically low DO leads to fish mortality. In the ocean, fish begin to be driven away at below DO of 6mg/L. Invertebrates like mollusks are affected below 20 mg/L.

For San Juan River, in terms of biochemical oxygen demand (BOD) majority of the measurement (58%) is above class B and half (50%) is above class C standard for surface water based on DAO 2016-08 (Figure 42). This indicates a higher concentration of decomposing bacteria in the water brought about by higher concetration of nutrients and organic matter. Both midtream and downsteam have 50% of mesurement above class B and class C, while the upstream has 75% of the measurement are above class B.

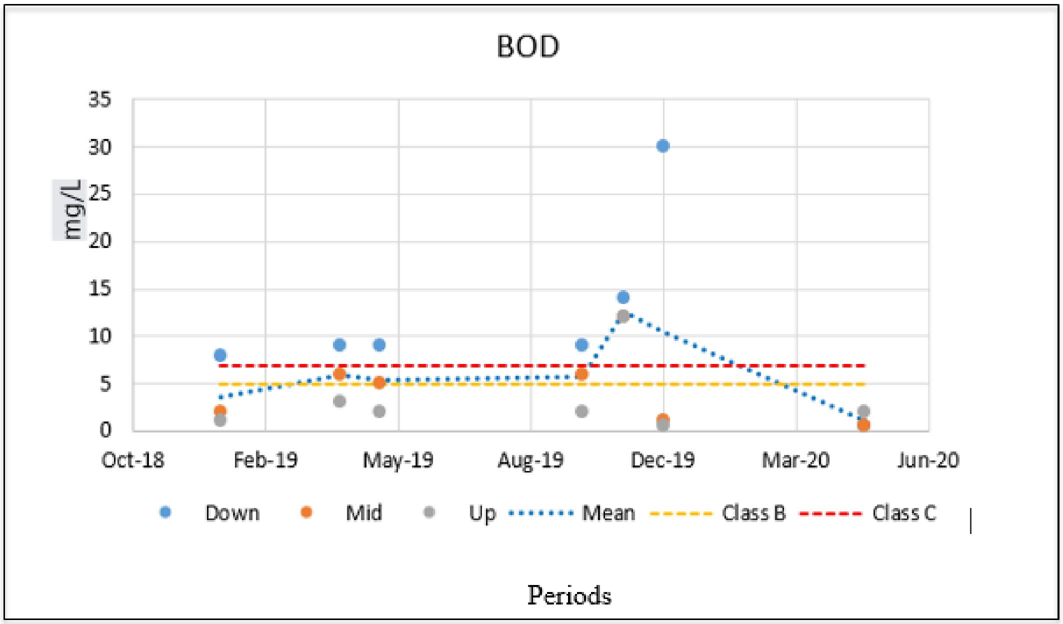

Figure 42. Levels of biochemical oxygen demand (BOD) along the mainstream of San Juan River in Laguna province from Sept 2019 to March 2020.

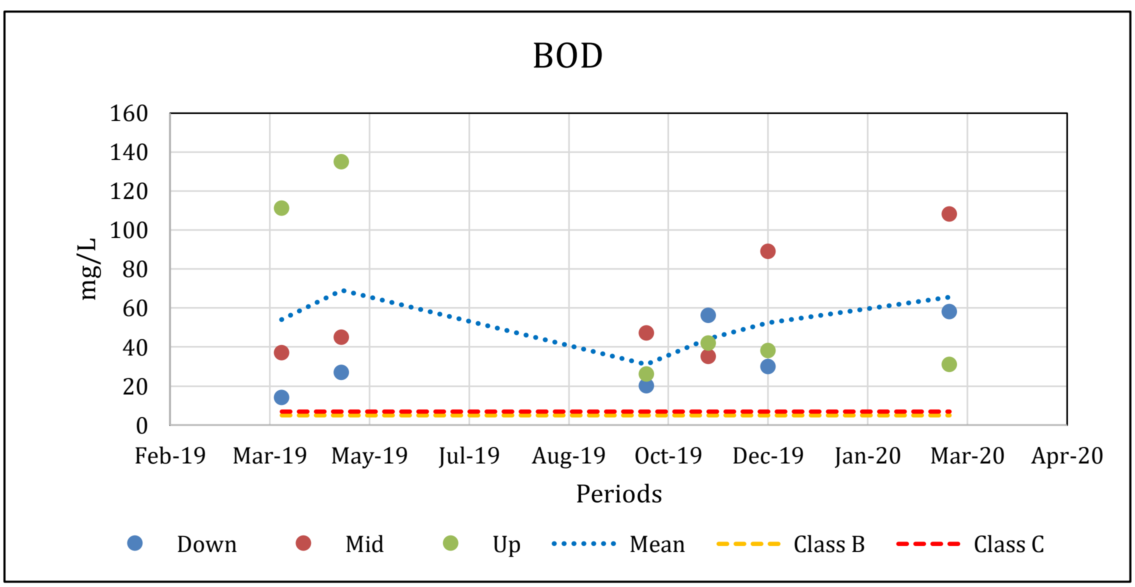

Figure 43. Levels of biochemical oxygen demand (BOD) along the mainstream of San Cristobal River in Laguna province from Feb 2019 to Apr 2020.

For San Cristobal River the biochemical oxygen demand (BOD) is at alarming levels with all (100%) of the measurement (58%) is above class B and class C standard for surface water based on DAO 2016-08 (Figure 43). This indicates a higher concentration of decomposing bacteria in the water due to a high concentration of nutrient and organic matter.

For Saran River the biochemical oxygen demand (BOD) is also needing attention with 48% and 38% of the measurement above class B and class C respectively based on DAO 2016-08 (Figure 44). Downsteam has also the poorest in terms of this parameter with 86% above the allowable limit for Class C. Similarly, this indicates high concentration of nutrients and organic matter in the stream.

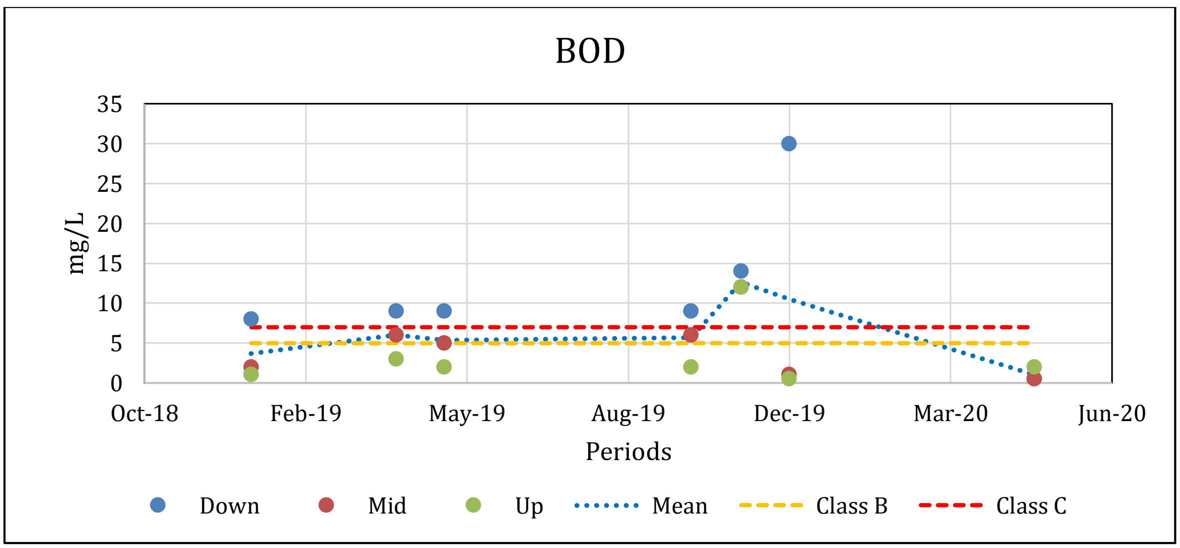

Figure 44. Levels of biochemical oxygen demand (BOD) along the mainstream of Saran River in Laguna province from Feb 2019 to Apr 2020.

Biochemical oxygen demand (BOD) indicates the amount of dissolved oxygen that is being used by microbes to decompose organic matter. High BOD implies that DO are falling at high rate which can be potentially dangerous to the river's aquatic life. High BOD is usually caused by high levels of organic pollution caused usually by poorly treated wastewater and high nitrate levels which trigger high plant growth. BOD is the main parameter used to monitor the status of wastewater treatment being employed in the watershed.

In terms of pH, all measurement from the three watersheds from October 2019 to March 2020 fall within the acceptable levels based on DAO 2016-08 (Figure 45). The minimum pH (acidity) for surface water is 6.5 while the maximum basicity is 9.5.

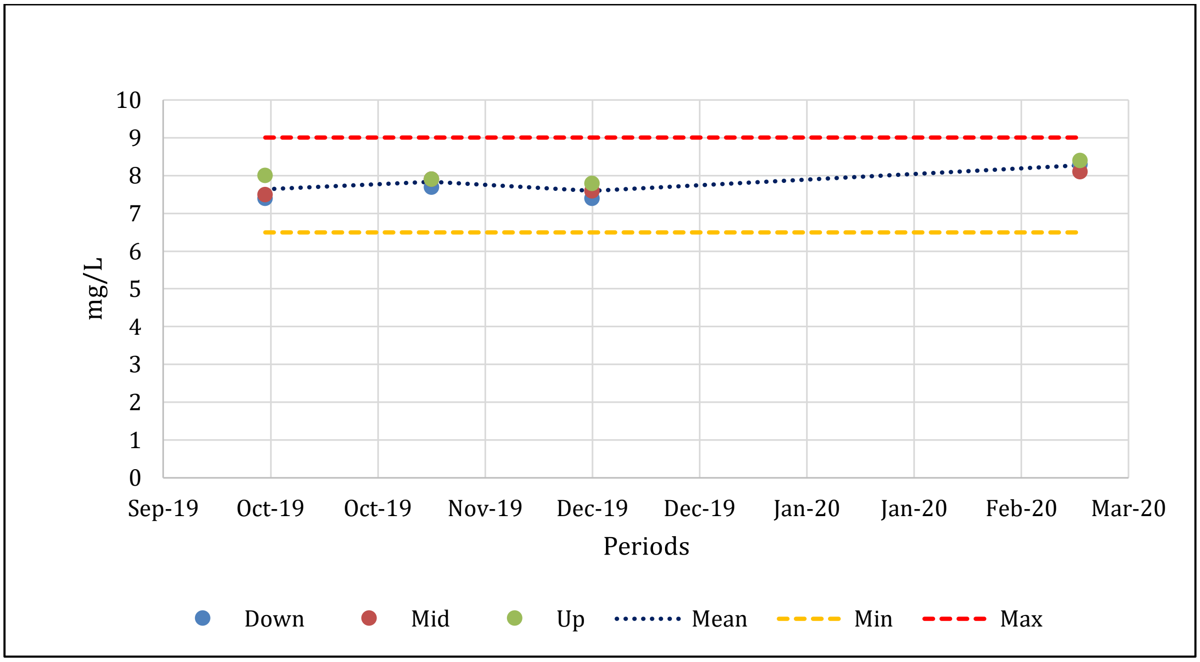

Figure 45. Levels of pH along the mainstream of San Juan River in Laguna province from Sept 2019 to March 2020.

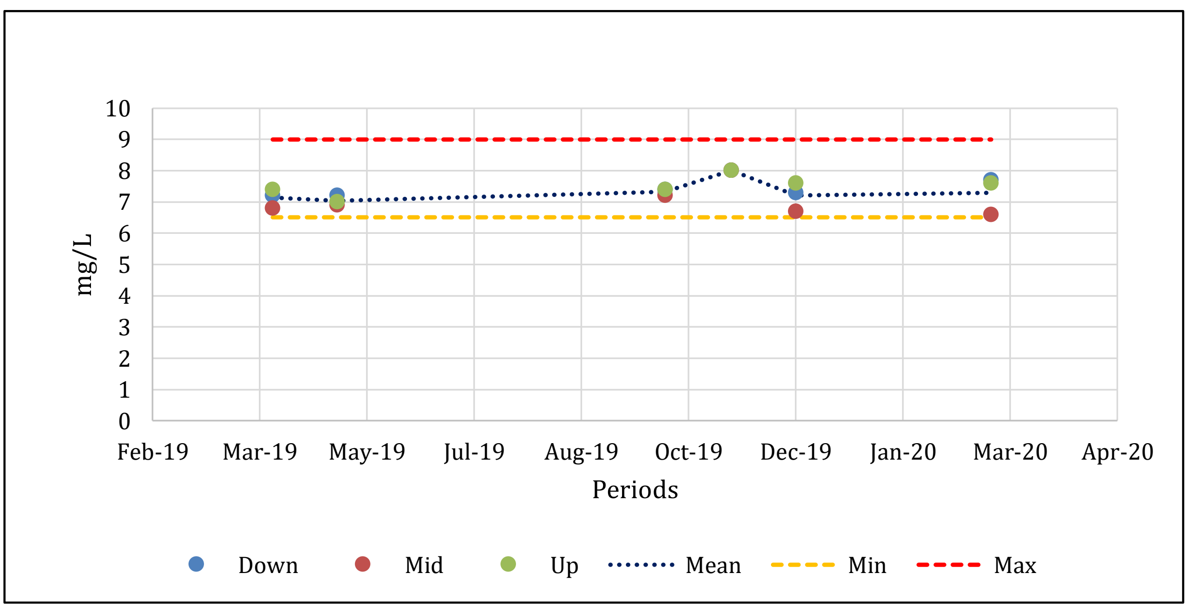

Figure 46. Levels of pH along the mainstream of San Cristobal River in Laguna province from Feb 2019 to Apr 2020.

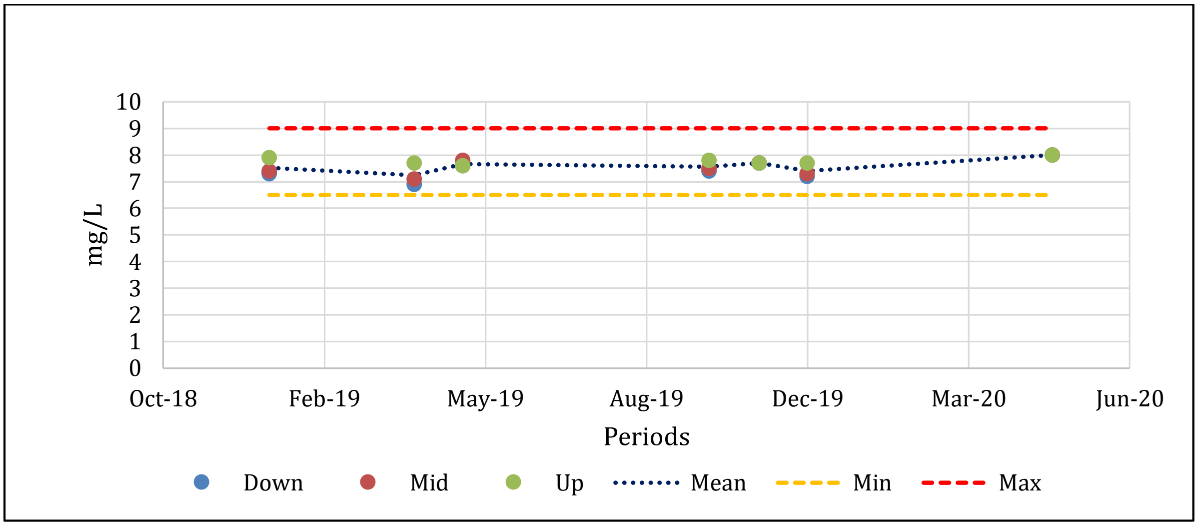

Figure 47. Levels of pH along the mainstream of Saran River in Laguna province from Feb 2019 to Apr 2020.

The pH tells the condition of water whether it's acidic, neutral, or basic. Water pH determines the solubility *(the amount that can be dissolved in water)* and biological availability *(the amount that can be utilized by aquatic organisms)* of nutrients and heavy metals. The pH ranges from 1 to 14 with 7 as neutral. A lower value indicates higher acidity while a higher value indicates basicity. Excessively high and low pH diminishes the water quality to support life. High water pH causes a bitter taste and causes the encrusting of deposits. The effectivity of chlorine for disinfection also diminishes with high pH. On the other hand, low pH corrodes and dissolve metals increasing their toxicity levels. Pollution can change a water's pH, which in turn can harm animals and plants living in the water.

Similarly, all measurement for nitrate level from October 2019 to March 2020 falls within the acceptable levels based on DAO 2016-08 (Figure 48). The maximum allowable level for surface water under class B is 7mg/L.

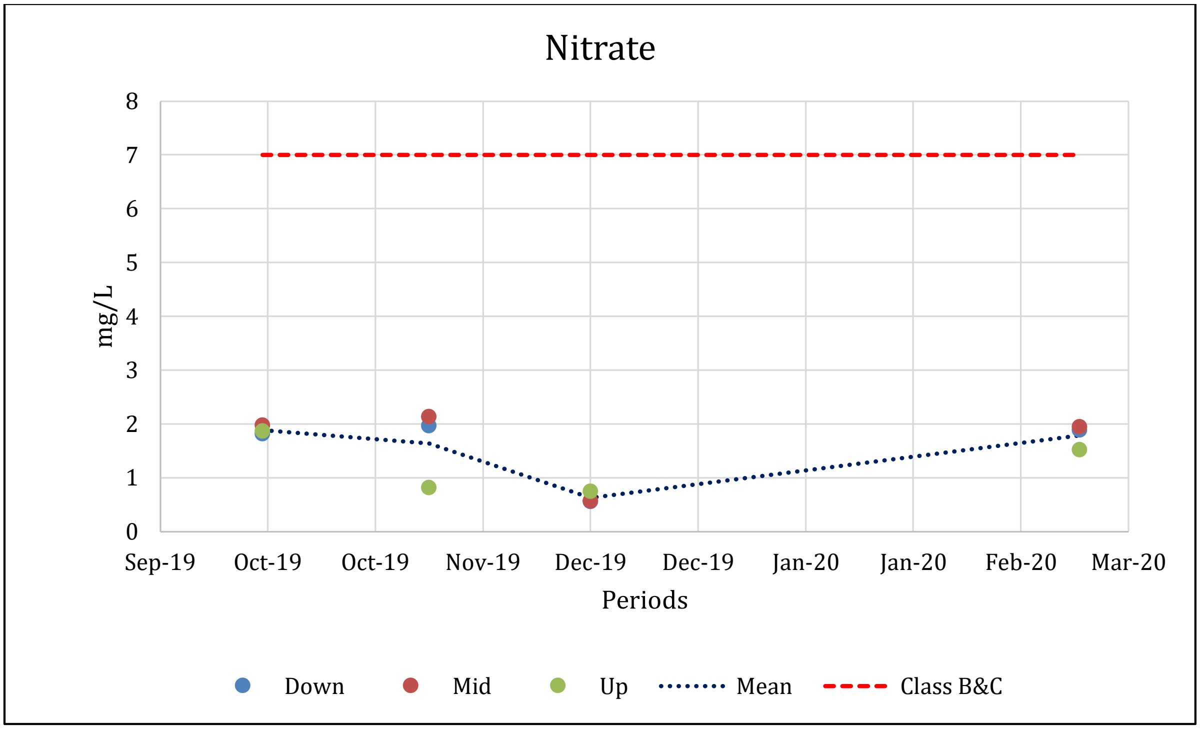

Figure 48. Levels of nitrate along the mainstream of San Juan River in Laguna province from Sept 2019 to March 2020.

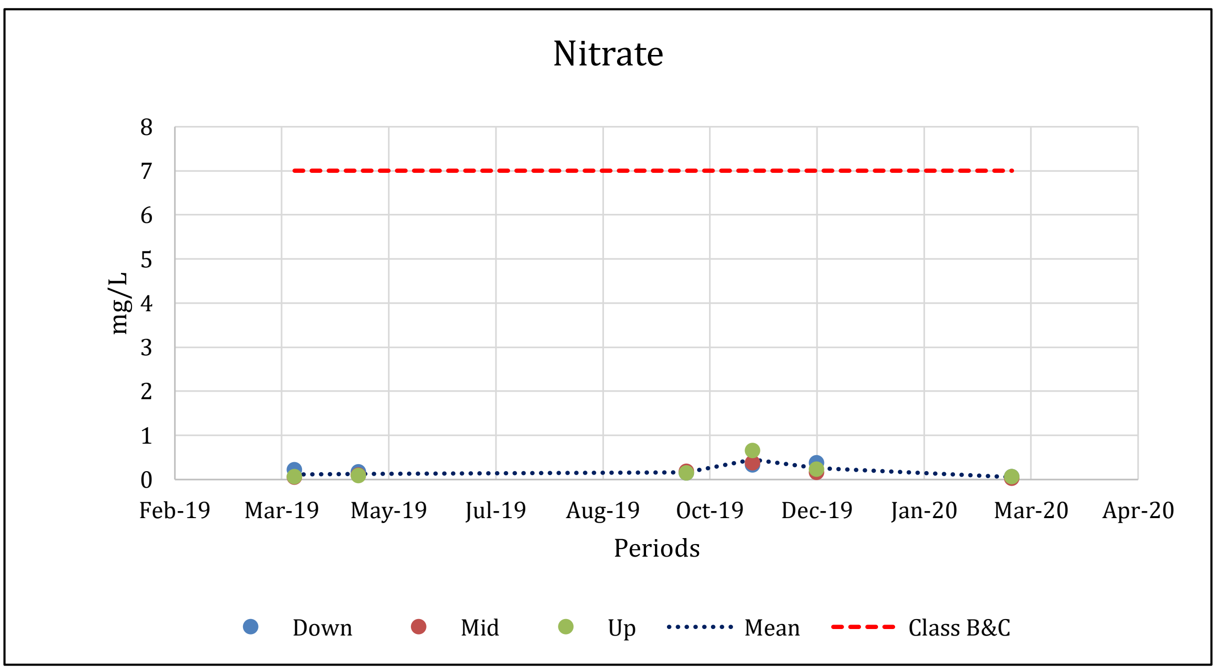

Figure 49. Levels of nitrate along the mainstream of San Cristobal River in Laguna province from Feb 2019 to Apr 2020.

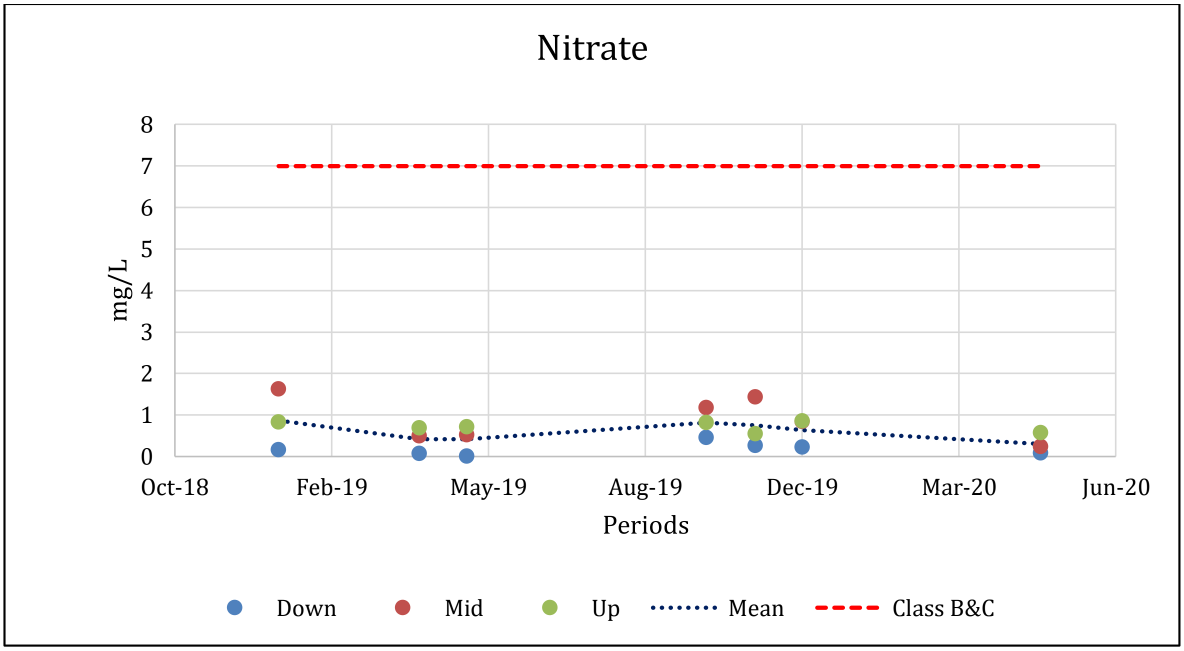

Figure 50. Levels of nitrate along the mainstream of Saran River in Laguna province from Feb 2019 to Apr 2020.

Nitrogen in the form of nitrates has no direct effects on aquatic life, however high levels of nitrogen together with phosphates increase the nutrient levels in the water. This condition encourages the growth of algae and aquatic plants. When these algae and aquatic plants die, microbes consume the dissolved oxygen during the decomposition process hence dramatically decreasing DO levels. Critically low levels of DO are fatal to most aquatic animals including fish. High levels of the nutrient in water can make the river eutrophic. Eutrophication is the process by which a body of water acquires a high concentration of nutrients, especially phosphates and nitrates. Complete lack of oxygen makes the river anoxic. Some nitrate enters the water from the atmosphere, which carries nitrogen-containing compounds derived from automobiles and other sources. Nitrate can also be formed in water bodies through the oxidation of other forms of nitrogen, including nitrite, ammonia, and organic nitrogen compounds such as amino acids. Ammonia and organic nitrogen can enter the water through sewage effluent and runoff from the land where manure has been applied or stored.

In terms of phosphate, for San Juan River all (100%) of the measurement falls above class B and class C for surface water based on DAO 2016-08 (Figure 51). All sampling stations in downstream, midstream and upstream have elevated levels of phosphates which records up to 8.6 mg/L. The allowable level for class B and C should be equal or below 0.5 mg/L.

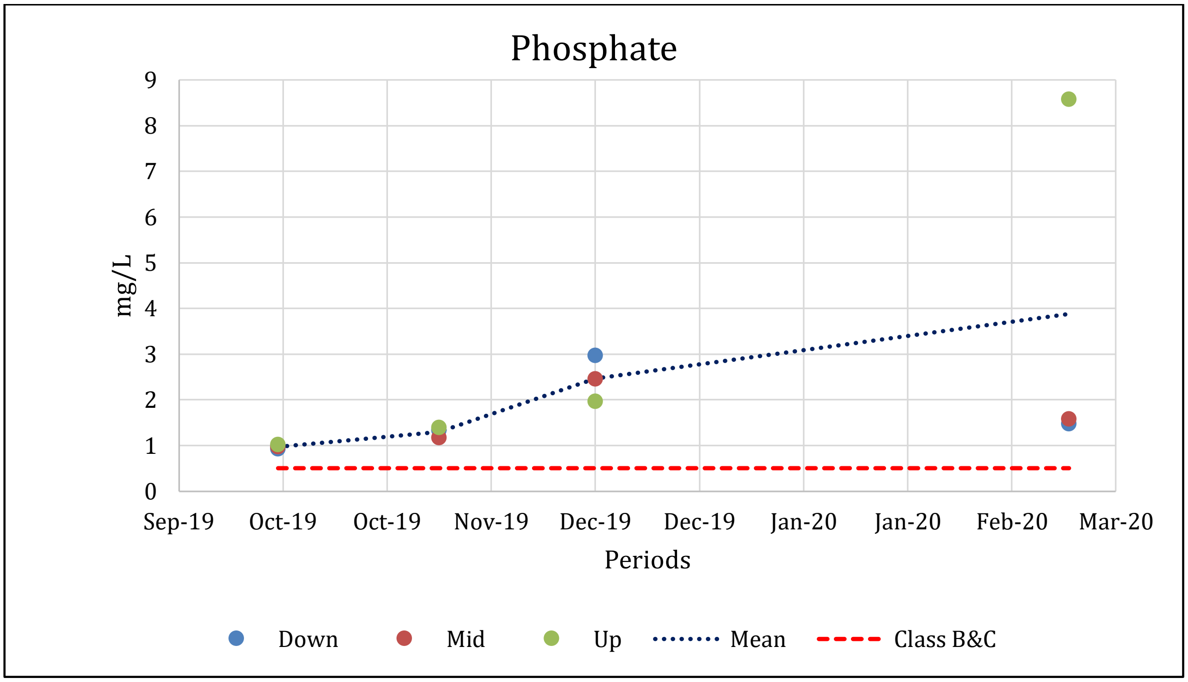

Figure 51. Levels of phosphate along the mainstream of San Juan River in Laguna province from Sept 2019 to March 2020.

For San Cristobal, 67% of the measurement falls above class B and class C for surface water based on DAO 2016-08 (Figure 52). Downstream and midstream areas have the poorest quality concerning this parameter with 100% measurement above class B. Measurement on the upstream area is all within the acceptable levels. The allowable level for class B and C should be equal to or below 0.5 mg/L.

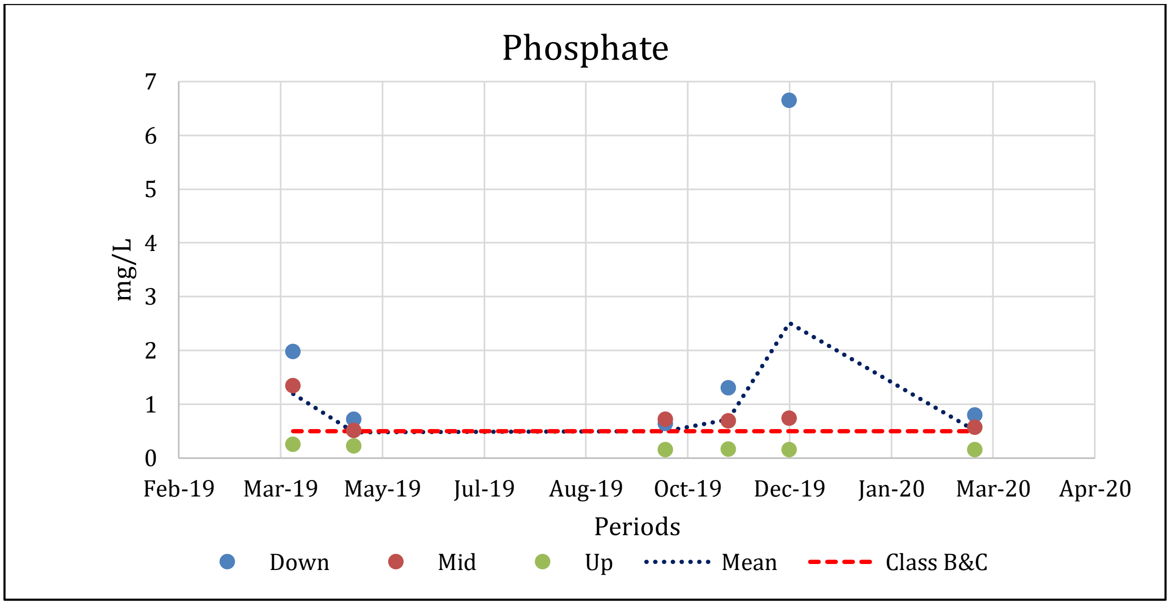

Figure 52. Levels of phosphate along the mainstream of San Cristobal River in Laguna province from Feb 2019 to Apr 2020.

Saran River appears to have similar water quality with San Cristobal. Overall measurement showed that 67% of the measurement is below class B and class C for surface water based on DAO 2016-08 (Figure 53). Downstream and midstream areas have the poorest quality concerning this parameter with 100% measurement above class B.

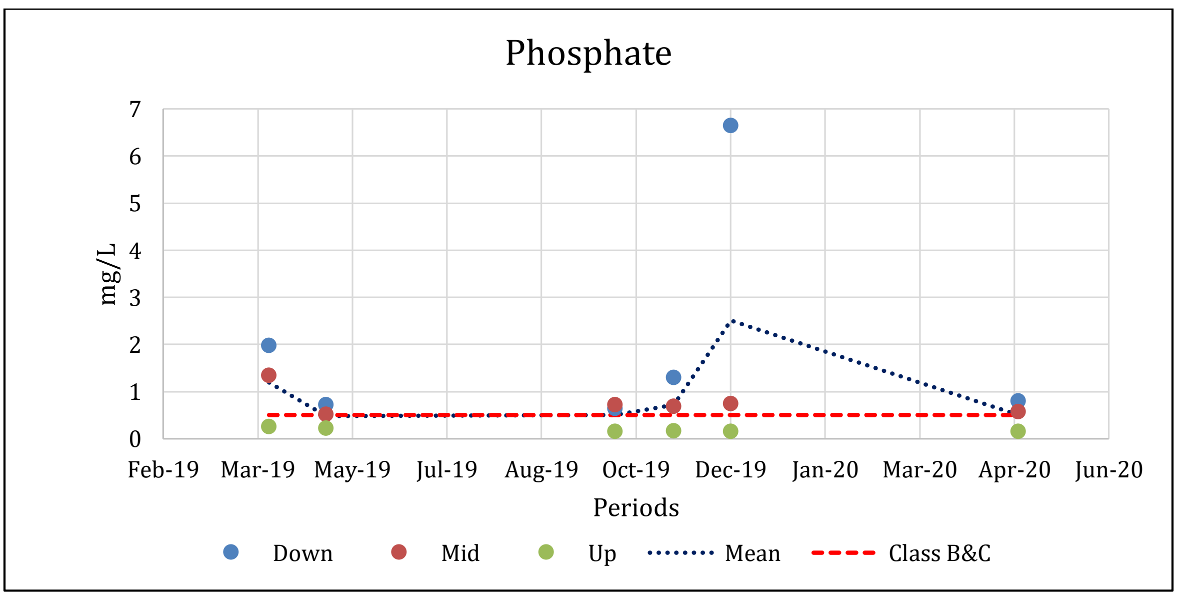

Figure 53. Levels of phosphate along the mainstream of Saran River in Laguna province from Feb 2019 to Apr 2020.

Phosphorus is a common constituent of agricultural fertilizers, manure, and organic wastes in sewage and industrial effluent. It is an essential element for plant life, but when there is too much of it in water, it can speed up the eutrophication of rivers and lakes. Soil erosion is also a major contributor of phosphorus to streams. Bank erosion occurring during floods can transport a lot of phosphorous from the river banks and adjacent land into a stream. Phosphorus also comes from untreated residential and industrial sewages that containing detergents.

Fecal coliform and total coliform are at alarming levels for the three rivers with all (100%) of the measurement way above class B and class C (

Table 18). Some measurements even reach 540,000 mpn/100mL for fecal coliform and 920,000 for total coliform in the downstream and midstream stations. Higher concentrations are more frequent in these areas. The acceptable levels are 200 mpn/100mL and 1000 mpn/100mL for fecal coliform and total coliform respectively.

Table 16. Concentrations of fecal coliform and total coliform in Saran River of Laguna Province.

Month	Fecal Coliform (200 MPN/ 100mL)*			Total Coliform (1000 MPN/ 100mL)*		
	Down	Mid	Up	Down	Mid	Up
Jan-19	9200	16000	16000	9200	16000	16000
Feb-19	35000	160000	11000	920000	240000	17000
Mar-19	140000	22000	17000	920000	92000	54000
Apr-19	350000	54000	35000	5400000	160000	92000
May-19	35000	16000	54000	92000	16000	160000
Oct-19	240000	350000	350000	350000	540000	920000
Nov-19	540000	24000	24000	1600000	35000	35000
Dec-19	54000	92000	35000	92000	160000	92000
May-20	24,000	1,300	3,500	35,000	3,500	5,400

Table 17. Concentrations of fecal coliform and total coliform in San Cristobal River of Laguna Province.

Month	Fecal Coliform (200 MPN/ 100mL)*			Total Coliform (1000 MPN/ 100mL)*		
	Down	Mid	Up	Down	Mid	Up
Feb-19	$16x10^5$	$16x10^5$	$35x10^4$	$16x10^5$	$>16x10^5$	$>16x10^5$
Mar-19	$16X10^5$	$>16X10^5$	$92X10^4$	$16X10^5$	$>16X10^5$	$>16X10^5$
Apr-19	$24x10^6$	$16x10^6$	$16x10^7$	$54x10^6$	$16x10^6$	$16x10^7$
May-19	$92x10^5$	$79x10^5$	$35x10^6$	$16x10^6$	$24x10^6$	$54x10^6$
Oct-19	$54x10^5$	$24x10^5$	$92x10^4$	$92x10^5$	$35x10^5$	$16x10^5$
Nov-19	$22x10^3$	$35x10^5$	$35x10^5$	$54x10^3$	$54x10^5$	$54x10^5$
Dec-19	$92x10^4$	$92x10^4$	$35x10^4$	$92x10^4$	$16x10^5$	$54x10^4$
May-20	5,400,000	540,000	2,400,000	16,000,000	1,600,000	5,400,000

Table 18. Concentrations of fecal coliform and total coliform in San Juan River of Laguna Province.

Fecal Coliform (200 MPN/ 100mL)*			Total Coliform (1000 MPN/ 100mL)*		
Down	Mid	Up	Down	Mid	Up
$24x10^4$	$54x10^4$	$92x10^3$	$54x10^4$	$16x10^5$	$16x10^4$
$24x10^5$	$92x10^3$	$24x10^3$	$13x10^5$	$16x10^4$	$35x10^3$
$54x10^4$	$35x10^4$	$24x10^4$	$92x10^4$	$54x10^4$	$54x10^4$
540,000	350,000	170,000	920,000	920,000	350,000

Fecal coliform bacteria are a subgroup of coliform bacteria that were used to establish the first microbial water quality criteria. The ability to grow at an elevated temperature separates these bacteria from the total coliforms and make it a more accurate indicator of fecal contamination by warm-blooded animals. The presence of fecal coliforms in water indicates that fecal contamination of the water by a warm-blooded animal has occurred, however, recent studies have found no statistical relationship between fecal coliform concentrations and swimmer-associated sickness. Consumption of or contact with water contaminated with feces of warm-blooded animals can cause a variety of illnesses.

Minor gastrointestinal discomfort is probably the most common symptom; however, pathogens that may cause only minor sickness in some people may cause serious conditions or death in others, especially in the very young, old, or those with weakened immunological systems.

Concentrations of heavy metals such as cadmium, lead, and mercury were within acceptable levels for class B and C based on DAO 2016-08 (Table 19). Heavy metals are naturally occurring elements that are present in the earth's crusts. Some heavy metals are present in water in very small quantities and are essential for biological and physiological functions. However, some of these elements can be toxic even in very small quantities. Because of this toxicity, heavy metals including arsenic, cadmium, chromium, lead, and mercury rank among the priority metals that are of public health significance. These metallic elements are considered systemic toxicants that are known to induce multiple organ damage, even at lower levels of exposure.

Table 19. Concentrations of selected heavy metals in San Juan River of Laguna Province.

Date	Cadmium (mg/L)			Lead (mg/L)			Mercury (mg/L)		
	Down	Mid	Up	Down	Mid	Up	Down	Mid	Up
Oct-19	<0.003	<0.003	<0.003	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001
Nov-19	<0.003	<0.003	<0.003	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001
Dec-19	<0.003	<0.003	<0.003	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001
Mar-20	<0.003	<0.003	<0.003	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001

Table 20. Concentrations of selected heavy metals in San Cristobal River of Laguna Province.

Cadmium (mg/L)			Lead (mg/L)			Mercury (mg/L)		
Down	Mid	Up	Down	Mid	Up	Down	Mid	Up
<0.003	<0.003	<0.003	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001
<0.003	<0.003	<0.003	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001
<0.003	<0.003	<0.003	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001

<0.003	<0.003	<0.003	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001

Table 21. Concentrations of selected heavy metals in Saran River of Laguna Province.

Cadmium (mg/L)			**Lead (mg/L)**			**Mercury (mg/L)**		
Down	Mid	Up	Down	Mid	Up	Down	Mid	Up
<0.003	<0.003	<0.003	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001
<0.003	<0.003	<0.003	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001
<0.003	<0.003	<0.003	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001
<0.003	<0.003	<0.003	<0.01	<0.01	<0.01	<0.0001	<0.0001	<0.0001

7. Flora and Fauna

Floral diversity plays a significant role in maintaining a healthy watershed. The presence of diverse flora encourages faunal diversity by providing habitat and food. In particular, riparian areas along the stream network play a vital role in trapping sediments and other pollutants for the land surface before entering the channel. These areas are usually lush, highly diverse, and biologically productive. It also serves as an ecological barrier between aquatic areas and terrestrial regions. The health of the riparian area is directly affected by human disturbance such as encroachment along with agricultural and economic activities. Measuring these impacts is relatively expensive and time-consuming due to the complex terrain and length of the river network. Hence, evaluation is usually done in small areas and usually sampled along the stream.

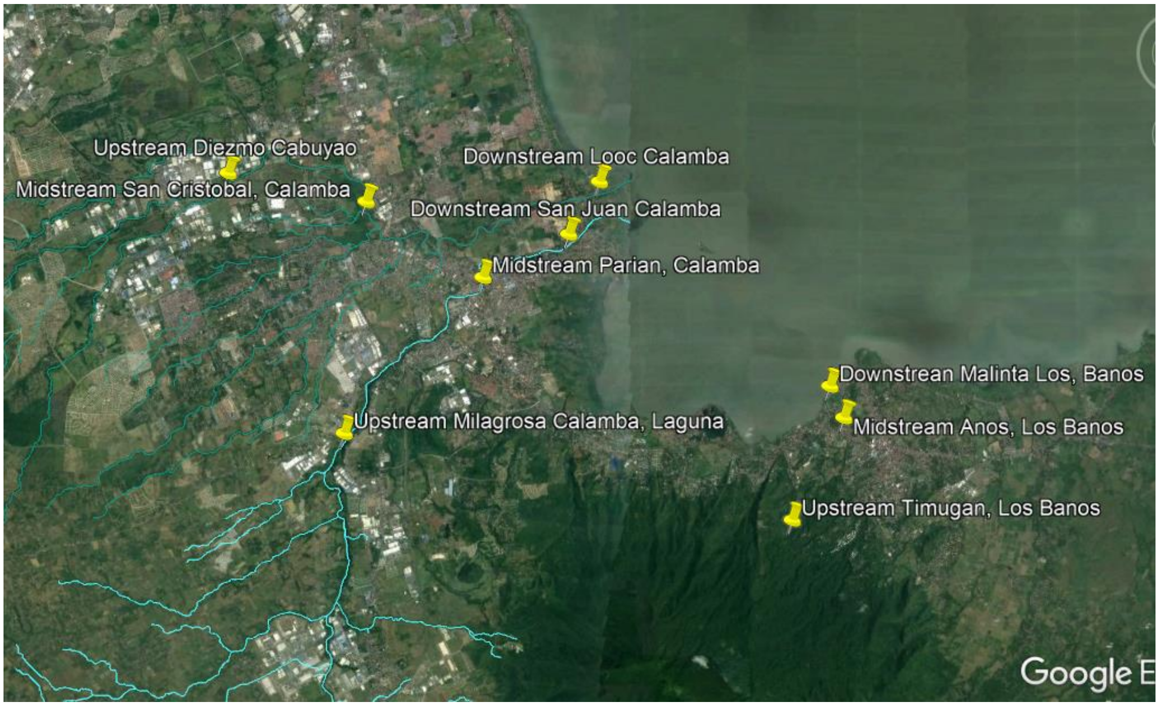

Figure 54. Sampling stations for water quality and biodiversity assessment and monitoring in San Juan River, San Cristobal River, and Saran River of Laguna Province.

Quadrant sampling was used to evaluate the floral composition and riparian condition for the San Juan River. Three (3) stations were established in the three (3) altitudinal range of the catchment. Higher vascular plants which include trees, shrubs and large herbaceous plants were surveyed. Specimens were collected and species identification were done both onsite and offsite.

For San Juan River, sampling stations were established along the steams of Barangays Milagrosa, Parian, San Juan, of Calamba City Laguna. Dominant species encountered are Ipil-ipil (*Leucaena leucocephala*), Tibig (*Ficus nota*), and Mahogany (*Swietenia macrophylla*) in the area. Mahogany (*Swietenia macrophylla*) has the highest percentage, probably because this species is fast-growing and and it is known commercially important lumber.

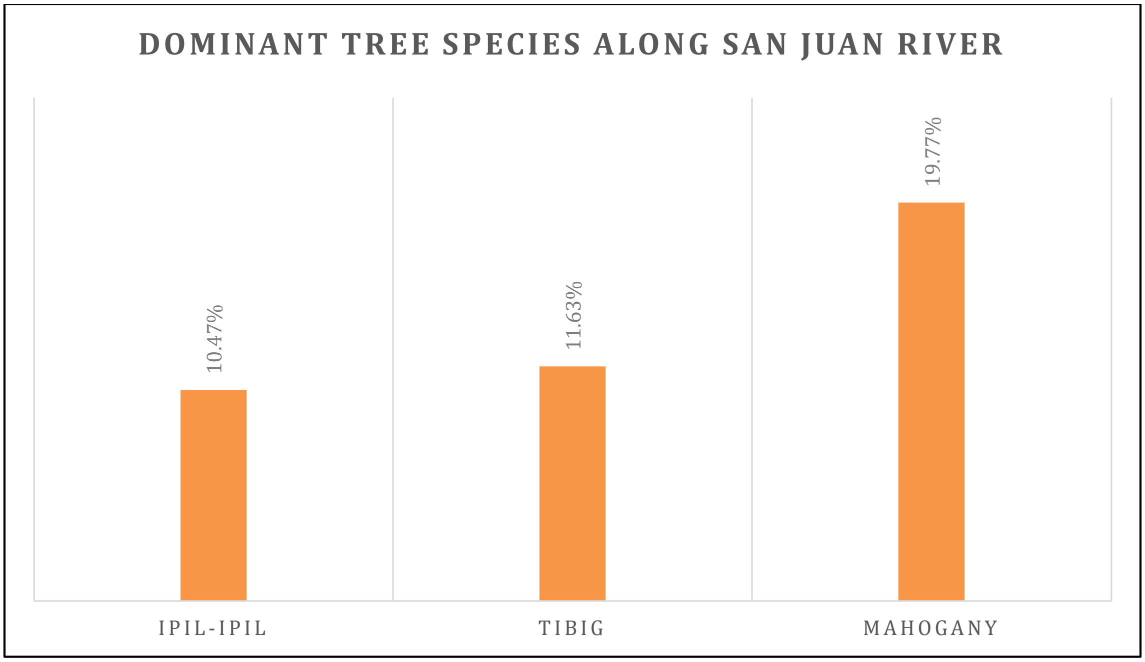

Figure 55. Dominant tree species ecountered on the sampling stations along San Juan River of Calamba City, Laguna.

Table 22. Tree species composition along the stream of Brgy. Milagrosa, upstream of San Juan River within Calamba City, Laguna.

Common Name	**Family**	***Scientific Name***	**Frequency**	**ORIGIN**
Duhat	Myrtaceae	*Syzygium cumini*	1	Indigenous
Neem Tree	Meliaceae	*Azadirachta indica A. Juss.*	1	Exotic
Aratiles	Muntingiaceace	*Muntingia calabura*	2	Exotic
Kakawate	Fabaceae	*Gliricidia sepium*	2	Indigenous
Mangga	Anacardeaceae	*Mangifera indica Linn.*	2	Indigenous
Niyog	Arecaceae	*Cocos nicifera Linn*	2	Exotic
Ipil-ipil	Mimosaceae	*Leucaena leucocephala*	3	Indigenous
Tibig	Moraceae	*Ficus nota*	3	Indigenous
Bayag-usa	Apocynaceace	*Voacanga globosa*	4	Indigenous

Mahogany	Meliaceace	*Swietenia mahogani*	4	Exotic
		TOTAL	**24**	

Table 23. Tree species composition along the stream of Brgy. Parian, midstream of San Juan River within Calamba City, Laguna.

Common Name	**Family**	***Scientific Name***	**Frequency**	**ORIGIN**
Talisay	Combretaceae	*Terminalia catappa L.*	1	Exotic
Duhat	Myrtaceae	*Syzygium cumini*	2	Indigenous
Kainito	Sapotaceae	*Chrysophyllum cainito*	2	Indigenous
Mangga	Anacardeaceae	*Mangifera indica Linn.*	2	Indigenous
Aratiles	Muntingiaceace	*Muntingia calabura*	3	Exotic
Kakawate	Fabaceae	*Gliricidia sepium*	3	Indigenous
Langka	Moraceae	*Artocarpus heterophyllus Lam.*	3	Indigenous
Ipil-ipil	Mimosaceae	*Leucaena leucocephala*	4	Indigenous
Tibig	Moraceae	*Ficus nota*	4	Indigenous
Mahogany	Meliaceace	*Swietenia mahogani*	6	Exotic
		TOTAL	**30**	

Table 24. Tree species composition along the upstream of San Juan River within Calamba City, Laguna.

Common Name	**Family**	***Scientific Name***	**Frequency**	**ORIGIN**
Kainito	Sapotaceae	*Chrysophyllum cainito*	1	Indigenous
Alagaw	Lamiaceace	*Premna odorata Blanco*	2	Indigenous
Alim	Euphorbiaceae	*multiglandulosa var.*	2	Indigenous
Aratiles	Muntingiaceace	*Muntingia calabura*	2	Exotic
Bayag-usa	Apocynaceace	*Voacanga globosa*	2	Indigenous
Ipil-ipil	Mimosaceae	*Leucaena leucocephala*	2	Indigenous

Talisay	Combretaceae	*Terminalia catappa L.*	2	Exotic
Mangga	Anacardeaceae	*Mangifera indica Linn.*	3	Indigenous
Neem Tree	Meliaceae	*Azadirachta indica A. Juss.*	3	Exotic
Niyog	Arecaceae	*Cocos nicifera Linn*	3	Exotic
Tibig	Moraceae	*Ficus nota*	3	Indigenous
Mahogany	Meliaceace	*Swietenia mahogani*	7	Exotic
		Total	**32**	

For San Cristobal River, stations were established in barangays Diezmos, San Cristobal and Looc. A total of ninety (90) tree species and six (6) associated wildlife species.

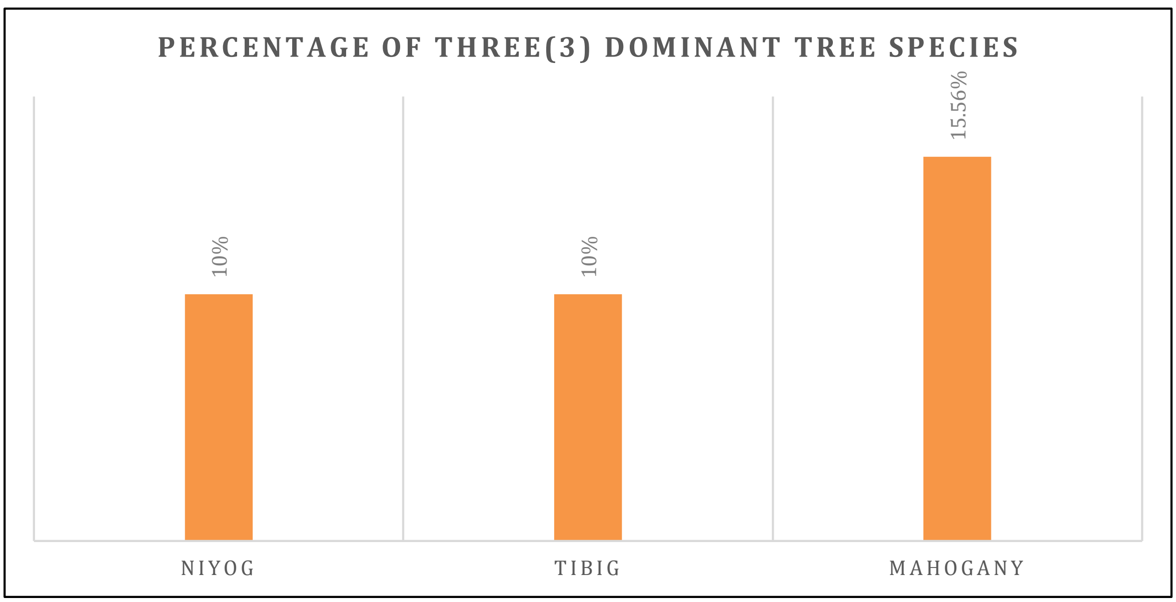

Figure 56. Percentage of dominant tree species ecountered on the sampling stations along San Cristobal River of Calamba City, Laguna.

Based on the results of the inventory in location 3 (San Cristobal River) has three dominant tree species were listed. Tibig (*Ficus nota)* belongs to the family of Moracea. Mahogany (*Swietenia macrophylla*) belongs to the family Meliaceae and coconut.

Table 25. Three composition in Brgy. Diezmos, Cabuyao (upstream).

Common Name	**Family**	***Scientific Name***	**Quantity**	**Origin**
Alim	Euphorbiaceae	*Multiglandulosa var.*	1	Indigenous
Mangga	Anacardeaceae	*Mangifera indica Linn.*	1	Indigenous
Sampalok	Fabaceace	*Tamarindus indica*	1	Indigenous
Amugis	Anacardeaceae	*Koordersiodendron pinnatum*	2	Indigenous
Antipolo	Moraceae	*Artocarpus blancoi*	2	Indigenous
Aratiles	Muntingiaceace	*Muntingia calabura*	2	Exotic
Hagimit	Moraceae	*Ficus minahassae*	2	Indigenous
Igyo	Meliaceace	*Dysoxylum gaudichadianum*	2	Indigenous
Ipil-ipil	Mimosaceae	*Leucaena leucocephala*	2	Indigenous
Tibig	Moraceae	*Ficus nota*	2	Indigenous
Binunga	Euphorbiaceae	*Macaranga tanarius*	3	Indigenous
Hauili	Moraceace	*Ficus septica var.septica*	3	Indigenous
Kawayang Tinik	Poaceae	*Bambusa blumeana*	3	Indigenous
Gmelina	Lamiaceae	*Gmelina arborea*	5	Exotic
		Total	31	

Table 26. Tree species composition in Brgy. San Cristobal, Cabuyao (midstream).

Common Name	**Family**	***Scientific Name***	**Quantity**	**Origin**
Igyo	Meliaceace	*Dysoxylum gaudichadianum*	2	Indigenous
Ipil-ipil	Mimosaceae	*Leucaena leucocephala*	2	Indigenous
Kawayang Tinik	Poaceae	*Bambusa blumeana*	2	Indigenous
Aratiles	Muntingiaceace	*Muntingia calabura*	3	Exotic
Hauili	Moraceace	*Ficus septica var.septica*	3	Indigenous
Mangga	Anacardeaceae	*Mangifera indica Linn.*	3	Indigenous

Niyog	Arecaceae	*Cocos nicifera Linn*	4	Exotic
Tibig	Moraceae	*Ficus nota*	4	Indigenous
Mahogany	Meliaceace	*Swietenia mahogani*	7	Exotic
		Total	**30**	

Table 27. Tree species composition in Brgy.Looc Calamba (downstream).

Common Name	Family	*Scientific Name*	Quantity	Origin
Hauili	Moraceace	*Ficus septica var.septica*	1	Indigenous
Kawayang Tinik	Poaceae	*Bambusa Blumeana*	2	Indigenous
Igyo	Meliaceace	*Dysoxylum gaudichadianum*	3	Indigenous
Tibig	Moraceace	*Ficus nota*	3	Indigenous
Ipil-ipil	Mimosaceae	*Leucaena leucocephala*	4	Indigenous
Mangga	Anacardeaceae	*Mangifera indica Linn.*	4	Indigenous
Niyog	Arecaceae	*Cocos nicifera Linn*	5	Exotic
Mahogany	Meliaceace	*Swietenia mahogani*	7	Exotic
		Total	**29**	

For Saran River, stations were established in barangays Timugan, Malinta, and Anos. There are total of 46 floral species and twelve (12) associated wildlife species.

Table 28. Three compositions in the sampling plot in Brgy. Timugan, upstream of Saran River in Los Banos Laguna

Common Name	Family	*Scientific Name*	Quantity	Origin
Antipolo	Moraceae	*Artocarpus blancoi*	1	Indigenous

Langka	Moraceae	*Artocarpus heterophyllus Lam.*	1	Indigenous
African Tulip	Bignoniaceae	*Spathodea campanulata .*	2	Exotic
Alibangbang	Fabaceae	*Bauhinia monandra Kurz*	2	Exotic
Amugis	Anacardeaceae	*Koordersiodendron pinnatum*	2	Indigenous
Avocado	Lauraceae	*Persesa americana Mill*	2	Exotic
Cacao	Sterculiaceae	*Theobroma cacao L.*	2	Exotic
Dao	Anacardiacerae	*Dracontomelon dao*	2	Indigenous
Himbabao	Moraceae	*Broussonetia luzonica*	2	Indigenous
Igyo	Meliaceace	*Dysoxylum gaudichadianum*	2	Indigenous
Kaong	Palmae	*Arenga pinnata*	2	Indigenous
Kape	Rubiaceae	*Coffea arabica Linn.*	2	Exotic
Kawayang Dilaw	Poaceae	*Bambusa vulgaris Schrad*	2	Exotic
Kawayang Tinik	Poaceae	*Bambusa blumeana*	2	Indigenous
Lanzsones	Meliaceace	*Lansium parasiticum*	2	Indigenous
Lipa	Urticaceae	*Laportea meyeniana Warb.*	2	Indigenous
Malaikmo	Ulmaceae	*Celtis philippensis Blanco*	2	Indigenous

Mangga	Anacardeaceae	*Mangifera indica Linn.*	2	Indigenous
Niyog-niyogan	Moraceace	*Ficus pseudopalma Blanco*	2	Indigenous
Rambutan	Sapindaceae	*Nephelium lappaceum Linn.*	2	Exotic
Acacia	Fabaceace	*Samanea saman*	3	Exotic
Alim	Euphorbiaceae	*multiglandulosa var.*	3	Indigenous
Bankal	Rubiaceaae	*Nauclea orientalis L.*	3	Indigenous
Kawayang Buho	Graminae	*Gigantochloa levis*	3	Indigenous
Niyog	Arecaceae	*Cocos nicifera*	3	Exotic
Tibig	Moraceae	*Ficus nota*	3	Indigenous
Ipil-ipil	Mimosaceae	*Leucaena leucocephala*	4	Indigenous
Gmelina	Lamiaceae	*Gmelina arborea*	5	Exotic
Narra	Narra	*Pterocarpus indicus Wild.*	5	Indigenous
Mahogany	Meliaceace	*Swietenia mahogani*	6	Exotic
		TOTAL	**76**	

Table 29. Three compositions in the sampling plot in Brgy. Malinta, midstream of Saran River in Los Banos Laguna.

Common Name	**Family**	***Scientific Name***	**Quantity**	**Origin**
Akleng Parang	Fabaceae	*Albizia procera*	1	Indigenous

Bagauak	Verbenaceae	*Clerodendrum quadriloculare*	1	Indigenous
Bolongeta	Ebenaceae	*Diospyros pilosanthera Blanco*	1	Indigenous
Kupang	Fabaceae	*Parkia javanica*	1	Indigenous
Paper Mulberry	Moraceace	*Broussonetia papyrifera*	1	Exotic
Acacia	Fabaceace	*Samanea Saman*	2	Exotic
Alim	Euphorbiaceae	*Multiglandulosa sp.*	2	Indigenous
Binunga	Euphorbiaceae	*Macaranga Tanarius*	2	Indigenous
Buboi	Malvaceae	*Ceiba pentandra*	2	Exotic
Hauili	Moraceace	*Ficus septica var.septica Burm..*	2	Indigenous
Igyo	Meliaceace	*Dysoxylum gaudichadianum*	2	Indigenous
Kakawate	Fabaceae	*Gliricidia sepium*	2	Indigenous
Malaikmo	Ulmaceae	*Celtis philippensis Blanco*	2	Indigenous
Molave	Verbenaceae	*Vitex parviflora*	2	Indigenous
Niyog-niyogan	Moraceace	*Ficus pseudopalma Blanco*	2	Indigenous
Ipil-ipil	Mimosaceae	*Leucaena leucocephala*	3	Indigenous
Narra	Narra	*Pterocarpus indicus Wild.*	3	Indigenous
Tibig	Moraceae	*Ficus nota*	3	Indigenous
Niyog	Arecaceae	*Cocos nicifera Linn*	4	Exotic
Mahogany	Meliaceace	*Swietenia mahogani.*	5	Exotic
Gmelina	Lamiaceae	*Gmelina arborea*	6	Exotic
		TOTAL	**49**	

Table 30. Three compositions in the sampling plot in Brgy. Anos, downstream of Saran River in Los Banos Laguna.

Common Name	Family	*Scientific Name*	Frequency	Origin
Anahaw	Arecaceae	*Saribus rotundifolius*	1	Indigenous
Balete	Moraceae	*Ficus elastica Roxb.*	1	Indigenous
Buli (Buri)	Arecaceae	*Corypha utan Lam.*	1	Indigenous
Butong Manok	Lecythidaceae	*Barringtonia asiatica*	1	Indigenous
Golden Shower	Fabaceae	*Cassis fistula Linn.*	1	Exotic
Himbabao	Moraceae	*Broussonetia luzonica*	1	Indigenous
Lanzsones	Meliaceace	*Lansium parasiticum*	1	Indigenous
Paper Mulberry	Moraceace	*Broussonetia papyrifera*	1	Exotic
Santol	Meliaceae	*Sandoricum koetjape*	1	Exotic
Acacia	Fabaceace	*Samanea Saman*	2	Exotic
Alim	Euphorbiaceae	*Multiglandulosa sp.*	2	Indigenous
Hauili	Moraceace	*Ficus septica var.septica Burm.f.*	2	Indigenous
Igem	Podocarpaceae	*Dacrycarpus imbricatus*	2	Indigenous
Igyo	Meliaceace	*Dysoxylum gaudichadianum*	2	Indigenous
Ipil-ipil	Mimosaceae	*Leucaena leucocephala*	2	Indigenous
Kakawate	Fabaceae	*Gliricidia sepium*	2	Indigenous
Kamuning	Rutaceae	*Murraya paniculata*	2	Indigenous
Kupang	Fabaceae	*Parkia javanica*	2	Indigenous
Mangga	Anacardeaceae	*Mangifera indica Linn.*	2	Indigenous
Narra	Narra	*Pterocarpus indicus Wild.*	2	Indigenous
Niyog	Arecaceae	*Cocos nicifera Linn*	2	Exotic
Niyog-niyogan	Moraceace	*Ficus pseudopalma Blanco*	2	Indigenous
Tibig	Moraceae	*Ficus nota*	4	Indigenous
Gmelina	Lamiaceae	*Gmelina arborea*	5	Exotic

		TOTAL	**44**	

While a complete or comprehensive inventory of faunal biodiversity is not feasible for most watershed characterization, several indicators have been put into focus. Freshwater vertebrates including fishes are good indicators of the water quality and stream condition. Most of these organisms are sensitive to significant changes in the physicochemical characteristics of water. The presence of wildlife within the watershed helps stabilize the ecosystem. Birds and other mammals help in spreading seeds and nutrient cycling thereby support vegetation growth. Generally, heavily polluted water is detrimental for the fish population, especially the presence of high nutrients which encourage algal broom making stream eutrophic. This condition dramatically increases BOD and decreases the DO making which can be fatal to larger freshwater vertebrates at critical levels.

Faunal survey was done through opportunistic sampling. Plot establishments and specimen collection were done on selected locations which are usually with higher chances of encounter and collection.

Table 31. Encountered faunal species along San Juan River within Calamba City, Laguna province.

Common Name	**Family**	***Scientific Name***	**Origin**	**IUCN Classification**
Pulangga	Pcynonotidae	*Pycnonotus goiavier*	Native	Least Concern (LC)
Janitor fish	Loricariidae	*Pterygoplichthys multiradiatus*	Non-Native	Least Concern (LC)
Maya	Passeridae	*Passer montanus*	Native	Least Concern (LC)
Layang-layang	Hirundinidae	*Hirundo rustica*	Non-Native	Least Concern (LC)
Tilapia	Cichilidae	*Oreochromis niloticus*	Native	Least Concern (LC)
Bayawak	Varanidae	*Varanus varius*	Native	Critically Endangered (CR)
Black-headed gull	Laridae	*Chroicocephalus ridibundus*	Non-Native	Least Concern (LC)

Tagak	Ardeidae	*Ardea alba*	Native	Least Concern (LC)
Gurami	Osphoro-nemidae	*Osphronemus goramy*	Native	Least Concern (LC)
Pusit/pipit	Nectarinidae	*Aethopyga flagrans*	Endemic	Least Concern (LC)

Table 32. Encountered faunal species within San Cristobal River.

Common Name	Family	Scientific Name	ORIGIN	IUCN Classification
Layang-layang	Hirundinidae	Hirundo rustica	Non-Native	Least Concern (LC)
Butterfly	Lycaenidae	Lampides boeticus (Linnaeus)	Native	Least Concern (LC)
Pulangga	Pcynono-tidae	Pycnonotus goiavier	Native	Least Concern (LC)
Pusit	Nectarinidae	Aethopyga flagrans	Endemic	Least Concern (LC)
Tilapia	Cichilidae	Oreochromis niloticus	Native	Least Concern (LC)
Water striders	Hemiptera/ Gerridae	Various spp.	Native	Least Concern (LC)

Table 33. Faual species encountered along Saran River in Los Baños, Laguna.

Common Name	Family	***Scientific Name***	Origin	IUCN Classification
Bankalang	Scincidae	*Lamprolepis smaragdina philippinica*	Native	Least Concern (LC)
Bayawak	Varanidae	*Varanus varius*	Native	Critically Endangered (CR)
Butterfly	Lycaenidae	*Lampides boeticus (Linnaeus)*	Native	Least Concern (LC)
Dalag	Galaxiidae	*Neochanna burrowsius*	Native	Least Concern (LC)
Dragonfly	Libellulidae	*Nesogonia blackburni (McLachlan)*	Native	Least Concern (LC)
Gurami	Osphoro-nemidae	*Osphronemus goramy*	Native	Least Concern (LC)
Hito	Clarias	*Clarias batrachus*	Native	Least Concern (LC)

Kasaykasay	Alcedinidae	*Ceyx argentatus*	Native	(NT)
Kingfisher	Alcedinidae	*Alcedo atthis*	Native	Least Concern (LC)
Palaka	Dicroglo-ssidae	*Limnonectes magnus*	Native	Ner Treatened (NT)
Pulangga	Pcynonotidae	*Pycnonotus goiavier*	Native	Least Concern (LC)
Pusit	Nectarinidae	*Aethopyga flagrans*	Endemic	Least Concern (LC)

B. Major Tributaries within the River System

A. San Juan River

The San Juan River in Calamba Ciy, Laguna has nine (9) tributaries/sub-basin connected to the main channel (Figure 57). The area of these sub-basin ranges from 4ha to 835ha. Sub-basin 1 is the largest consisting of the downstream barangays while sub-basin eigth (8) is the smallest with only four (4) ha. The distribution of each sub-basin in localities (barangays) of each municipality is presented bellow below.

Table 34. Area in hectare of sub-basin/tributary of San Juan River within the 31 barangays of Calamba City, Laguna.

Barangay	**Tributary/Sub-basin area (ha)**									
	1	2	3	4	5	6	7	8	9	Grand Total
Banadero	60									60
Barandal	29									29
Barangay 1	27									27
Barangay 2	21									21
Barangay 3	13									13
Barangay 4	10									10
Barangay 5	31									31
Barangay 6	16									16
Barangay 7	11									11

Bubuyan		72								72
Bunggo		19								19
Burol		98								98
Camaligan									74	74
Kay-Anlog	4	169	91				58			322
Lawa	5									5
Lecheria	5									5
Lingga	17									17
Looc	1									1
Makiling	11		4	1	125	95		4	20	260
Palingon	56									56
Parian	47									47
Prinza	17									17
Punta	52	36								88
Real	78									78
Saimsim					23				20	43
Sampiruhan	12									12
San Jose	4									4
San Juan	70									70
Tulo	135		14							149
Turbina	102									102
Ulango			3	4	5	127	70	0		209
Grand Total	835	393	112	5	153	222	128	4	114	1,966

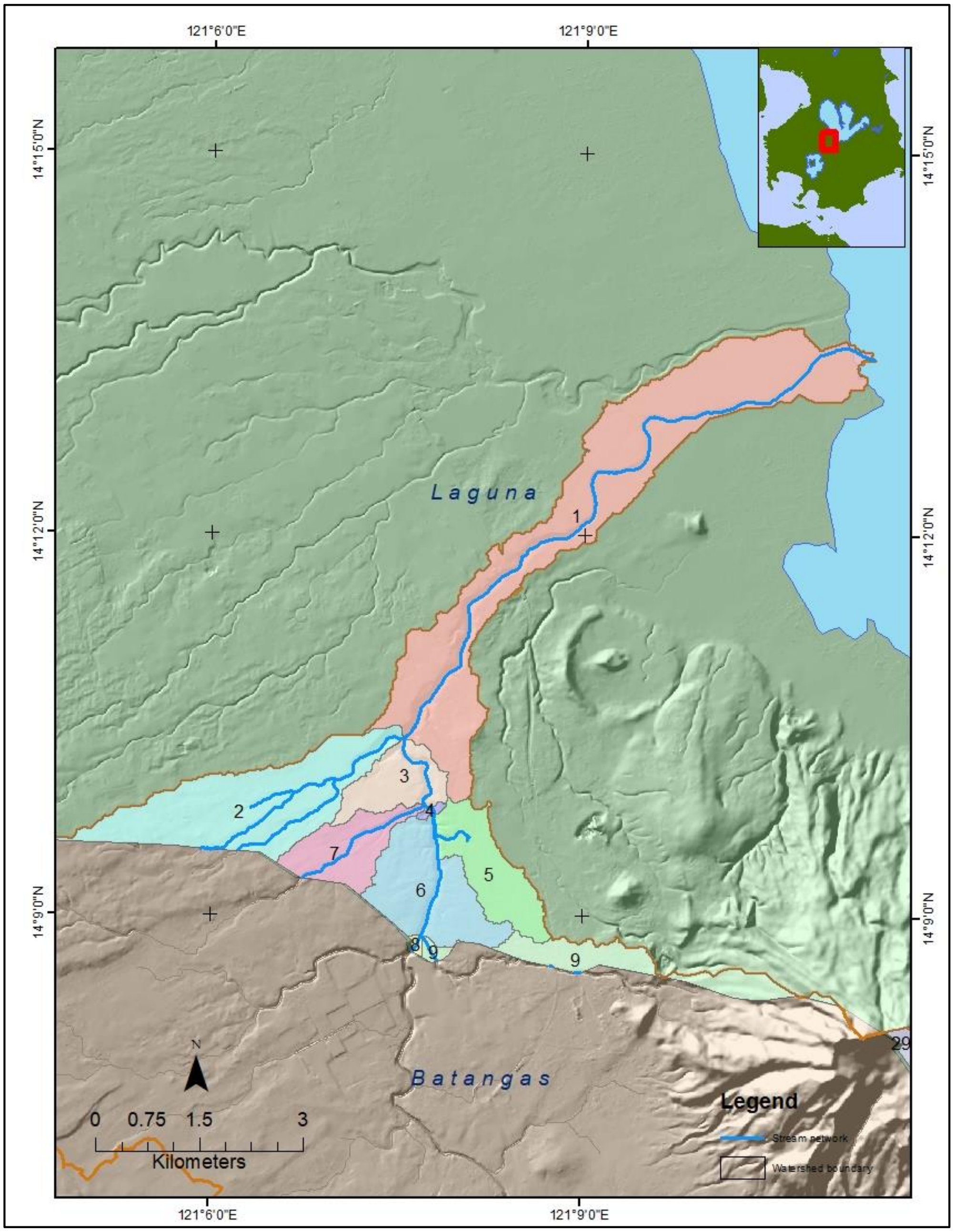

Figure 57. Map of major tributaries/ sub-basins of San Juan River wihtin Laguna Province.

B. San Cristobal River

The boundary of San Cristobal River traverses two (2) cities (Calamba City and Sta. Rosa City) and one municipality (Cabuyao). There are sixty-two (62) tributaries/sub-basin connected to the main channel. The area of these sub-basin ranges from 12ha to 734ha. The distribution of each sub-basin in localities (barangays) of each municipality is presented below.

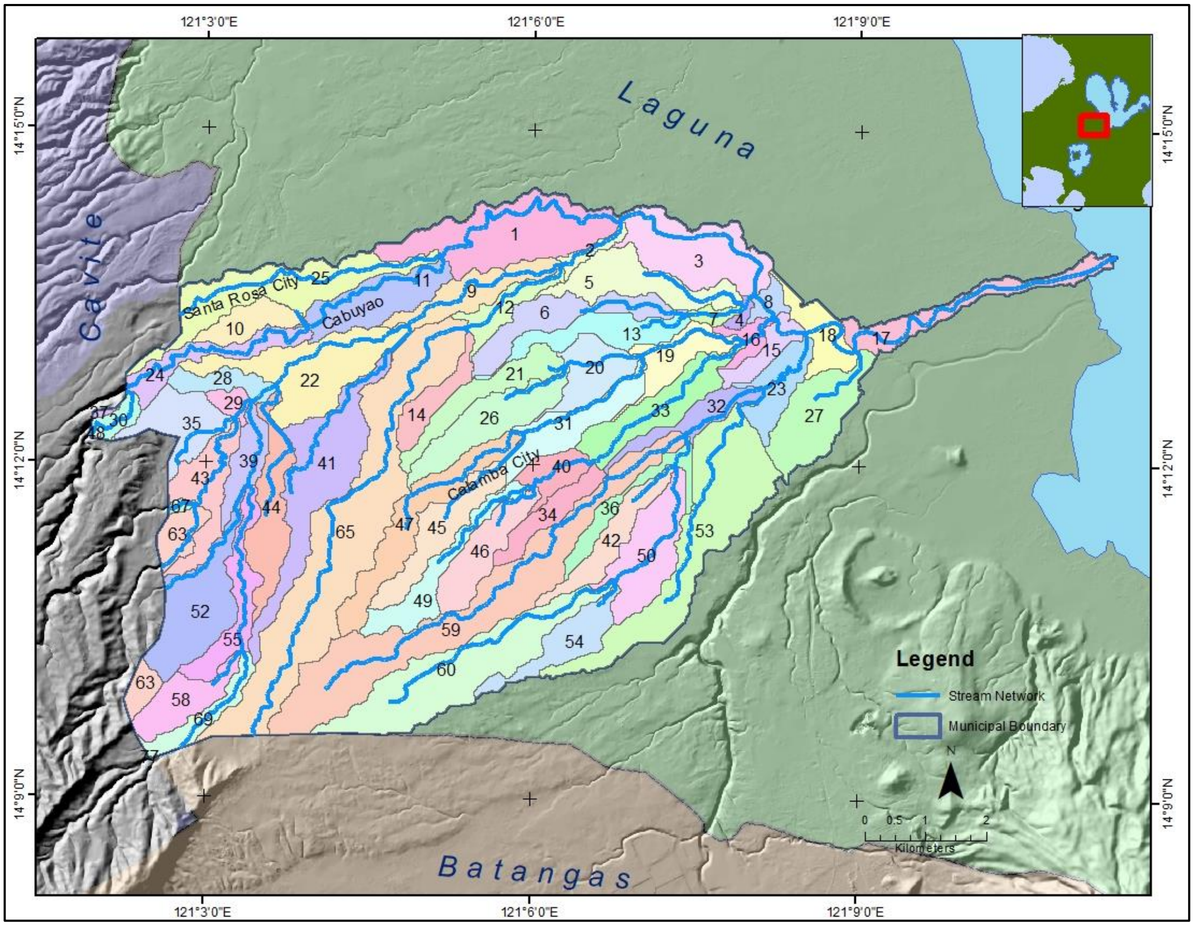

Figure 58. Major tributaries of San Cristobal River are overlaid to each corresponding subwatershed.

a. Cabuyao

Table 35. Area in hectare of sub-basin/tributary of San Cristobal River within the five (5) barangays of Cabuyao Laguna.

Sub-basin/ Tributary	Banlic	Casile	Diezmo	Pittland	San Isidro	Total
1			231.34	27.02		258.37
2			8.74			8.74
3	12.70		10.40		0.29	23.39

9			17.64	32.13		49.77
10		8.69		16.15		24.84
11				153.10		153.10
12			0.00			0.00
22		23.65		69.68		93.33
24		65.67		38.02		103.68
25		15.21		37.60		52.81
28		47.47		3.76		51.24
29		18.77				18.77
30		31.09				31.09
35		78.25				78.25
37		3.30				3.30
38		0.10				0.10
48		2.06				2.06
Total	**12.70**	**294.24**	**268.12**	**377.47**	**0.29**	**952.83**

The largest sub-basin within Cabuyao is sub-basin no. 1 with total area of 258 hectares distributed in barangays of Diezmo (231 ha) and Pittland (27 ha).

b. Calamba City

Table 36. Area of sub-basin/tributary of San Cristobal River within the 13 barangays of Calamba City, Laguna.

Sub-basin	**Banadero**	**Barandal**	**Batino**	**Bubuyan**	**Bunggo**	**Burol**	**Canlubang**	**Hornalan**	**Laguerta**	**Lawa**	**Looc**	**Mabato**	**Majada Labas**
1													
2													

15	**14**	**13**	**12**	**9**	**8**	**7**	**6**	**5**	**4**	**3**
2.9										
	72.1	114.5	63.3	68.8		0.0	138.9	61.8		16.1

28	**27**	**26**	**23**	**22**	**21**	**20**	**19**	**18**	**17**	**16**
									29.2	
	10.1		61.7							
7.7		156.8		156.5	113.0	75.1	50.7			
	38.6		16.5					10.6		
									9.8	
						0.6				

42	**41**	**40**	**39**	**36**	**35**	**34**	**33**	**32**	**31**	**29**
0.0				20.4				22.1		
								24.5		
5.8										
	280.0	0.6	74.4		42.6	8.0	1.1		9.7	8.1
5.7						0.1				
		62.6				53.8	0.0	0.4	54.3	

55	**54**	**53**	**52**	**50**	**49**	**47**	**46**	**45**	**44**	**43**
		157.5		41.7						
		32.5								
	97.7	29.5		27.8						
	9.3									
86.1			148.9		48.1	126.5	95.3	107.0	151.1	127.9
					65.8	54.1	20.0	30.9		
30.0			55.7							
					1.8		7.8			

Grand Total	**77**	**69**	**67**	**65**	**63**	**60**	**59**	**58**
29.2								
245.4							3.6	
131.6								
223.3						62.6		
233.0				40.0		90.2	102.8	
20.7						11.4		
2,934.7		22.5	7.6	414.1	52.9		18.9	8.0
554.8				98.7		111.9	173.4	
167.6						65.2	96.7	
65.7								
9.8								
273.1	0.1	45.5		12.9	32.6			96.3
187.8							6.4	

Table 37. Area of sub-basin/tributary of San Cristobal River within the additional 13 barangays of Calamba City, Laguna.

Sub-basin	Mapagong	Mayapa	Paciano Rizal	Palo-Alto	Parian	Prinza	Punta	Real	Sampiruhan	San Cristobal	San Juan	Sirang Lupa	Turbina	Grand Total
1	1.2													1.2
2	16.4													16.4
3	166.8									12.2				195.0
4	0.7		11.5											12.2
5	96.4		0.8											159.0
6	5.9		0.0											144.8
7	8.0		12.1											20.2
8	3.3		6.8							18.9				29.0

21	20	19	18	17	16	15	14	13	12	9
									5.1	1.2
	6.7	21.3			0.0	1.4				
		23.1	1.5		33.7	48.2		0.2		
			50.6	52.8		1.8				
				13.5						
			21.4	1.1		0.0				
				0.0						
	23.4									
113.0	105.7	95.2	84.0	106.4	33.7	54.3	72.1	114.7	68.5	70.1

22														156.5
23			1.8		1.2	12.8								94.1
26												3.0		159.8
27					19.2	101.5		1.2					0.3	171.0
28														7.7
29														8.1
31		33.5										31.8		129.3
32		21.3	0.0	7.5										75.8
33		119.5	9.8	0.4										130.9
34				13.7										75.6
35														42.6

36				52.9										73.4
39														74.4
40														63.2
41														280.0
42				89.7										101.2
43														127.9
44														151.1
45												1.6		139.6
46														123.2
47												9.8		190.3
49														115.8

50	52	53	54	55	58	59	60	63	65	67
						1.0				
51.1						111.1	0.5			
		65.7								
54.9		106.0	0.7							
		1.5								
175.5	204.6	392.6	107.6	116.0	104.2	513.8	341.6	85.5	565.8	7.6

69														68.0
77														0.1
Grand Total	**305.1**	**204.7**	**149.5**	**326.9**	**125.6**	**180.0**	**161.6**	**1.2**	**13.5**	**53.5**	**0.0**	**69.5**	**1.9**	**6,669.8**

The largest sub-basin fo San Cristobal River within Calamba City is no. 65 located in barangays of Canlubang (414 ha), Hornalan (98ha), Bunggo (40ha), and Mabato (12ha).

c. Sta. Rosa City

Table 38. Area of sub-basin/tributary of San Cristobal River within the two (2) barangays of Sta. Rosa City, Laguna.

Sub-basin/Tributaries	Don Jose	Santo Domingo	Grand Total
1	1.4	33.7	35.1
10		49.3	49.3
11		0.4	0.4
25		183.8	183.8
Grand Total	1.4	267.1	268.5

The largest sub-basin within Cabuyao in no. 25 is located wihin Brgy. Sto. Domingo with an area of 183.8 ha.

C. Saran River

The catchment of Saran River is composed of seven sub-basins. Sub-basin no. 7 is the largest with 102.60 ha while the smallest is sub-basin no. 4. Sub-basin no. 7 is located on the headwaters of Saran River on the slope of Mt. Makiling.

Table 39. The seven tributary/sub-basin of Saran River and its primary land uses.

Sub-basin/Tributary and its primary landuse	Area (ha)
1	13.03
Other land, built-up area	3.90
Other land, cultivated, annual crop	9.13
2	24.17
Other land, cultivated, annual crop	24.17
3	25.69
Other land, built-up area	0.36
Other land, cultivated, annual crop	25.33
4	18.20
Other land, cultivated, annual crop	18.20
5	27.12
Other land, cultivated, annual crop	27.12
6	34.64
Other land, cultivated, annual crop	34.64
7	102.60
Open forest, broadleaved	42.01
Other land, cultivated, annual crop	60.59
Total	**245.45**

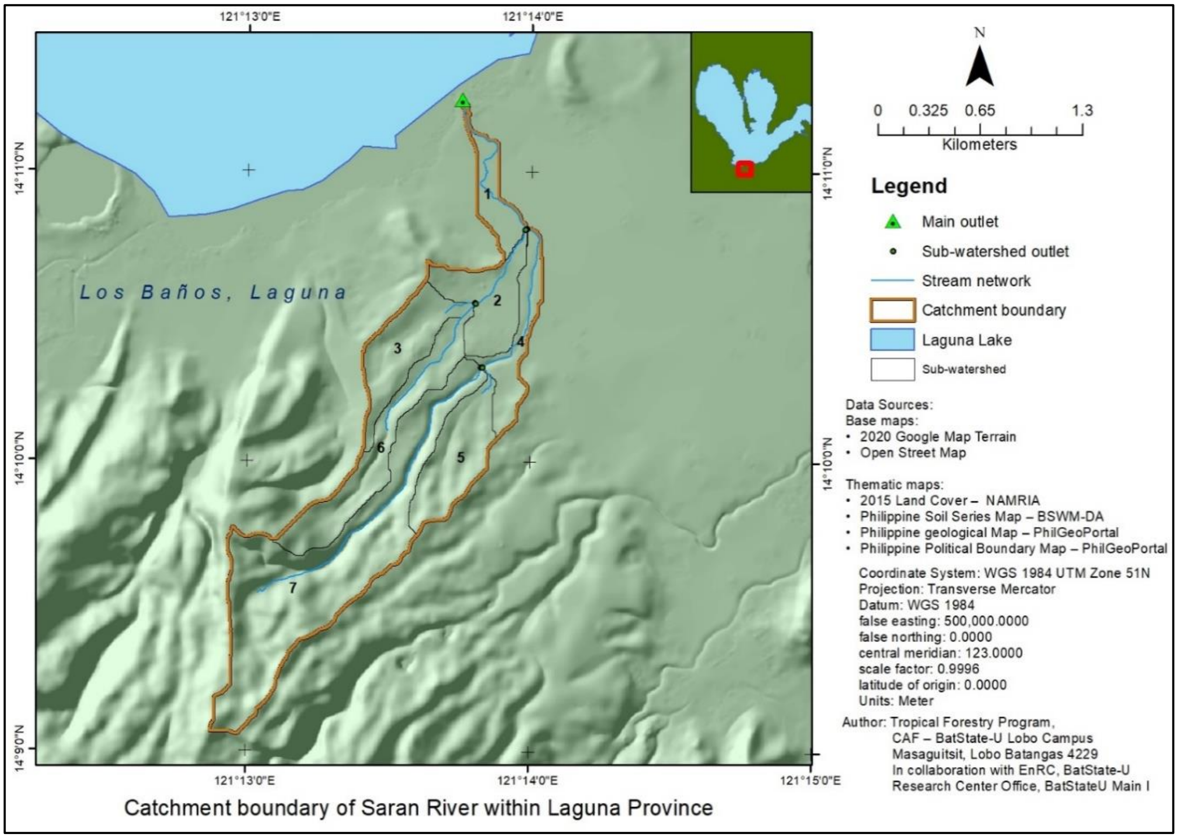

Figure 59. Major tributaries of Saran River are overlaid to each corresponding subwatershed.

C. Covered City/Municipality Profile

1. Population and Land Area of the Barangays in the Municipality Covered in the River System

a. People/ Population

Humans are the most important driver of change in the watershed. They are the primary drivers of land-use/land-cover changes. A shift to less vegetative land use through agricultural and commercial expansion greatly affects the hydrology of the watershed. On the other hand, vegetation enhancement encourages better infiltration and water storage thereby regulating floods and improve water quality. The rate of water extraction and wastewater generation is dictated by the size of the human population within the catchment. Aside from wastewater generation, solid waste generation is also dictated by population size within the catchment. This also varies with the level of economic activities within the watershed. The watershed which is more economically active will generate more waste than those with similar population size.

A. San Juan River

Based on the data from LGU of Calamba City, it is estimated that the total population within San Juan catchment in Laguna province is approximately 250,320 in the year 2020.

Table 40. Population of the 30 barangays of Calamba City, Laguna within the catchment of San Juan River.

Barangay	Population as of 2020 (projected by LGU of Calamba City)
Parian	25,400
Looc	25,023
Real	16,557
Kay-Anlog	16,042
Barandal	14,408

Lawa	12,867
Makiling	12,377
Banadero	11,977
Sampiruhan	10,824
Lecheria	10,477
Barangay 2	8,958
Barangay 5	7,461
Lingga	6,966
Barangay 1	6,711
Saimsim	6,704
Palingon	6,539
Turbina	6,041
Barangay 3	5,493
San Juan	5,065
Punta	4,802
Prinza	4,303
San Jose	4,277
Bunggo	3,751
Barangay 4	3,725
Barangay 7	3,550
Burol	2,641
Barangay 6	2,588
Bubuyan	2,489
Camaligan	1,421
Ulango	883
Total	**250,320**

Many people in the province are employed by resource-based industries, including agriculture, conventional and in situ oil and gas, forestry, mining (aggregate and coal), tourism, and recreation. The combined effects of water use, infrastructure needs, agriculture, industry, forestry, and resource extraction impose stresses on the water, the lands, and the ecosystem. Measuring, evaluating, and comparing stresses and understanding how they interact will be an ongoing challenge.

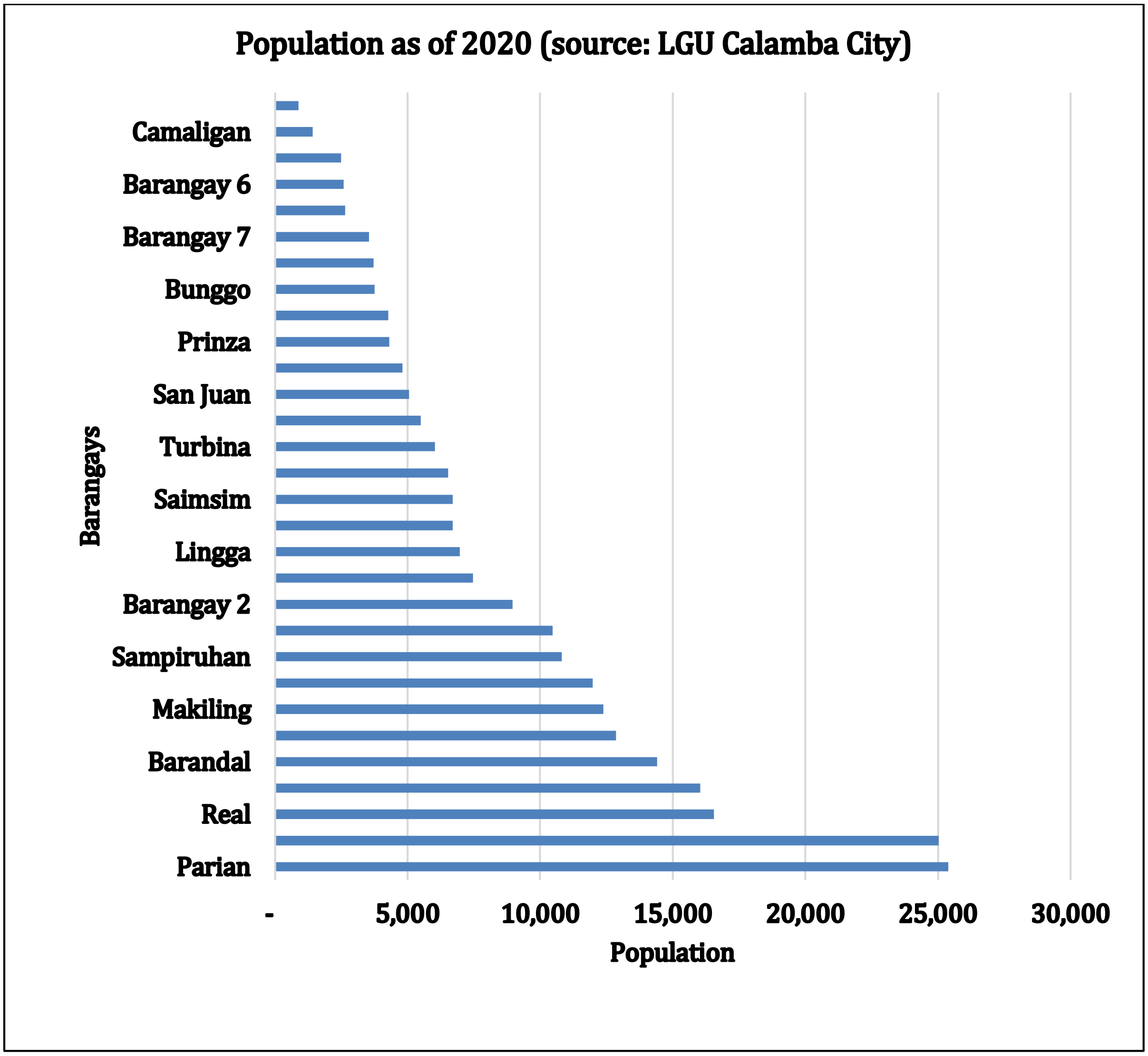

Figure 60. Population distribution in the different villages (barangays) within San Juan River of Laguna province.

The catchment of San Juan River within the Laguna province is composed of four (4) Municipalities with a total of 39 Barangays. Calamba City has the largest area with an average of 95.47% (31,966.97ha). Followed by Los Baños with 3.28 % (67.54 ha), while the Municipality of Bay has the lowest area with only 0.48 % (9.96 ha).

Table 41. Political boundary within the Catchment of San Juan Watershed in Laguna Province

Municipality	Barangay	Area (ha)	Percent (%)
Calamba City	Prinza	17.33	1%
Calamba City	Real	77.56	4%
Calamba City	Punta	88.01	4%
Calamba City	Banadero	59.66	3%
Calamba City	Barangay 6	15.8	1%
Calamba City	Barangay 5	30.77	2%
Calamba City	Barangay 1	27.48	1%
Calamba City	Parian	46.88	2%
Calamba City	Saimsim	42.94	2%
Calamba City	Tulo	148.92	8%
Calamba City	Barangay 2	21.3	1%
Calamba City	Makiling	260.05	13%
Calamba City	Burol	97.58	5%
Calamba City	Lingga	17.02	1%
Calamba City	Turbina	102.7	5%
Calamba City	Looc	0.92	0%
Calamba City	Barangay 7	11.31	1%
Calamba City	Lawa	5.22	0%
Calamba City	Camaligan	74.48	4%
Calamba City	Kay-Anlog	321.84	16%
Calamba City	San Jose	4.19	0%
Calamba City	San Juan	69.69	4%
Calamba City	Barangay 3	13.67	1%
Calamba City	Bubuyan	72.01	4%
Calamba City	Ulango	208.98	11%

Calamba City	Bunggo	18.51	1%
Calamba City	Barandal	29.22	1%
Calamba City	Palingon	56.28	3%
Calamba City	Sampiruhan	11.62	1%
Calamba City	Lecheria	4.98	0%
Calamba City	Barangay 4	10.05	1%
TOTAL		**1,966.97**	**100%**

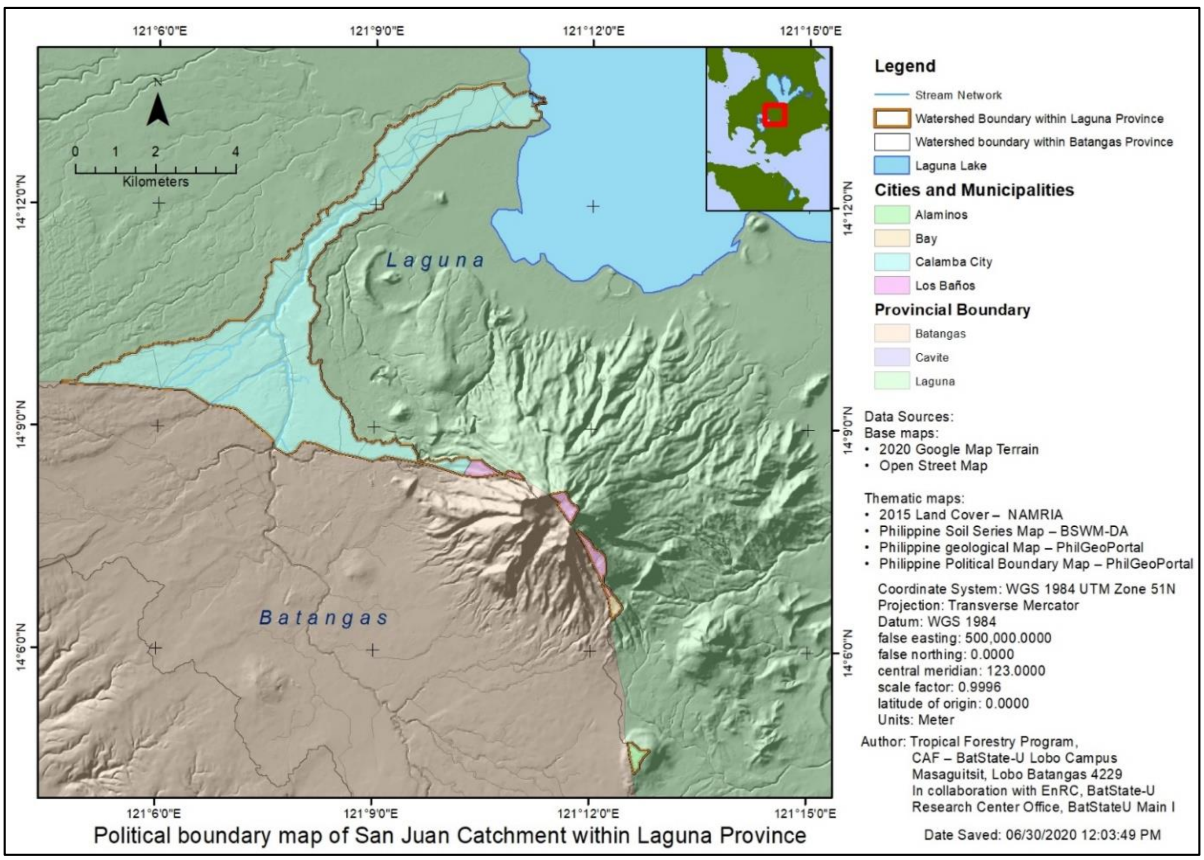

Figure 61. Political Boundary distribution within San Juan Watershed in Laguna Province.

B. San Cristobal River

Based on the data from LGU of Calamba City, it is estimated that the total population within San Cristobal catchment in Laguna province is approximately 353,870 based on the 2015 census.

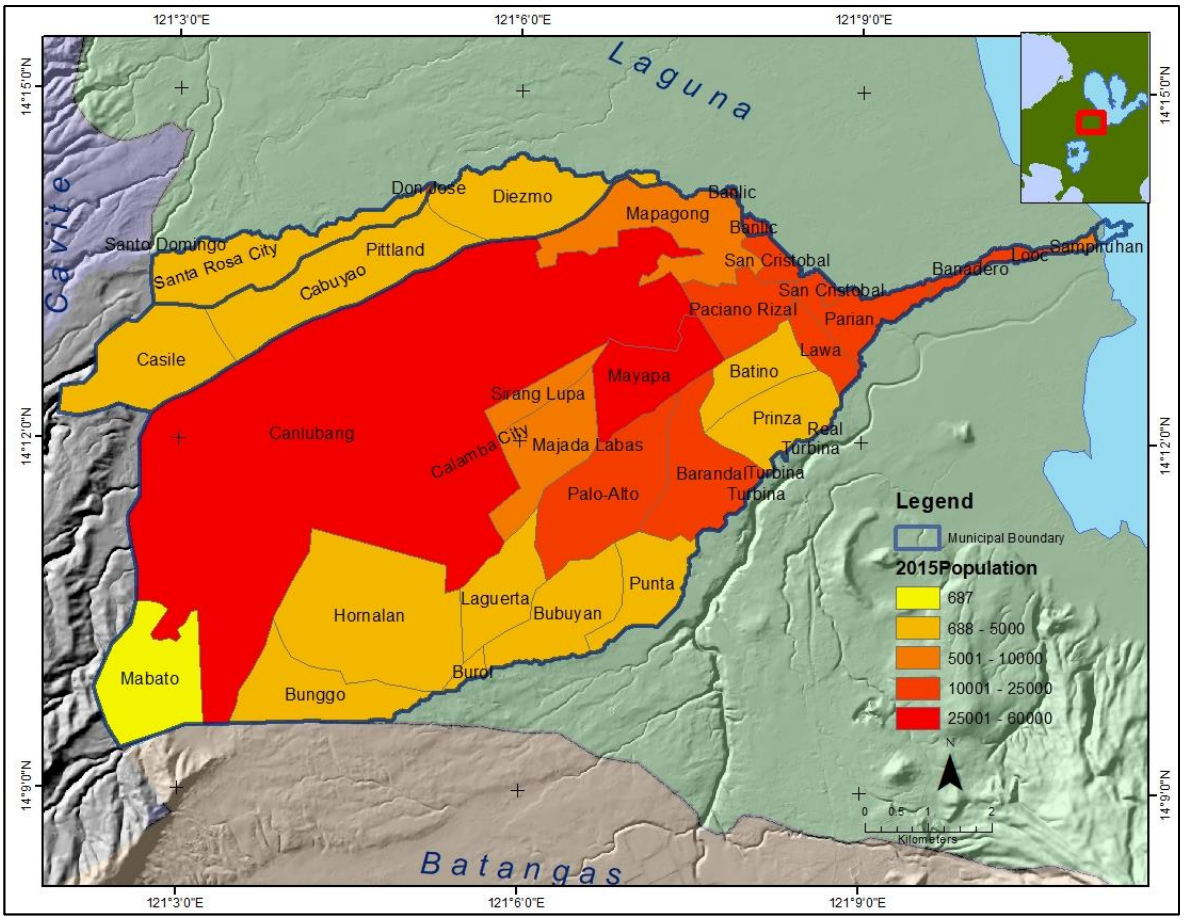

Figure 62. Spatial distribution of 2015 population within the catchment of San Cristobal River in Laguna province.

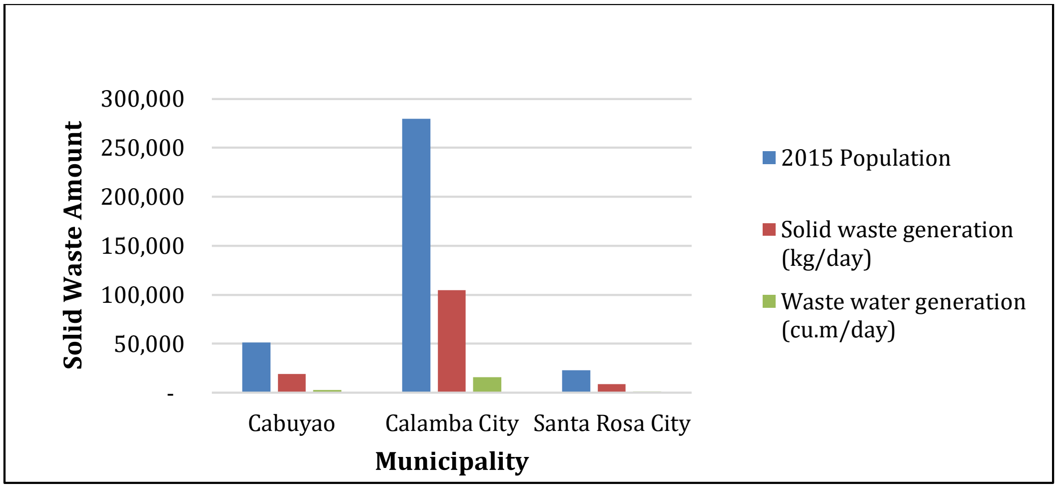

Figure 63. The 2015 population and the estimated wastewater and solid waste generation.

The solid waste and wastewater were estimated based on the waste generation per capita.

Table 42. Population of the five (5) barangays of Cabuyao, Laguna covered by San Cristobal River.

Barangay	2015 Population
Diezmo	4,468
Banlic	16,854
San Isidro	24,446
Pittland	3235
Casile	2,393
Total	**51,396.00**

Table 43. Population of the twenty-six (26) barangays of Calamba City, Laguna covered by San Cristobal River.

Barangay	**2015 Population**
Banadero	10,412
Barandal	12,526
Batino	1,274
Bubuyan	2,164
Bunggo	3,261
Burol	2,296
Canlubang	54,943
Hornalan	1,736
Laguerta	2,332
Lawa	11,186
Looc	21,754
Mabato	687
Majada Labas	6,471
Mapagong	6,014
Mayapa	26,211
Paciano Rizal	15,081
Palo-Alto	15,208
Parian	22,082
Prinza	3,741
Punta	4,175
Real	14,394
Sampiruhan	9,410
San Cristobal	13,690
San Juan	4,403
Sirang Lupa	8,807
Turbina	5,252
Total	**279,510.00**

Table 44. Population of the two barangays of Sta. Rosa City, Laguna covered by San Cristobal River.

Barangay	2015 Population
Don Jose	18,872
Santo Domingo	4092
Total	**22,964.00**

The catchment of San Cristobal River within the Laguna province is composed of three (3) Municipalities with a total of 33 Barangays. Calamba City has the largest area with an average of 84.75% (6,788.48ha). This was followed by Cabuyao with 11.90 % (952.83 ha), while the City of Santa Rosa has the lowest area with only 3.35 % (268.50 ha).

Table 45. Political boundary within the catchment of San Cristobal Watershed in Laguna Province

Municipality	Barangay	Area (ha)
Calamba City	Prinza	180.05
Calamba City	Real	1.22
Calamba City	Parian	125.65
Calamba City	Punta	161.60
Calamba City	Banadero	29.17
Calamba City	Mabato	273.07
Calamba City	Mapagong	305.14
Calamba City	Burol	20.66
Calamba City	Paciano Rizal	149.52
Calamba City	Canlubang	3025.14
Calamba City	Majada Labas	213.07
Calamba City	Turbina	1.87
Calamba City	Looc	9.78
Calamba City	Batino	131.61

Calamba City	Lawa	68.62
Calamba City	Mayapa	204.67
Calamba City	Laguerta	167.65
Calamba City	San Juan	0.03
Calamba City	San Cristobal	53.55
Calamba City	Sirang Lupa	69.49
Calamba City	Bubuyan	223.31
Calamba City	Hornalan	554.84
Calamba City	Bunggo	232.96
Calamba City	Barandal	245.39
Calamba City	Sampiruhan	13.53
Calamba City	Palo-Alto	326.87
Cabuyao	Diezmo	268.13
Cabuyao	Banlic	12.70
Cabuyao	San Isidro	0.29
Cabuyao	Pittland	377.47
Cabuyao	Casile	294.24
Santa Rosa City	Don Jose	1.42
Santa Rosa City	Santo Domingo	267.08
Laguna lake	Laguna Lake	11.91
Total		**8,021.70**

C. Saran River

Based on the data from Philippine Statistics Authority, it is estimated that the total population within Saran catchment in Laguna province is approximately 8,324 based on the 2015 census.

Table 46. Population of the four (4) barangays of Los Baños, Laguna covered by Saran River.

Barangay	Area (ha)	Estimated population
Anos	96.07	4,490

Batong Malake	69.24	946
Malinta	6.54	892
Timugan	73.60	1,995
Total	**245.45**	**8,324**

The catchment of Saran River within the Laguna province is composed of four (4) Barangays of Los Baños. Brgy. Anos has the largest area with an average of 39.14% (96.24 ha). This was followed by Brgy. Timugan with 29.98 % (73.6 ha), while the Malinta has the lowest area with only 2.66% (6.54 ha).

Table 47. Political boundary within the catchment of Saran Watershed in Laguna Province

Barangay	Sum of Area (ha)	%
Anos	96.07	39.14%
Batong Malake	69.24	28.21%
Malinta	6.54	2.66%
Timugan	73.60	29.98%
Grand Total	**245.45**	**100.00%**

2. Land Use Classification

The overall condition of the watershed including the hydrologic regime is directly influenced with existing land use. Generally, water quantity, quality, and timing are among the most important characteristics that are affected by land-use choices. Water quality is also improved in streams with lush vegetation cover. Soil erosion and non-point source pollution are also influenced by the prevailing land use. Most of the studies concluded that the lesser vegetation promotes erosion and enhances non-point source pollution.

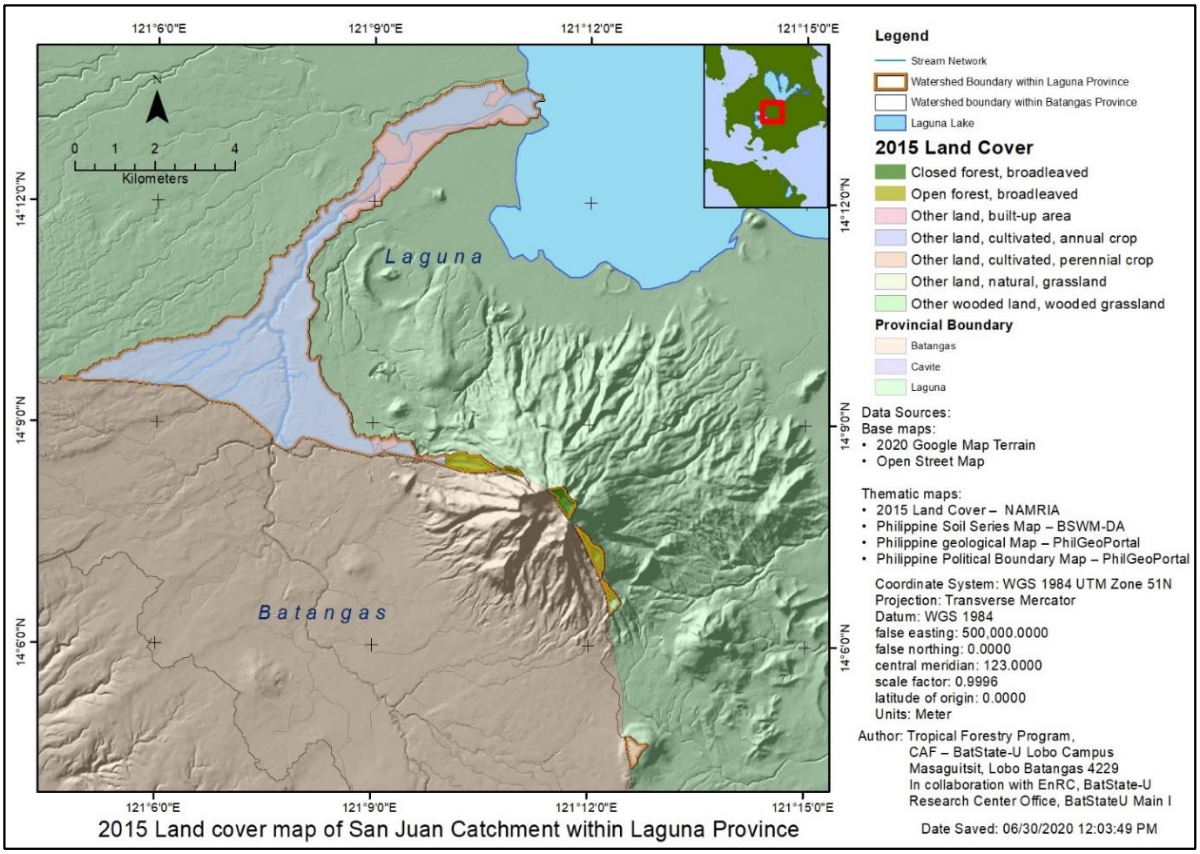

Figure 64. The 2015 land cover map of San Juan Catchment within Laguna Province

Studies have also shown that watersheds with more vegetation cover exhibit long water retention and reduce the incidence of accelerated peak flow. Lesser runoff is generated in watersheds with more vegetation cover to intercept and transpire water. On the other hand, excessive runoff is generated in watersheds with too much forest clearing, row cropping, grazing, pavement, urbanization, and other types of development. Higher runoff produces faster-rising flood and encourages further erosion. Over-exploitation of agricultural lands, conversion of forest to agricultural land, and rapid urbanization are the key anthropogenic drivers that this processes. Land use is usually classified based on the existing land cover. Aerial photographs and satellite image analysis has become the most useful tool for classifying land use.

a. San Juan River

Based on the 2015 land cover maps from NAMRIA, the catchment of San Juan River in Laguna Province is composed of six (6) land types. Other land, cultivated annual crop has the largest composition with an average of 81.52% (1,684.55ha). This is followed by Other built up area with an average of 313.14 % (271.54 ha). Other wooded land, wooded grassland has the lowest composition with 0.28% (5.73 ha).

Table 48. Land Cover within the catchment of San Juan Watershed in Calamba City, Laguna Province.

Classification	Area (ha)	Percent (%)
Other land, cultivated, perennial crop	15.74	0.76
Other land, built-up area	271.54	13.14
Closed forest, broadleaved	21.05	1.02
Open forest, broadleaved	67.91	3.29
Other wooded land, wooded grassland	5.73	0.28
Other land, cultivated, annual crop	1,684.55	81.52
Total	**2,066.52**	**100**

b. San Cristobal river

Meanwhile, San Cristobal River in Laguna Province has also composed of six (6) land cover types. Other land, cultivated annual crop has the largest composition with an average of 77.26% (6197.46ha) followed by other built-up area with an average of 14.75

% (1,182.89 ha). The land cover with the smallest distribution is the other land, cultivated, and perennial crop with only 8.39 ha.

Table 49. Land Cover within the entire catchment of San Cristobal Watershed in Laguna Province.

Land Classification	Area (ha)	Percentage
Other land, natural, barren land	26.18	0.33
Other land, cultivated, annual crop	6197.46	77.26
Other land, built-up **area**	1182.89	14.75
Other wooded land, shrubs	606.79	7.56
Other land, cultivated, perennial crop	8.39	0.10
Inland water	0.02	0.00
Total`	**8021.73**	**100.00**

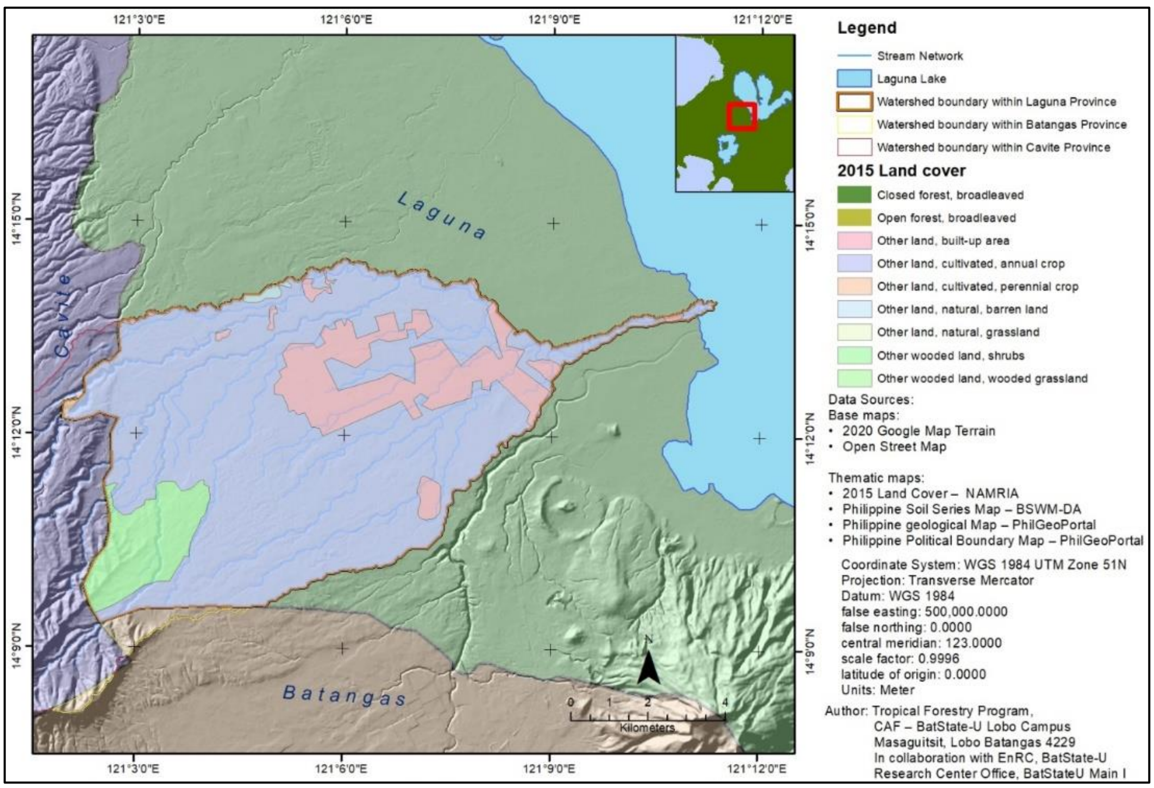

Figure 65. The 2015 land cover map of San Cristobal Catchment within Laguna Province.

c. Saran River

Saran River in Laguna Province is composed of three (3) land cover types (Table 50). The land cover type with the highest distribution is the other land and cultivated annual crop covering 81.16% (199.28 ha). The second is the open forest and broadleaved with 17.11 % (42.01ha) while the other land and built-up area have the lowest composition with 1.73% (4.25 ha).

Table 50. Land use/ Land cover within the catchment of Saran River in Los Baños, Laguna based on 2015 classification of NAMRIA.

Land cover	Sum of Area (ha)	%
Open forest, broadleaved	42.01	17.11%
Other land, built-up area	4.25	1.73%
Other land, cultivated, annual crop	199.19	81.15%
Total	**245.45**	**100%**

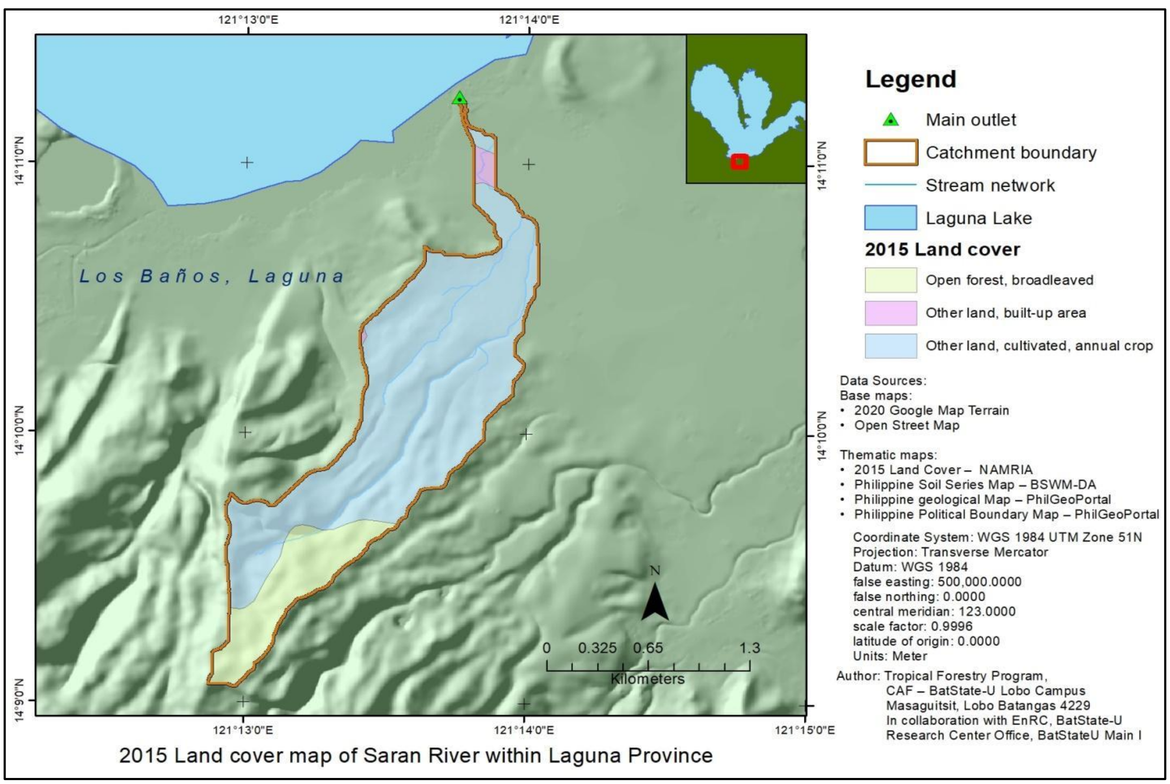

Figure 66. The 2015 land cover map of Saran Catchment within Laguna Province.

3. Built-up Areas

The built-up areas affect the environment both positively and negatively. In areas with limited spaces, buildings are a reflection of using the space wisely. The advantage of built-up areas is the improved economic activities of the area and high purchasing power. Urbanization will become an opportunity for everyone who wants to seek better jobs, nice housing, better education, and a higher standard of living. This can pave way for the development of more civic spaces or green spaces. However, if other open spaces will just be used for the construction of another vertical structure, this will harm the environment making it more congested causing a hotter environment. Moreover, the wastes of the people occupying the buildings, if not disposed of properly, will affect the environment by adding up to air and water pollution.

Table 51. Distribution of built-up areas in the localities within the San Juan River in Laguna Province.

Barangays	**Built-up area (ha)**
Barandal	29.10
Batino	51.95
Canlubang	531.18
Lawa	51.89
Looc	0.97
Majada Labas	32.40
Mapagong	9.94
Mayapa	148.92
Paciano Rizal	80.30
Palo-Alto	0.83
Parian	32.01
Prinza	24.28
Punta	35.71
Real	0.41
Sampiruhan	5.56

San Cristobal	27.69
Sirang Lupa	66.49
Total	**1,129.65**

Table 52. Distribution of built-up areas in the tree localities within the San Cristobal River in Laguna Province.

City/Municipality	Built-up area (ha)
Cabuyao	44.13
Calamba City	1,132.63
Santa Rosa City	6.12
Grand Total	**1,182.89**

Table 53. Distribution of built-up areas in the two localities within the Saran River in Laguna Province.

Barangays	Built-up area (ha)
Malinta	3.90
Timugan	0.36
Total	**4.25**

4. Solid Waste Generation

According to the World Bank report, the estimated average solid waste generation per capita is 0.40 kg per day for both rural and urban in 2016. It is estimated that solid waste generation within the watershed could reach up to 93.62 tons per day.

A. San Juan River

Table 54. Estimated solid-waste generation of the population within the thirty (30) barangays of Calamba City, Laguna within the catchment of San Juan river.

Barangay	Population as of 2020 (projected by LGU of Calamba City)	Estimated Solid waste generation (ton/day)
Parian	25,400	9.50
Looc	25,023	9.36
Real	16,557	6.19
Kay-Anlog	16,042	6.00
Barandal	14,408	5.39
Lawa	12,867	4.81
Makiling	12,377	4.63
Banadero	11,977	4.48
Sampiruhan	10,824	4.05
Lecheria	10,477	3.92
Barangay 2	8,958	3.35
Barangay 5	7,461	2.79
Lingga	6,966	2.61
Barangay 1	6,711	2.51
Saimsim	6,704	2.51
Palingon	6,539	2.45
Turbina	6,041	2.26
Barangay 3	5,493	2.05
San Juan	5,065	1.89
Punta	4,802	1.80
Prinza	4,303	1.61
San Jose	4,277	1.60
Bunggo	3,751	1.40
Barangay 4	3,725	1.39

Barangay 7	3,550	1.33
Burol	2,641	0.99
Barangay 6	2,588	0.97
Bubuyan	2,489	0.93
Camaligan	1,421	0.53
Ulango	883	0.33
Total	**250,320**	**93.62**

B. San Cristobal River

Table 55. Estimated solid-waste generation of the population within the five (5) barangays of Cabuyao, Laguna within the catchment of San Cristobal river.

Barangay	Estimated solid-waste generation (kg/day)
Diezmo	1,671
Banlic	6,303
San Isidro	9143
Pittland	1210
Casile	895
Total	**19,222**

Table 56. Estimated solid-waste generation of the population within the twenty-six (26) barangays of Calamba City, Laguna within the catchment of San Cristobal river.

Barangay	Estimated solid-waste generation (kg/day)
Banadero	3894
Barandal	4685
Batino	476
Bubuyan	809
Bunggo	1220
Burol	859

Canlubang	20549
Hornalan	649
Laguerta	872
Lawa	4184
Looc	8136
Mabato	257
Majada Labas	2420
Mapagong	2249
Mayapa	9803
Paciano Rizal	5640
Palo-Alto	5688
Parian	8259
Prinza	1399
Punta	1561
Real	5383
Sampiruhan	3519
San Cristobal	5120
San Juan	1647
Sirang Lupa	3294
Turbina	1964
Total	**104,536.74**

Table 57. Estimated solid-waste generation of the population within the two (2) barangays of Sta. Rosa City, Laguna within the catchment of San Cristobal river.

Barangay	Estimated solid-waste generation (kg/day)
Don Jose	7058
Santo Domingo	1530
Total	**115089.52**

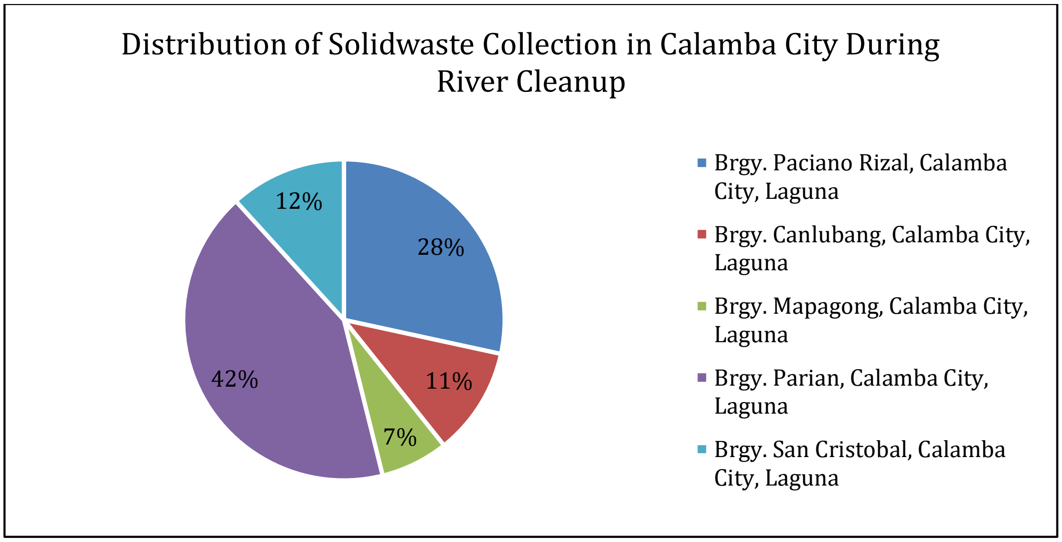

Figure 67. Distribution of volume of collected solid-waste from five (5) barangays during the river clean-up spearheaded by DENR Laguna.

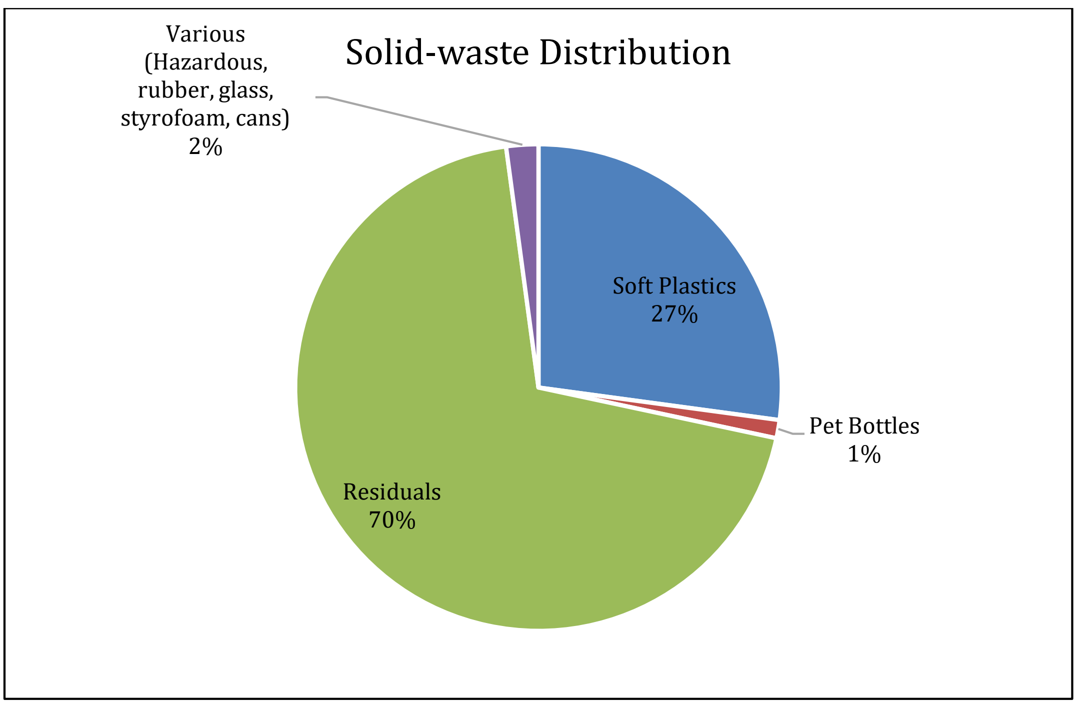

Figure 68. Distribution of volume of collected solid-waste from selected stream segment during the river clean-up spearheaded by DENR Laguna.

C. Saran River

Table 58. Estimated solid-waste generation of the population within the catchment of Saran River in Los Baños, Laguna.

Barangay	**Area (ha)**	**Estimated population**	**Estimated solid-waste generation (kg/day)**
Anos	96.07	4,490	1,679
Batong Malake	69.24	946	354
Malinta	6.54	892	334
Timugan	73.60	1,995	746
Total	**245.45**	**8,324**	**3,113**

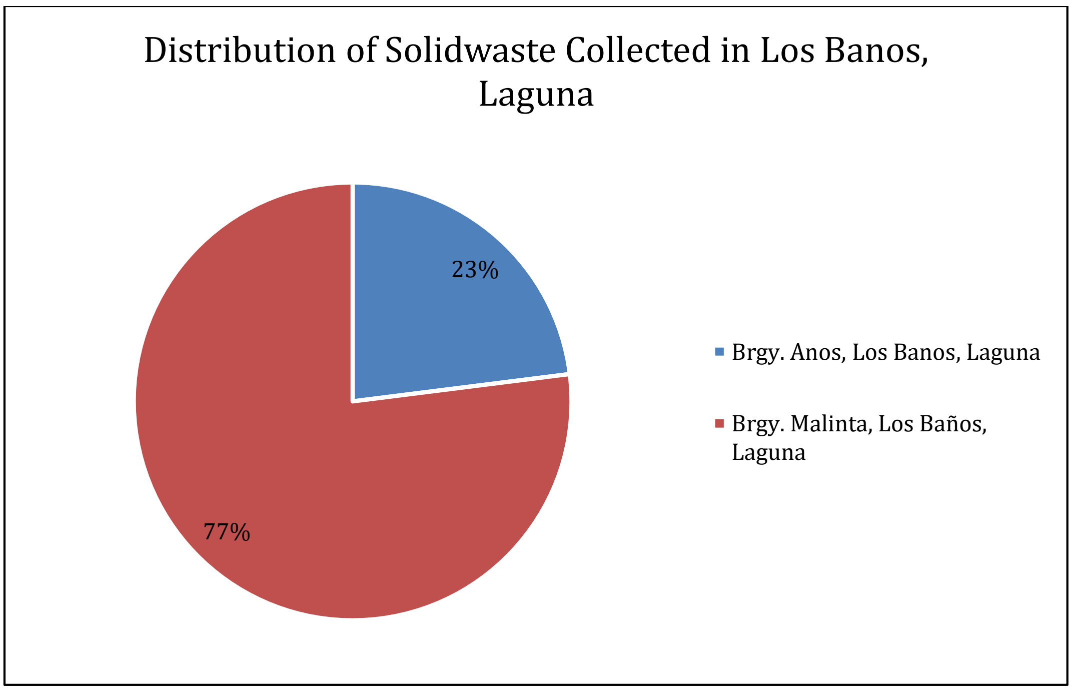

Figure 69. Distribution of volume of collected solid-waste from two (2) barangays during the river clean-up spearheaded by DENR Laguna.

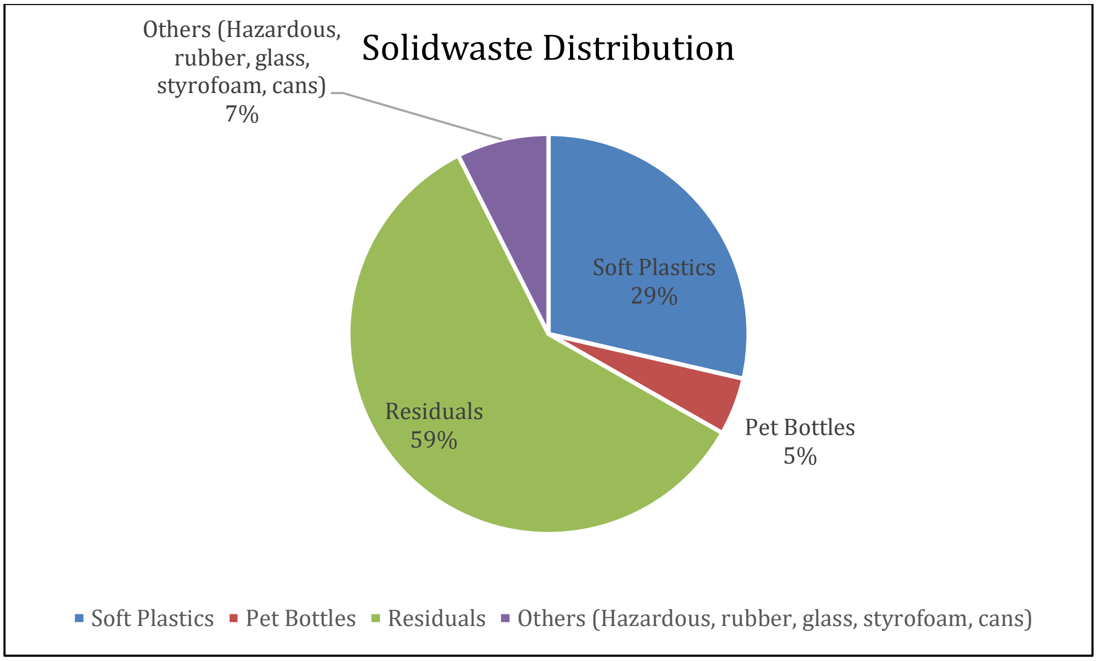

Figure 70. Distribution of volume of collected solid-waste from selected stream segment during the river clean-up spearheaded by DENR Laguna.

Table 59. Estimated solid-waste generation of the population within the two (2) barangays within the catchment of Saran River in Los Baños, Laguna

Barangay	**Stream length**	**Biodegradable**	**Non-biodegradable**	**Residuals**
Brgy. Anos, Los Baños	1485	42	300	112
Brgy. Malinta, Los Baños	700	0	504	0
Total	**2185**	**42**	**804**	**112**

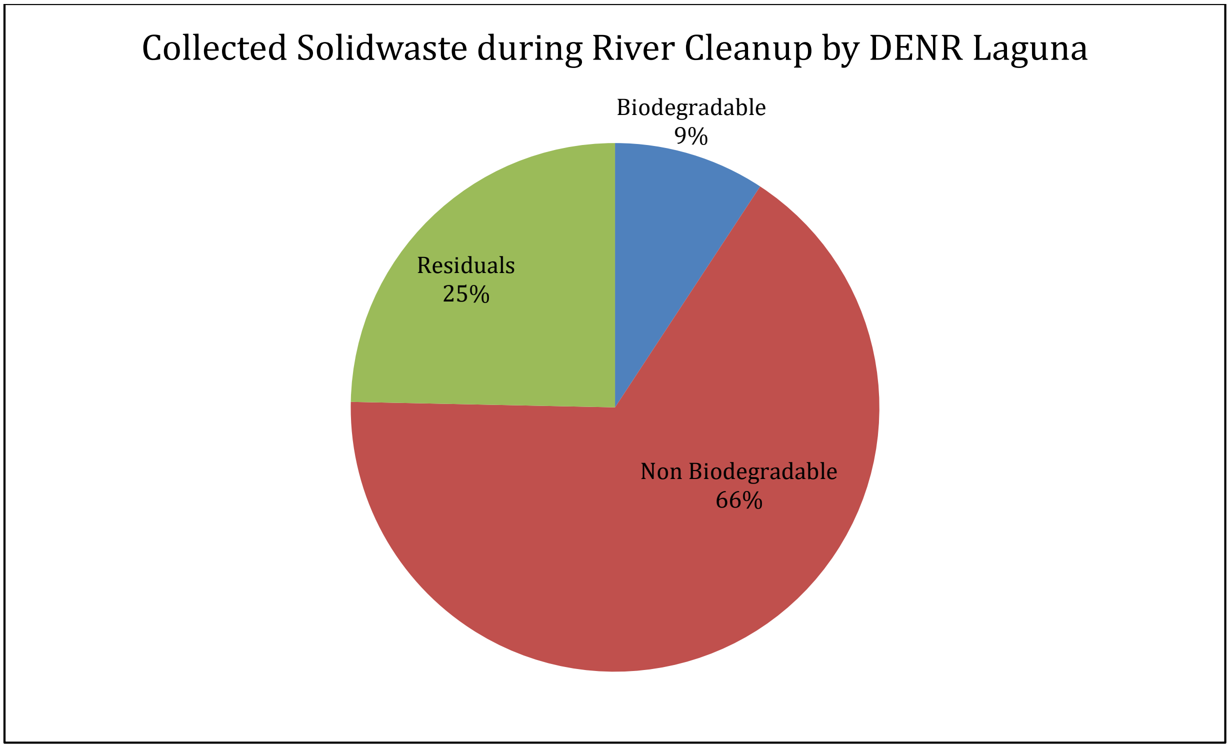

Figure 71. Distribution of volume of collected solid-waste from selected stream segment during the river clean-up spearheaded by DENR Laguna.

5. Wastewater Generation

Domestic wastewater is sludge produced by residential households that contain organic substances and soaps. This effluent usually reaches streams and water bodies via a residential sink and pipe system connected to a sewage canal which usually drains to streams. Sewage is the common term for this type of wastewater which is primarily from the kitchen, bathroom, and laundry sources. The choice of water quality monitoring parameters directly depends on the existing industries within the sub-watersheds.

It is estimated that 14 million liters of domestic water waste are generated within the catchment of the San Juan River in Laguna Province.

Table 60. Estimated waste-water generation of the population within the 30 barangays of Calamba City, Laguna within the catchment of San Juan River.

Barangay	Population as of 2020 (projected by LGU of Calamba City)	Estimated Wastewater Generation per Day (L/day)
Parian	25,400	1,422,400
Looc	25,023	1,401,288
Real	16,557	927,192
Kay-Anlog	16,042	898,352
Barandal	14,408	806,848
Lawa	12,867	720,552
Makiling	12,377	693,112
Banadero	11,977	670,712
Sampiruhan	10,824	606,144
Lecheria	10,477	586,712
Barangay 2	8,958	501,648
Barangay 5	7,461	417,816
Lingga	6,966	390,096
Barangay 1	6,711	375,816
Saimsim	6,704	375,424
Palingon	6,539	366,184
Turbina	6,041	338,296
Barangay 3	5,493	307,608
San Juan	5,065	283,640
Punta	4,802	268,912
Prinza	4,303	240,968
San Jose	4,277	239,512
Bunggo	3,751	210,056
Barangay 4	3,725	208,600
Barangay 7	3,550	198,800

Burol	2,641	147,896
Barangay 6	2,588	144,928
Bubuyan	2,489	139,384
Camaligan	1,421	79,576
Ulango	883	49,448
Total	**250,320**	**14,017,920**

It is estimated that 19.8 million liters of domestic waste-water are generated within the catchment of San Cristobal River in Laguna Province. On the other hand, the population within Saran River can generate an estimated that 446,139 liters of domestic waste-water.

Table 61. Estimated wastewater generation of the population within Saran River in Los Baños, Laguna Province.

Barangay	Estimated population	Estimated wastewater generation (L/day)
Anos	4,490	251,451
Batong Malake	946	52,974
Malinta	892	49,972
Timugan	1,995	111,743
Total	**8,324**	**466,139**

6. Informal Settlers Families (ISFs) along the rivers

The rising urban population in the Philippines and the inadequacy of living spaces cause informal settlers along rivers/easement to rise. This has adverse effects on the riparian and riverine environment as more humans are situated near the rivers. Since these areas were not originally designed for the building of houses, most houses are temporarily built without a good sewerage system. Solid and water wastes tend to go to the water which causes pollution. Moreover, the clogging of rivers due to wastes hamper the daily lives of people such as transporting goods or getting clean water for household use. Clogging of rivers also causes and/or aggravates flooding during the rainy season. Because of limited spaces and the inability to avail of permanent housing, many end up living in low-lying, mountainous, and hazard-prone areas thereby increasing their exposure to hazards. Moreover, low-quality housing makes them more vulnerable.

The presence of Informal Settler Families (ISFs) along river easements and riparian areas can cause erosion in the riverbanks as the flow of water is modified due to the presence of their solid waste and their constructions along the riverbank changes the physical makeup of the bank. Vegetation cleared during the settling of ISFs could have protected against erosion and shade can lower the water temperature which in turn supports higher oxygen levels in the water need to maintain aquatic life.

There is no single solution to reduce their vulnerabilities but it should be a series of actions that holistically seeks to alleviate poverty. Amongst to be the most effective include increasing job accessibility, near city socialized, and transferring industries outside city centers. This can reduce their vulnerabilities and negative environmental impacts.

A. San Juan River

Table 62. Informal Settler Families (ISF) along the riverbank of San Juan River in the seventeen (17) Barangays of Calamba City, Laguna.

Barangays	Families
Brgy 1	66
Brgy 2	216
Brgy 5	122
Brgy 6	33
Brgy 7	113
Bubuyan	6
Kay anlog	39
Lingga	14
Makiling	39
Palingon	11
Parian	26
Real	219

San juan	55
Sanpiruhan	50
Tulo	71
Turbina	172
Ulanggo	5
TOTAL	**1,257**

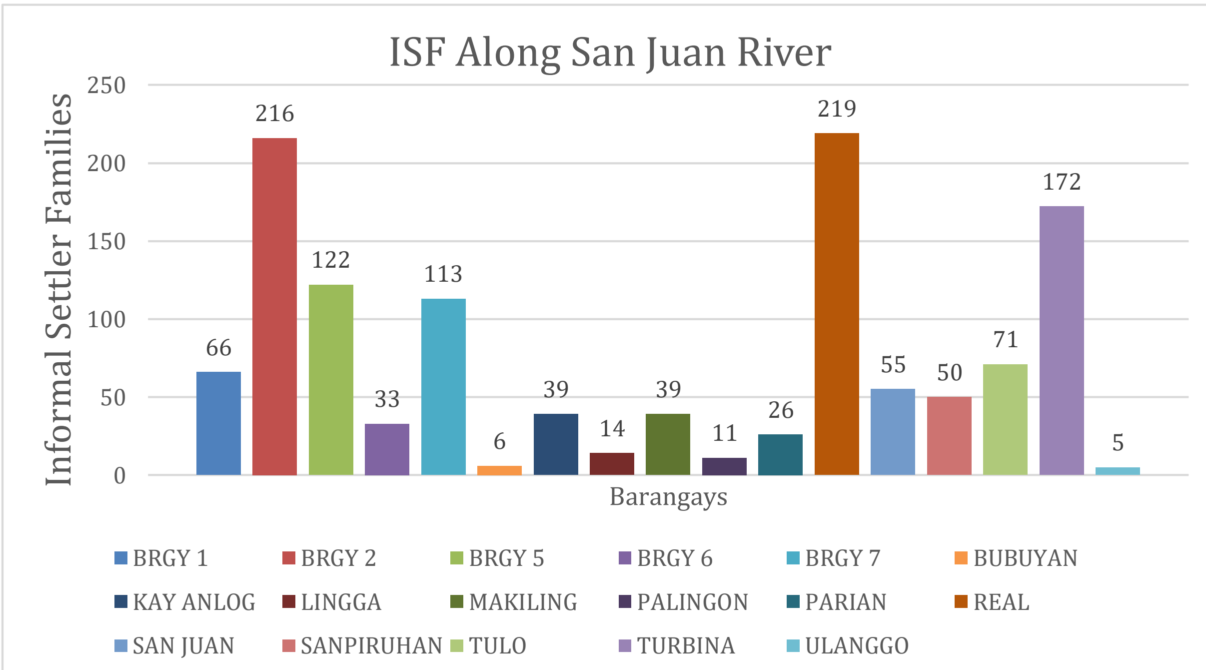

Figure 72. Distribution of informal settler families (ISF) in different villages (barangays) along San Juan River.

Among the barangays of Calamba City within the catchment of San Juan River, Real has the highest number of ISFs with 219 followed by Brgy. 2 with 216 (Figure 72). Brgy. Ulanggo has the lowest ISFs population with only five (5) families.

B. San Cristobal River

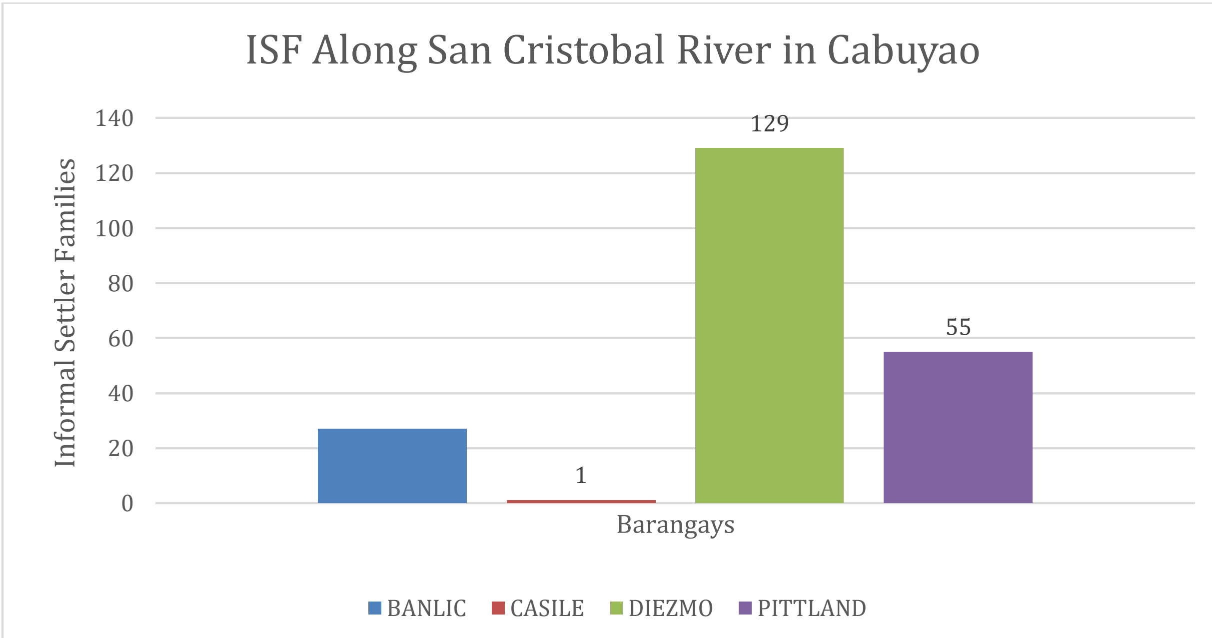

Figure 73. Distribution of informal settler families (ISF) along the riverbank of San Cristobal River in the five (5) barangays of Cabuyao Laguna covered by San Cristobal River.

Meanwhile, there are four (4) identified barangays of Cabuyao Laguna within San Cristobal River with presence of ISFs along the easement of the river. Brgy. Diezmo has the highest ISF population with 129 families followed by Brgy. Pittland with fifty-five (55). Brgy. Casile has the lowest with only one identified ISF (Figure 73).

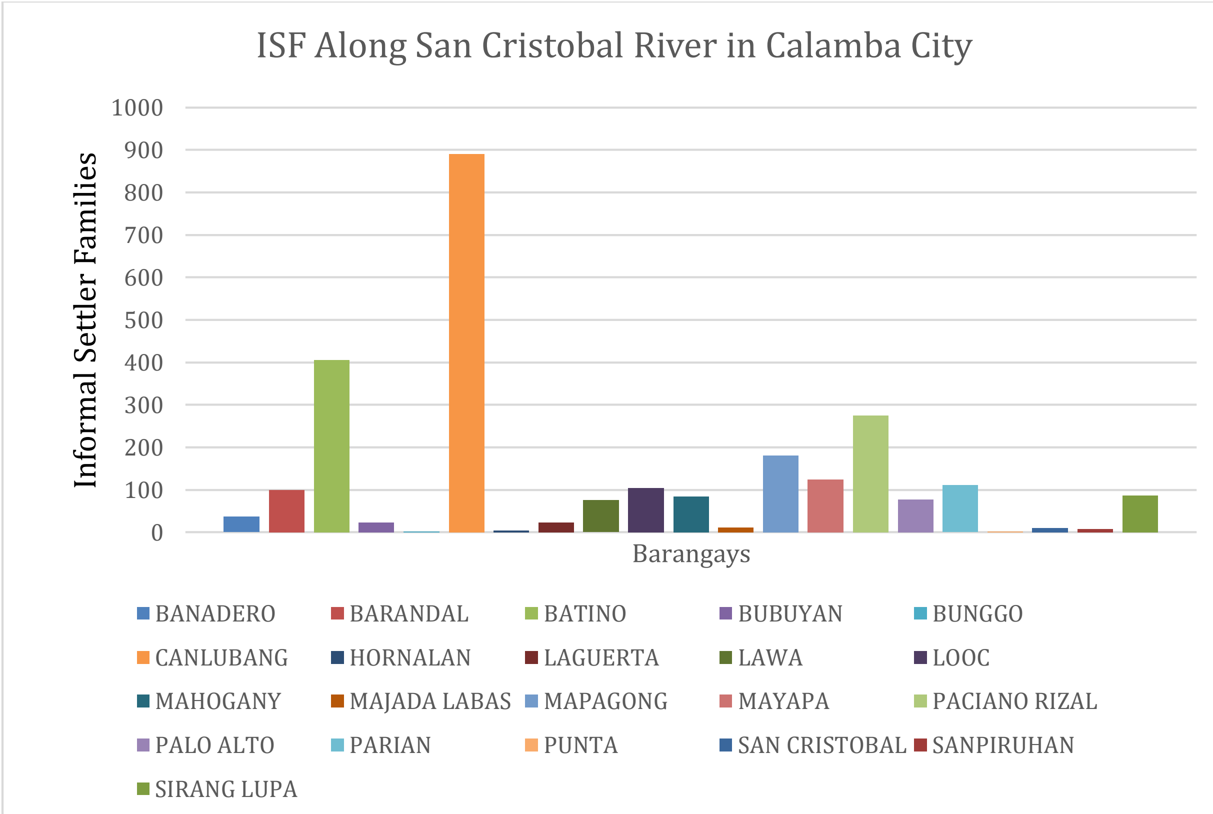

Figure 74. Distribution of informal settler families (ISF) along the riverbank of San Cristobal River in the twenty-six (26) barangays of Calamaba City, Laguna covered by San Cristobal River.

For Calamba City, there are twenty-six (26) barangays identified with ISFs. Brgy. Canlubang has the highest with 891 families followed by Brgy. Batino with 406 families (Figure 57).

C. Saran River

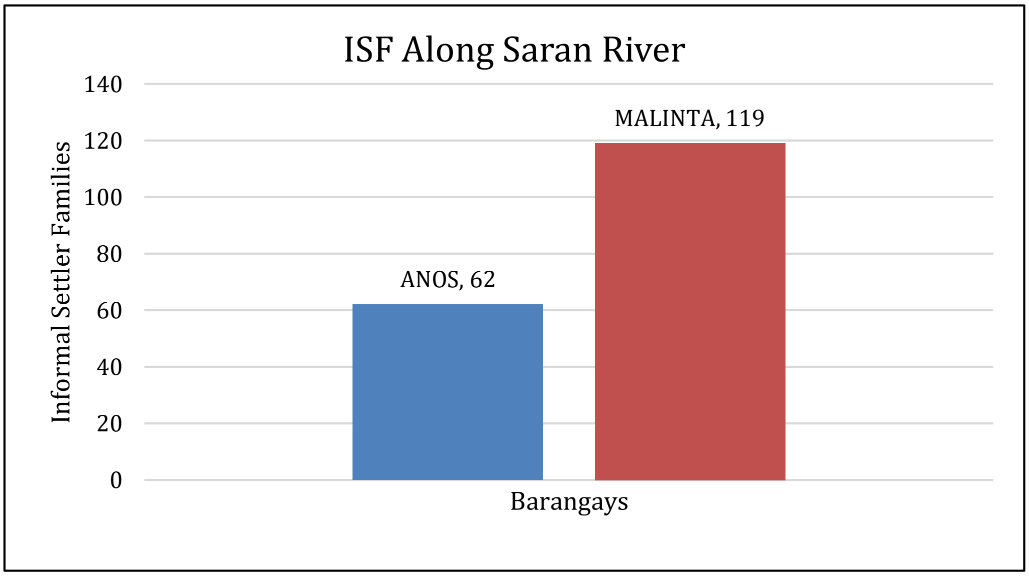

Figure 75. Distribution of informal settler families (ISF) along the riverbank of Saran River in Los Baños Laguna.

There two barangays within the cathment of Saran River with the presence of ISFs. Brgy. Malinta has the highest with 119 ISFs while Brgy. Anos has sixty-two (62) (Figure 75).

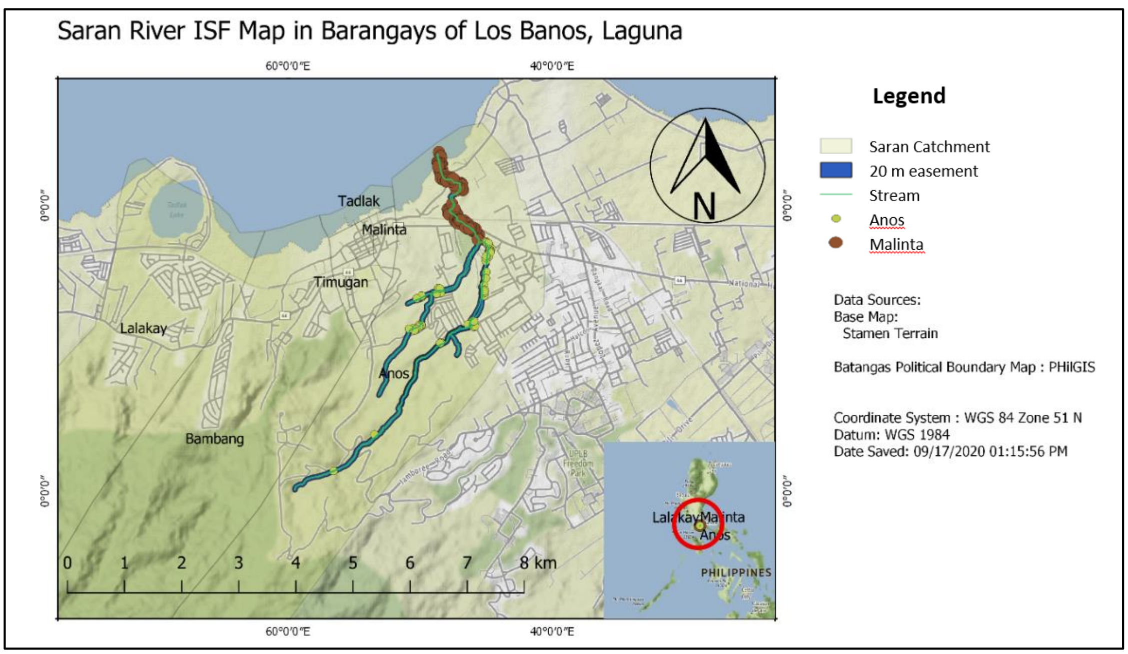

Figure 76. ISF Maps along Saran River in Los Baños, Laguna.

7. Piggeries and Poultries

The swine and poultry industry has long been at the forefront of livestock production development in the Philippines particularly in CALABARZON region including Laguna province. Around 30% is backyard production and is spread more evenly around the Philippines. The number of pigs sold/sows/year is required to increase from 18.8 in 2015 to 30 in 2027. CALABARZON has 1.53 million heads of swine.

Table 63. Status of piggeries along San Cristobal River based on the survey of DENR Laguna.

Specific Location	No.of piggery surveyed							No. poultry surveyed
	ECC/CNC		Discharge permit		Septic tank		Total	
	With	Without	With	Without	with	Without		
Brgy. Canlubang, Calamba City	0	0	0	0	0	0	0	0
Brgy. Looc, Calamba City	0	3	0	3	0	3	3	0
Brgy Uwisan, Calamba City	0	12	0	12	0	12	12	3
Brgy. Banlic, Calamba City	0	8	0	8	0	8	8	0
Brgy. Batino, Calamba City	0	0	0	0	0	0	0	0
Brgy. Sirang Lupa, Calamba City	0	0	0	0	0	0	0	0
Brgy. Majada Out, Calamba City	0	0	0	0	0	0	0	0
Brgy. San Cristobal, Calamba City	0	4	0	4	3	1	4	0
Brgy. Mayapa, Calamba City	0	0	0	0	0	0	0	0
Brgy. Mapagong	0	0	0	0	0	0	0	0
Total	**0**	**27**	**0**	**27**	**3**	**24**	**0**	**0**

Phosphorus and nitrogen levels are the two pollutants from improper piggery and poultry disposal. At high concentrations, these pollutants encourage algal growth which reduces dissolved oxygen when decomposed by bacteria. Sludge also often contains pathogens such as salmonella, e coli, and pharmaceuticals like antibiotics. Larger piggery farms usually have retaining ponds to avoid the direct flow of sludge to the stream network. Biogas digest is often integrated into the waste management system to utilize the methane from decomposing organic matter.

Small and backyard swine raisers however cannot afford the cost for construction, maintenance, and management of retaining pond and biogas digester. Although viewed as a small and insignificant contributor, these backyards and small-scale piggery and poultry become significant contributors when combined. Direct runoff and spills from the retaining pond and lagoons are the most common sources of pollution.

There are 27 piggeries surveyed are not compliant to have ECC/CNC and discharge permit and only 3 piggeries out of 27 piggeries have their own septic tank. The highest number of piggeries found along the San Cristobal river are found in Brgy. Uwisan followed by Brgy. Banlic and Brgy. San Cristobal. There are 3 poultry farms are also found in Brgy. Uwisan (Table 63).

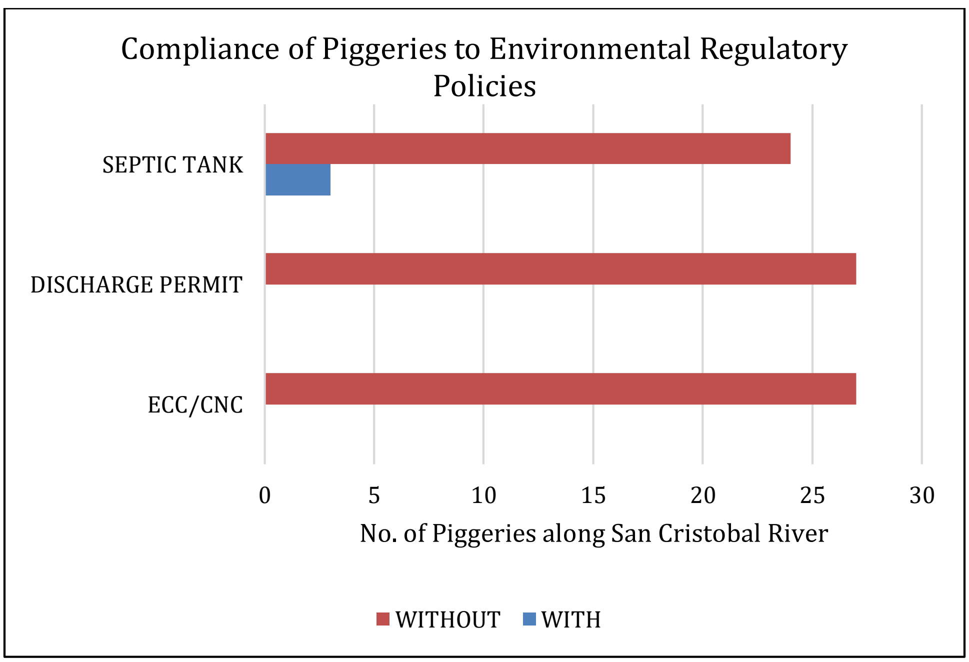

Figure 77. Level of compliance to environmental regulatory policies of piggeries along San Cristobal River based on the survey of DENR Laguna.

Table 64. Status of piggeries along Saran River based on the survey of DENR Laguna.

Specific Location	No.of piggery surveyed							No. poultry surveyed
	ECC/CNC		Discharge permit		Septic tank		Total	
	With	Without	With	Without	with	Without		
Brgy. Anos, Los Baños	0	1	0	1	0	1	1	1
Total	**0**	**1**	**0**	**1**	**0**	**1**	**1**	**1**

There is only 1 piggery surveyed in Brgy. Anos. The piggery is not compliant to ECC/CNC nor having a discharge permit and it has no septic tank for waste generated. In the same barangay, only 1 poultry farm was surveyed (Table 64).

8. Wastewater Pipes and Canals from Households directly draining to the River

Quantifying the volume of this type of water waste is very challenging due to the extent of sources. This effluent can come from communities located in proximity to the stream channel and from within inland areas. Originally considered as a point source, they conglomerate into the sewer and eventually end up into steam in diffuse form.

Kitchen wastewater, soap, and detergents are the most common contaminants carried on these effluents. This contaminant contains high amounts of phosphorous and nitrogen which can increase nutrients in the water. This condition encourages rapid algal growth which can lead to hypoxia upon decomposition. Household wastewater of inland communities mostly drains through the canals and conglomerate to the main sewer before reaching the stream. In the absence of a treatment plant which is usually common in a developing country, this effluent usually reaches streams and water bodies untreated.

For communities located near the riverbank, pipes and canals usually drain directly to the river. This effluent may have higher concentrations since it directly drains from the source to the water body and has not undergone any degradation or absorption by bacteria and aquatic plants during transport as compared to those from inland sources. This is the most common for the informal settler families (ISFs) and other legal occupants located within the prescribed easement or riparian areas.

Table 65. Waste-water disposal status of ISFs along San Cristobal River based on the survey of DENR Laguna.

Specific location	**No. of ISF surveyed**						
	Wastewater pipes/ canals		**Septic tank**		**Waste segregation**		**Total**
	Directly draining	**Indirectly draining**	**With**	**Without**	**Practicing**	**Not practicing**	
Brgy. Canlubang, Calamba City	0	0	0	0	0	0	0
Brgy. Looc, Calamba City	0	0	0	0	0	0	0
Brgy Uwisan, Calamba City	24	0	0	24	0	24	24
Brgy. Banlic, Calamba City	71	0	71	0	0	71	71
Brgy. Batino, Calamba City	113	0	113	0	0	113	113
Brgy. Sirang Lupa, Calamba City	0	0	0	0	0	0	0
Brgy. Majada Out, Calamba City	0	0	0	0	0	0	0

Brgy. San Cristobal, Calamba City	611	0	611	0	304	307	611
Brgy. Mayapa, Calamba City	115	0	111	4	0	115	115
Brgy. Mapagong, Calamba City	620	0	0	620	0	620	620
Brgy. Parian, Calamba City	0	0	0	0	0	0	0
Total	**1554**	**0**	**906**	**648**	**304**	**1250**	

There are 1,554 ISFs surveyed has found directly draining their wastewater to San Cristobal River. The highest contributors are found in Brgy. Mapagong with 620 followed by Brgy. San Cristobal with 611, Brgy. Mayapa with 115, Brgy. Batino with 113, Brgy. Banlic with 71, and Brgy. Uwisan with 24 (Table 65).

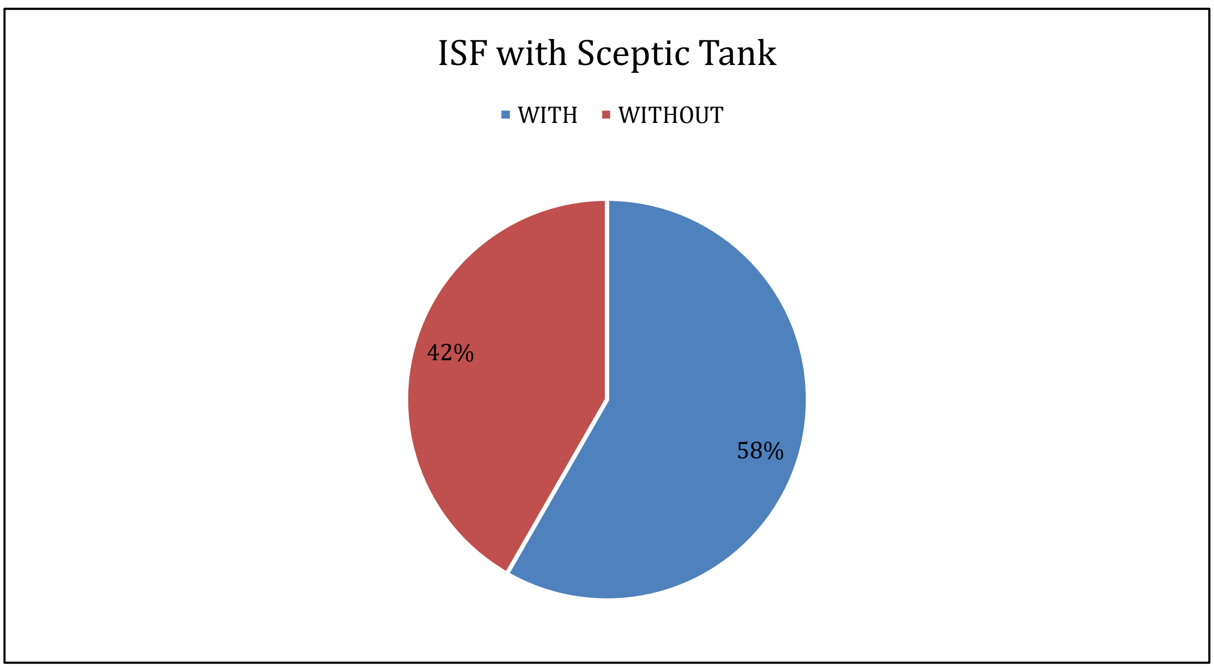

Figure 78. Propotion of ISF population with the septic tank along San Cristobal River.

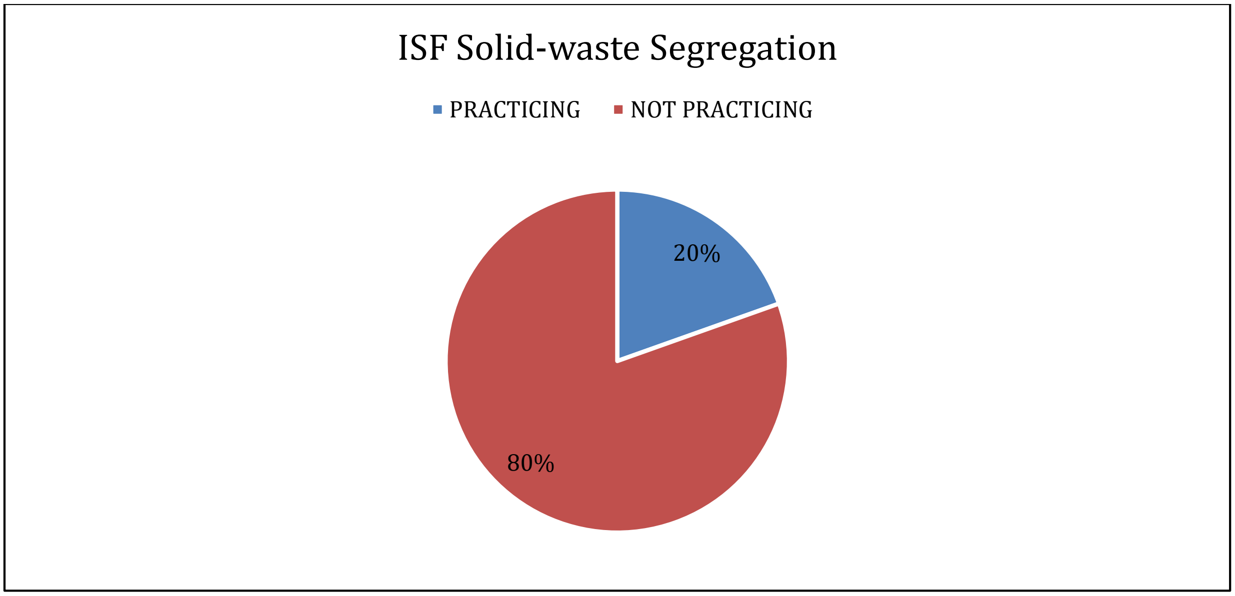

Figure 79. Propotion of ISF population in terms of solid-waste segregation along San Cristobal River.

Table 66. Waste-water disposal status of ISFs along Saran River based on the survey of DENR Laguna.

Specific location	**No. of ISF surveyed**						
	Wastewater pipes/ canals		**Septic tank**		**Waste segregation**		**Total**
	Directly draining	**Indirectly draining**	**With**	**Without**	**Practicing**	**Not practicing**	
Brgy. Malinta, Los Baños	0	0	0	0	0	0	0
Brgy. Anos, Los Baños	58	0	0	58	58	0	58
Total	**58**	**0**	**0**	**58**	**58**	**0**	**58**

In terms of number of presence of septic tank, 58% of ISF are with septic tank and 42% without are septic tank. The highest number of ISF with septic tank are found in the Brgy. San Cristobal with 611 followed by Brgy. Batino with 113, Brgy. Mayapa with 111, and Brgy. Banlik 71.

9. Non-Point Pollution Sources (NPS) along the River System

Non-point pollution source is pollution that comes from extensive sources, unlike point source which results from a single source. Surface run-off, seepage, and deposition are the primary process that carries pollutants from various sources like agricultural areas, urban and suburban areas, highway, and even forestry and mining. Controlling non-point pollution sources is very difficult because it usually comes from everyday activities and originating from very wide and diverse sources. Agricultural activities such as soil tillage and fertilization are considered to be the primary sources of non-point pollution source. Urban and highway run-off in the form of stormwater washed-off from parking lots, roads and highways, and lawns are also significantly contributing to this pollution type.

NPS can be categorized into sediment, nutrients, toxic contaminants, and chemicals. Sediment includes silt and suspended solids. A high concentration of this can cause turbidity in water bodies reducing the amount of light affecting its aquatic ecology. Nutrients mainly refer to inorganics matter originating from livestock, landfills, and croplands. Of these, nitrogen and phosphorus are the primary pollutants. These two inorganics can encourage excessive algal growth at very high concentrations. During bacterial decomposition, dissolved oxygen can drop critically making it hypoxia. This condition is detrimental to fish and aquatic organisms, particularly for vertebrates. Toxic chemicals include lead, mercury, zinc, and cadmium, polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs), fire retardants, and other substances while toxic chemicals which include organic and inorganic compounds like DDT, acids, and salts can threaten the health of both humans and aquatic organisms. Pathogens are bacteria and viruses which contaminate runoff due to poorly manage livestock, faulty septic tank, poorly maintained sewers, and sanitary sewer overflows.

NPS is very difficult to measure and monitor, hence selected parameters are used to measure and estimate the level of pollution. NPS modeling is now becoming an effective tool to estimate NPS loadings. This, however, needs sufficient observed data to calibrate modeling parameters and validate results. For this characterization, the Soil and Water Assessment Tool (SWAT) model was used to estimate the NPS generation of the watershed. Primary model inputs are topography in the form of digital elevation model (DEM), soil data, observed weather data, and land cover. Below are the tables showing the average annual sediment yield, organic nitrogen yield, and organic phosphorus yield of each barangay within the catchment of San Juan River in Calamba City, Laguna.

A. San Juan River

a. Sediment yield

Table 67. Estimated sediment yield of different land uses within the 31 barangays of Calamba City, Laguna.

Barangay	**Average Sediment Yield (tons/ha)**
Banadero	6,970
Barandal	6,970
Barangay 1	6,970
Barangay 2	6,970
Barangay 3	6,970
Barangay 4	6,970
Barangay 5	6,970
Barangay 6	6,970
Barangay 7	6,970
Bubuyan	513
Bunggo	513
Burol	513
Camaligan	1,212
Kay-Anlog	4,424
Lawa	6,970

Lecheria	6,970
Lingga	6,970
Looc	6,970
Makiling	5,001
Palingon	6,970
Parian	6,970
Prinza	6,970
Punta	3,742
Real	6,970
Saimsim	697
Sampiruhan	6,970
San Jose	6,970
San Juan	6,970
Tulo	8,225
Turbina	6,970
Ulango	4,593
Grand Mean	**5,626**

The average sediment yield in 31 barangay of San Juan River in Laguna is 5,626 tons/ha. Barangay Tulo has the highest contribution with 8,225 tons/ha and the lowest contribution with only 513 tons/ha are found in barangays of Bubuyan, Bunggo, Burol. As observed the larger areas for cultivation and other land uses may yield higher distribution of sediments. Sediments in the river ecosystem are similar to soil in the terrestrial ecosystem as they are the source of substrate nutrients and micro and macro flora and fauna that are the basis of support to living aquatic resources. Decreasing of fish resources, loss of wetlands, changes in balance nutrients, increases in turbidity, and coastline alteration are among the impacts of sedimentation in the environment.

b. Organic nitrogen

Table 68. Estimated organic nitrogen yield of different land uses within the 31 barangays of Calamba City, Laguna.

Barangay	Average organic nitrogen yield (kg/ha)
Banadero	13
Barandal	13
Barangay 1	13
Barangay 2	13
Barangay 3	13
Barangay 4	13
Barangay 5	13
Barangay 6	13
Barangay 7	13
Bubuyan	29
Bunggo	29
Burol	29
Camaligan	29
Kay-Anlog	25
Lawa	13
Lecheria	13
Lingga	13
Looc	13
Makiling	25
Palingon	13
Parian	13
Prinza	13
Punta	21
Real	13
Saimsim	20
Sampiruhan	13

San Jose	13
San Juan	13
Tulo	22
Turbina	13
Ulango	27
Grand mean	**18**

The organic nitrogen yield in thirty-one (31) barangays of San Juan River in Calamba City has an average total of 18 tons/ha. Barangays of Bubuyan, Bunggo, Burol, Calamigan and Kay-Anlog has the highest organic nitrogen yield with 29 tons/ha and there are 16 barangays shows lowest organic nitrogen yield with only 13 tons/ha. Organic nitrogen (Norg) plays a key role in soil N cycling and crop production and it is an important constituent of soil organic matter (SOM). As observed the areas with agricultural and cultivated land uses contributes to high yield of nitrogen.

c. Organic phosphorus

Table 69. Estimated organic phosphorus yield of different land uses within the 31 barangays of Calamba City, Laguna.

Barangay	**Average organic phosphorus yield (kg/ha)**
Banadero	2
Barandal	2
Barangay 1	2
Barangay 2	2
Barangay 3	2
Barangay 4	2
Barangay 5	2
Barangay 6	2
Barangay 7	2
Bubuyan	4
Bunggo	4
Burol	4

Camaligan	3
Kay-Anlog	4
Lawa	2
Lecheria	2
Lingga	2
Looc	2
Makiling	3
Palingon	2
Parian	2
Prinza	2
Punta	3
Real	2
Saimsim	3
Sampiruhan	2
San Jose	2
San Juan	2
Tulo	3
Turbina	2
Ulango	4
Grand mean	**3**

In terms of average organic phosphorous, thirty-one (31) barangays of San Juan River in Calamba City have an average total of three (3) tons/ha. Barangays of Bubuyan, Bunggo, Burol, Ulanggo and Kay-Anlog have the highest organic phosphorous yield averaging four (4) tons/ha. On the other hand, twenty-one (21) barangays has lower organic phosphorous yield with only two (2) tons/ha (Table 69).

B. San Cristobal River

a. Sediment yield

Table 70. Estimated sediment yield of sub-basins in the five (5) barangays of Cabuyao Laguna based on landuse, topography, soil, and precipitation.

Barangay	**Average of Sediment yield (tons/ha)**
Banlic	431
Casile	413
Diezmo	445
Pittland	646
San Isidro	431
Grand Mean	**496**

The average annual sediment yield of the five (5) barangays of Cabuyao Laguna within the catchment of San Cristobal River is 496 tons/ha. Among these barangays, Pittland has the highest with 646 tons/ha followed by Barangay Diezmo with 445 tons/ha. Meanwhile, Barangay Casile has the lowest estimated sediment yield with 413 tons/ha.

Table 71. Estimated sediment yield of sub-basins in the twenty-six (26) barangay of Calamba City based on landuse, topography, soil, and precipitation.

Barangay	**Average of Sediment yield (tons/ha)**
Banadero	151
Barandal	253
Batino	161
Bubuyan	306
Bunggo	500
Burol	347
Canlubang	298
Hornalan	441
Laguerta	359
Lawa	187
Looc	151
Mabato	78
Majada Labas	262
Mapagong	337
Mayapa	178
Paciano Rizal	164
Palo-Alto	282
Parian	180
Prinza	195
Punta	258
Real	241
Sampiruhan	151
San Cristobal	252
San Juan	151
Sirang Lupa	205
Turbina	212
Grand Total	**250**

The estimated average annual sediment yield for the twenty-six (26) barangays of Calamba City within the catchment of San Cristobal is 250 tons/ha. The highest sediment yield was estimated at Barangay Bunggo with 550 tons/ha followed by Barangay Hornalan with 441 tons/ha and Barangay Laguerta with 359 tons/ha. The lowest sediment yield was estimated at Barangay Mabato.

Table 72. Estimated sediment yield of sub-basins in the two barangays of Sta. Rosa City based on landuse, topography, soil, and precipitation.

Barangay	Average of Sediment yield (tons/ha)
Don Jose	141
Santo Domingo	376.625
Grand Mean	**329.5**

Lastly, the average annual sediment yield for the two (2) barangays of Sta. Rosa City is estimated to be 329.5 tons/ha. Between the two barangays, Sto. Domingo can generate higher sediment of up to 376.6 tons/ha compared with Don Jose with only 141 tons/ha.

a. Organic nitrogen

Table 73. Estimated organic nitrogen yield of sub-basins in the five (5) barangays of Sta. Rosa City based on landuse, topography, soil, and precipitation.

Barangay	Average of Organic N (kg/ha)
Banlic	13
Casile	27
Diezmo	14
Pittland	25
San Isidro	13
Grand Mean	**22**

In terms of the average annual organic nitrogen yield, it was estimated that the five (5) barangays of Sta. Rosa City within San Cristobal watershed can generate 22 kg/ha. Similar to other non-point source pollutants, Barangay Casile estimate to generate the highest with

27 kg/ha followed by Barangay Pittland with 25 kg/ha. The two (2) barangays of Banlic and San Isidro have the lowest estimate with 13 kg/ha.

Table 74. Estimated organic nitrogen yield of sub-basins in the twenty-six (26) of Calamba City based on landuse, topography, soil, and precipitation.

Barangay	**Average of Organic N (kg/ha)**
Banadero	8
Barandal	25
Batino	16
Bubuyan	29
Bunggo	29
Burol	29
Canlubang	23
Hornalan	29
Laguerta	29
Lawa	14
Looc	8
Mabato	25
Majada Labas	26
Mapagong	14
Mayapa	17
Paciano Rizal	12
Palo-Alto	26
Parian	12
Prinza	21
Punta	29
Real	25
Sampiruhan	8
San Cristobal	12

San Juan	8
Sirang Lupa	20
Turbina	27
Grand Mean	**20**

The average annual organic nitrogen yield of the twenty-six (26) barangays of Calamba City within the catchment of San Cristobal watershed is 20 kg/ha. The highest nitrogen yield was estimated from six barangays namely barangays of Babuyan, Bunggo, Burol, Hornalan, Laguerta, and Punta with 29 kg/ha. Meanwhile, the lowest estimated nitrogen yield is at 8 kg/ha from the four (4) barangays of Looc, Sampiruhan, San Juan, and Banadero.

Table 75. Estimated organic ntirogen yield of sub-basins in the two barangays of Sta. Rosa City based on landuse, topography, soil, and precipitation.

Barangay	Average of Organic N (kg/ha)
Don Jose	5
Santo Domingo	20
Grand Mean	**17**

For the two barangays of Sta. Rosa, within the San Cristobal catchment, the overall average annual organic nitrogen yield is 17 kg/ha. Between the two, Barangay Sto. Domingo is higher with 20 kg/ha compared with Barangay Don Jose with only 5 kg/ha.

b. Organic phosphorus

Table 76. Estimated organic phosphorus yield of sub-basins in the five (5) barangays of Cabuyao based on landuse, topography, soil, and precipitation.

Barangay	Average of Organic P (kg/ha)
Banlic	2
Casile	4

Diezmo	2
Pittland	3
San Isidro	2
Grand Mean	**3**

In terms of organic phosphorus, the annual average yield of the five (5) barangay of San Cristobal River in Cabuyao, Laguna is 3 kg/ha. Among the barangays, Casile has the highest organic phosphorus yield with 50 tons/ha followed by Pittland with 3 kg/ha. Meanwhile, Barangay Banlic and San Isidro have lower organic phosphorus yields with 2 kg/ha.

Table 77. Estimated organic phosphorus yield of sub-basins in the twenty-six (26) barangays of Calamba City, Laguna based on landuse, topography, soil, and precipitation.

Barangay	**Average of Organic P (kg/ha)**
Banadero	1
Barandal	4
Batino	2
Bubuyan	4
Bunggo	4
Burol	4
Canlubang	3
Hornalan	4
Laguerta	4
Lawa	2
Looc	1
Mabato	3
Majada Labas	3
Mapagong	2
Mayapa	2
Paciano Rizal	2
Palo-Alto	4

Parian	2
Prinza	3
Punta	4
Real	3
Sampiruhan	1
San Cristobal	2
San Juan	1
Sirang Lupa	3
Turbina	4
Grand Mean	**3**

For the areas of the San Cristobal watershed within Calamba City, the annual average phosphorus yield is at 3 kg/ha. The highest phosphorus yield is at 4 kg/ha. There are nine (9) barangays with this level of output namely Barangays of Babuyan, Bunggo, Burol, Hornalan, Laguerta, Punta, Palo-Alto, Barandal, and Turbina. On the other hand, there are four (4) barangays with the lowest yield of 1 kg/ha. This includes barangays of Banadero, Looc, Sampiruhan, and San Juan.

Table 78. Estimated organic phosphorus yield of sub-basins in the two (2) barangays of Sta. Rosa City based on landuse, topography, soil, and precipitation.

Barangay	Average of Organic N (kg/ha)
Don Jose	1
Santo Domingo	3
Grand Mean	**2**

Lastly, the average annual organic phosphorus yield of two (2) barangay within the catchment of San Cristobal River in Sta Rosa City is 2 kg/ha. The majority of the sediment yield is coming from Barangay Santo Domingo with 3 kg/ha. On the other hand, Barangay Don Jose has a lower organic phosphorus output with only 2 kg/ha (Table 78).

A. Saran River

a. Sediment yield

Table 79. Estimated sediment yield in the four (4) barangays of Los Baños, Laguna based on landuse, topography, soil, and precipitation.

Barangay	**Average of Sediment Yield (tons/ha)**
Anos	642.41
Batong Malake	598.84
Malinta	0.37
Timugan	829.58
Grand Mean	**638.39**

The average annual sediment yield of Saran River catchment 638.39 tons/ha. Barangay Timugan has the highest sediment yield with 829.58 tons /ha followed by Anos with 642. 41tons/ha, while Barangay Malinta has the lowest sediment yield distribution with 0.37 tons/ha.

b. Organic Nitrogen

Table 80. Estimated organic nitrogen yield of sub-basins in the the four (4) barangays of Los Baños, Laguna based on landuse, topography, soil, and precipitation.

Barangay	**Average of Organic N (kg/ha)**
Anos	22.33
Batong Malake	24.50
Malinta	7.00
Timugan	25.18
Grand Mean	**638.39**

In terms of average annual organic nitrogen yield, the Saran River in Los Bańos Laguna is yielding 638.39 kg/ha. Barangay Timugan has the highest output with 25.18 kg/N followed by Barangay Malake with 24.50 kg/ha. The barangay with the lowest output of organic nitrogen is Barangay Malinta with only 7.00 kg/ha.

c. Organic phosphorus

Table 81. Estimated organic phosphorus yield of sub-basins in the four (4) barangays of Los Baños, Laguna based on landuse, topography, soil, and precipitation.

Barangay	**Average of Organic P (kg/ha)**
Anos	2.67
Batong Malake	3.00
Malinta	1.00
Timugan	3.00
Grand Mean	**638.39**

The average annual organic phosphorus yield of four (4) barangay in Saran River in Los Baños Laguna is 638.39 kg/ha. Barangay Batong Malake and Barangay Timugan have the highest phosphorus yield with 3.00 kg/ha followed by Barangay Anos with 2.67 kg/ha (Table 81). Barangay Malinta has the lowest average phosphorus yield with only 1.00 kg/ha.

III. ATTACHMENTS

1. Geo-tagged Photos

A. San Juan River

Figure 80. Hydrologic survey in the monitoring station of the upstream of San Juan River wtihin Calamba City, Laguna.

Figure 81. Capture aerial image of structure along the midstream of San Juan River in Brgy. Parian, Calamba City, Laguna.

Figure 82. Riparian vegetation along the upstream of San Juan River located in Brgy. Milagrosa, Calamba City, Laguna.

Figure 83. Fresh water turtle encountered during biodiversity survey along the stream of San Juan River at Brgy. San Juan, Calamba City, Laguna.

Figure 84. Load of silt created an island along the downstream of San Juan River at Brgy. San Juan, Calamba City, Laguna.

Figure 85. Informal settlers in midstream of San Juan River in Brgy. Parian, Calamba City, Laguna.

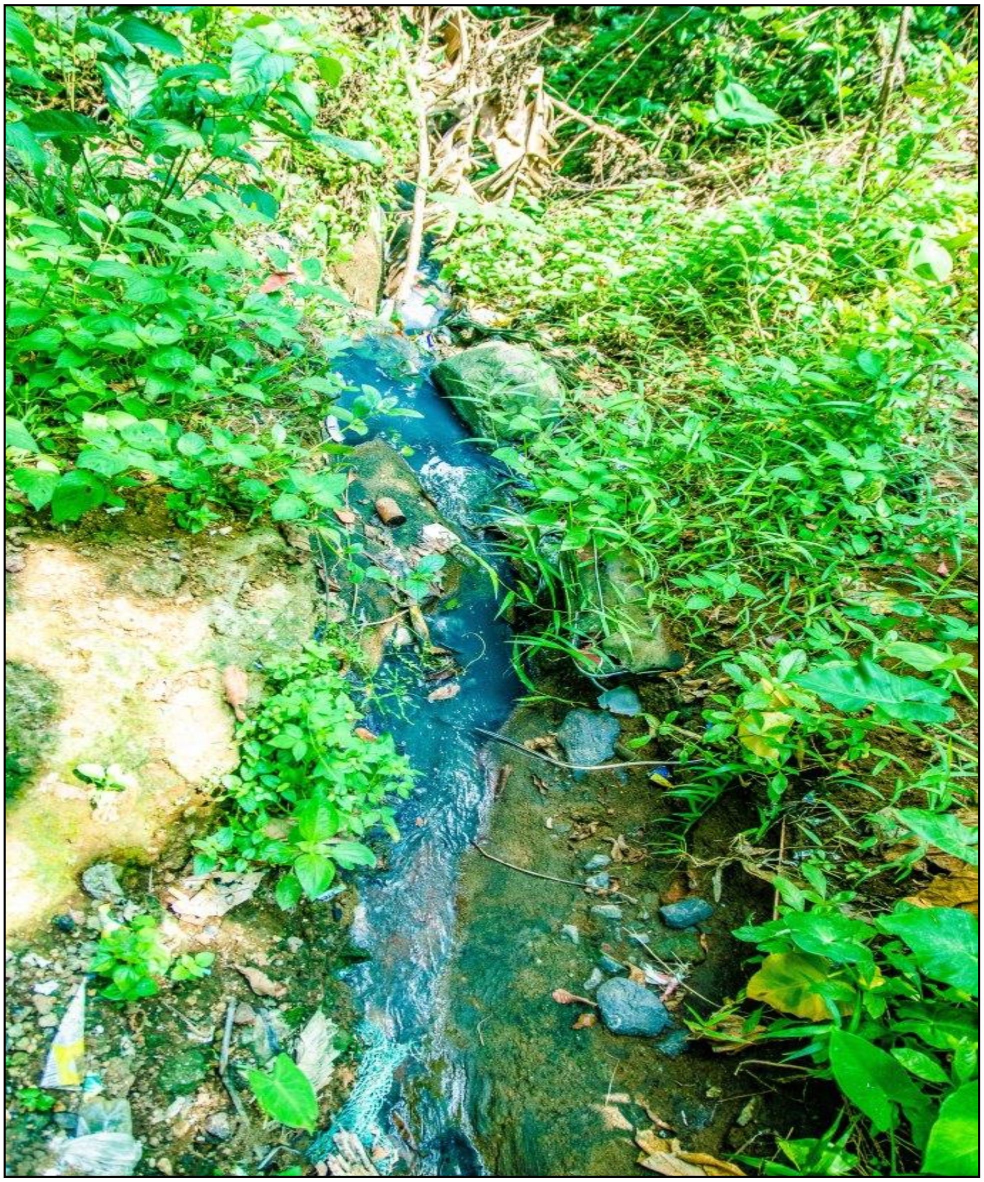

Figure 86. Domestic water waste from informal settlers in San Juan River midstream at Brgy. Parian, Calamba City, Laguna.

Figure 87. Vegetation in San Juan River midstream at Brgy. Parian, Calamba City

B. San Cristobal River

Figure 88. Measuring streamflow depth and velocity in the upstream of Diezmo, Cabuyao, Laguna.

Figure 89. Plant diversity along the upstream of San Cristobal River in Barangay Diezmo, Cabuyao Laguna.

Figure 90. Water flow in the upstream of San Cristobal River in Brgy. Diezmo, Cabuyao, Laguna.

Figure 91. Measuring the stream depth and velocity in the midstream at San Cristobal River.

Figure 92. Drone shot of Informal Settler Families (ISFs) along the midstream of San Cristobal River

C. Saran River

Figure 93. Measuring of cross-sectional area and streamflow in the upstream of Saran River.

Figure 94. Vegetation cover along the upstream of Saran River in Brgy. Timugan, Los Baños, Laguna.

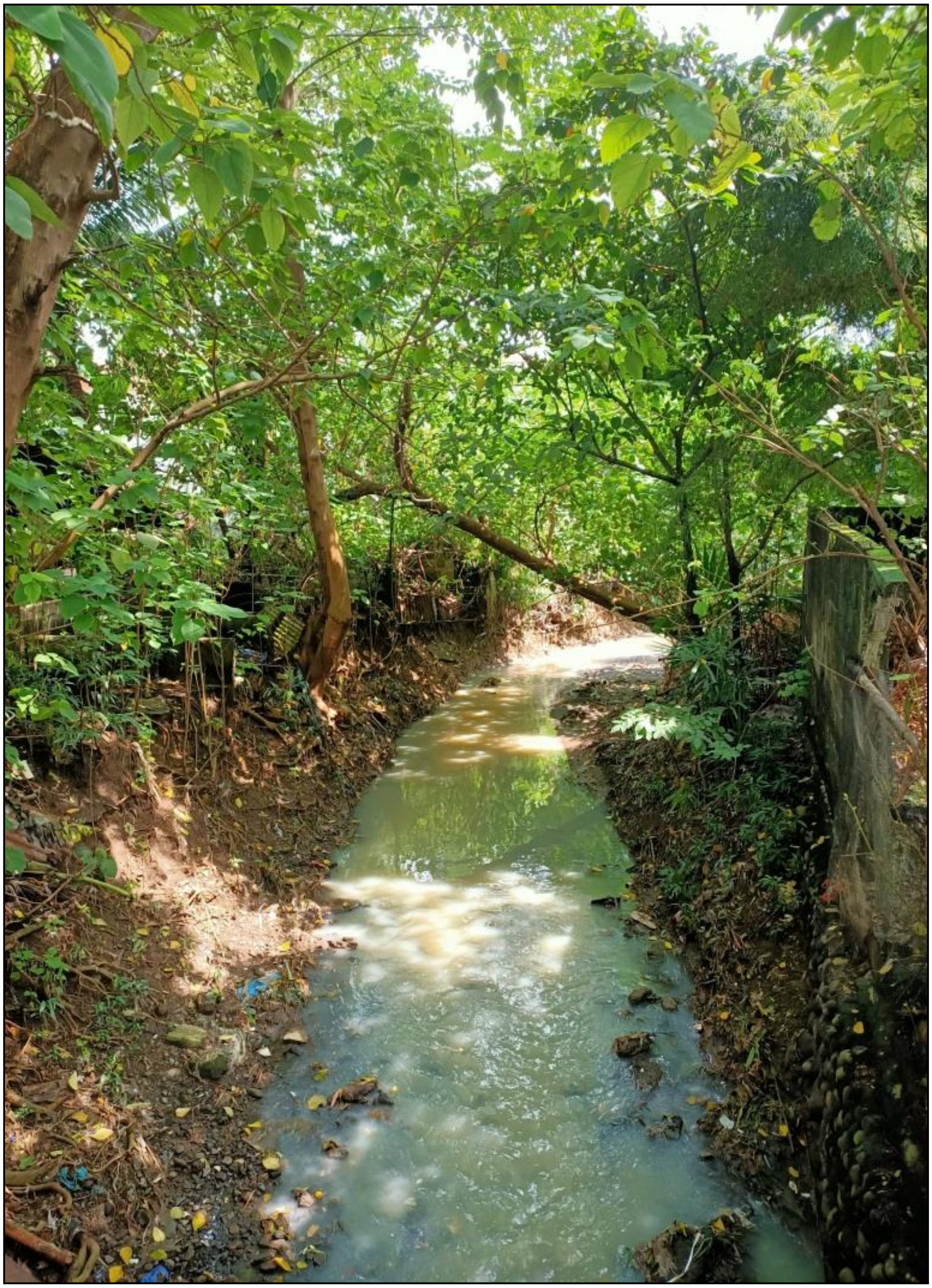

Figure 95. Turbid water flow in Saran River at Brgy. Malinta, Los Baños, Laguna.

Figure 96. Settlers along midstream of Saran River in Brgy. Malinta, Los Baños, Laguna.

Figure 97. Domestic waste draining along the midstream of Saran River in Brgy. Anos, Los Baños, Laguna.

Figure 98. Measuring the stream flow depth and velocity along the midstream of Saran River in Brgy. Anos, Los Baños, Laguna.

Figure 99. Screened debris of solid waste in the midstream of Saran River and turbid water flow at Brgy. Anos, Los Baños, Laguna.

Figure 100. Aerial photo of ISFs along the downstream of Saran River in Brgy. Malinta, Los Baños, Laguna.

2. Maps

Sediment Yield Rate in San Juan River Catchment Maps

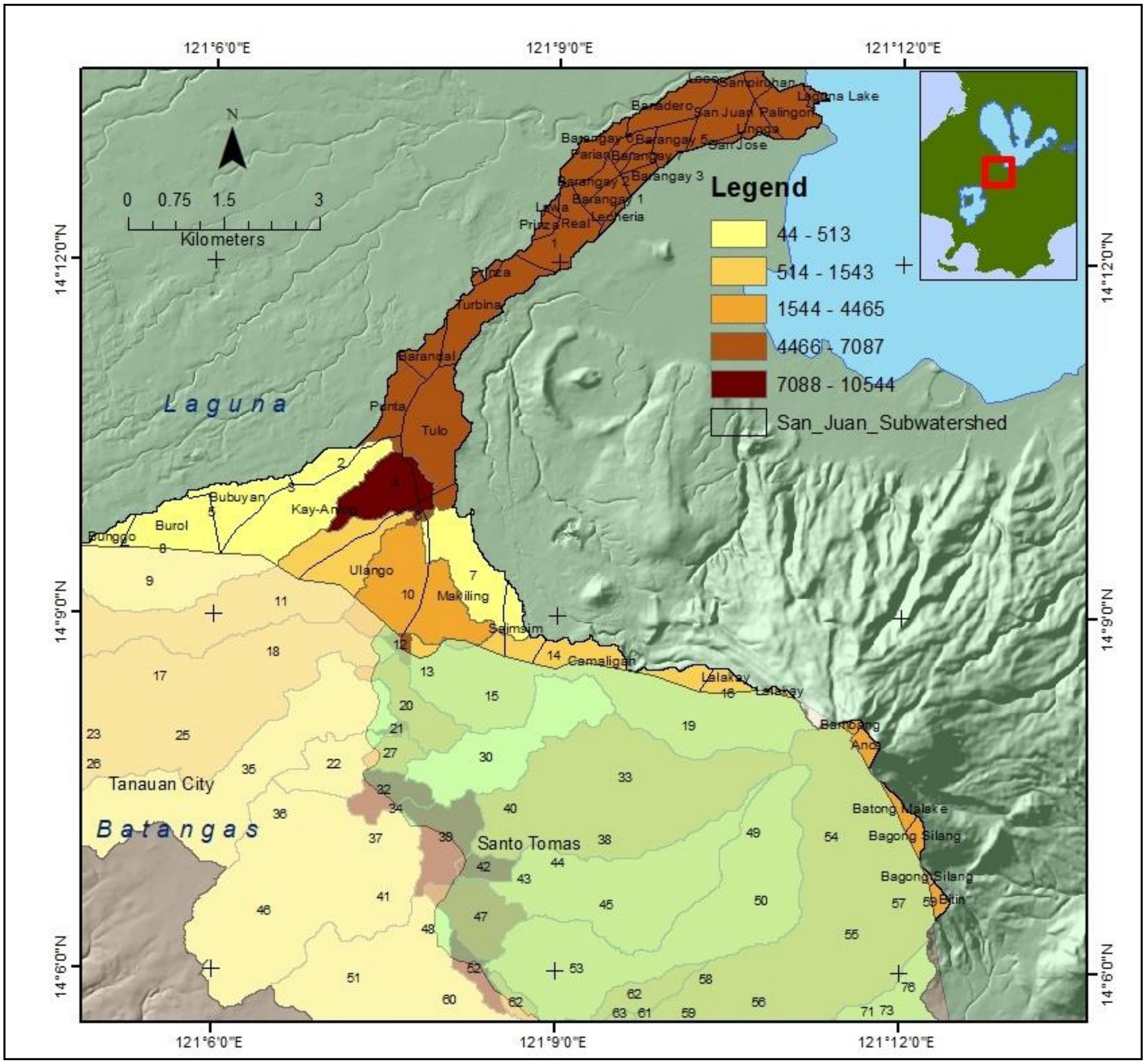

Figure 101. Sediment yield map within catchment of San Juan River in Laguna Province.

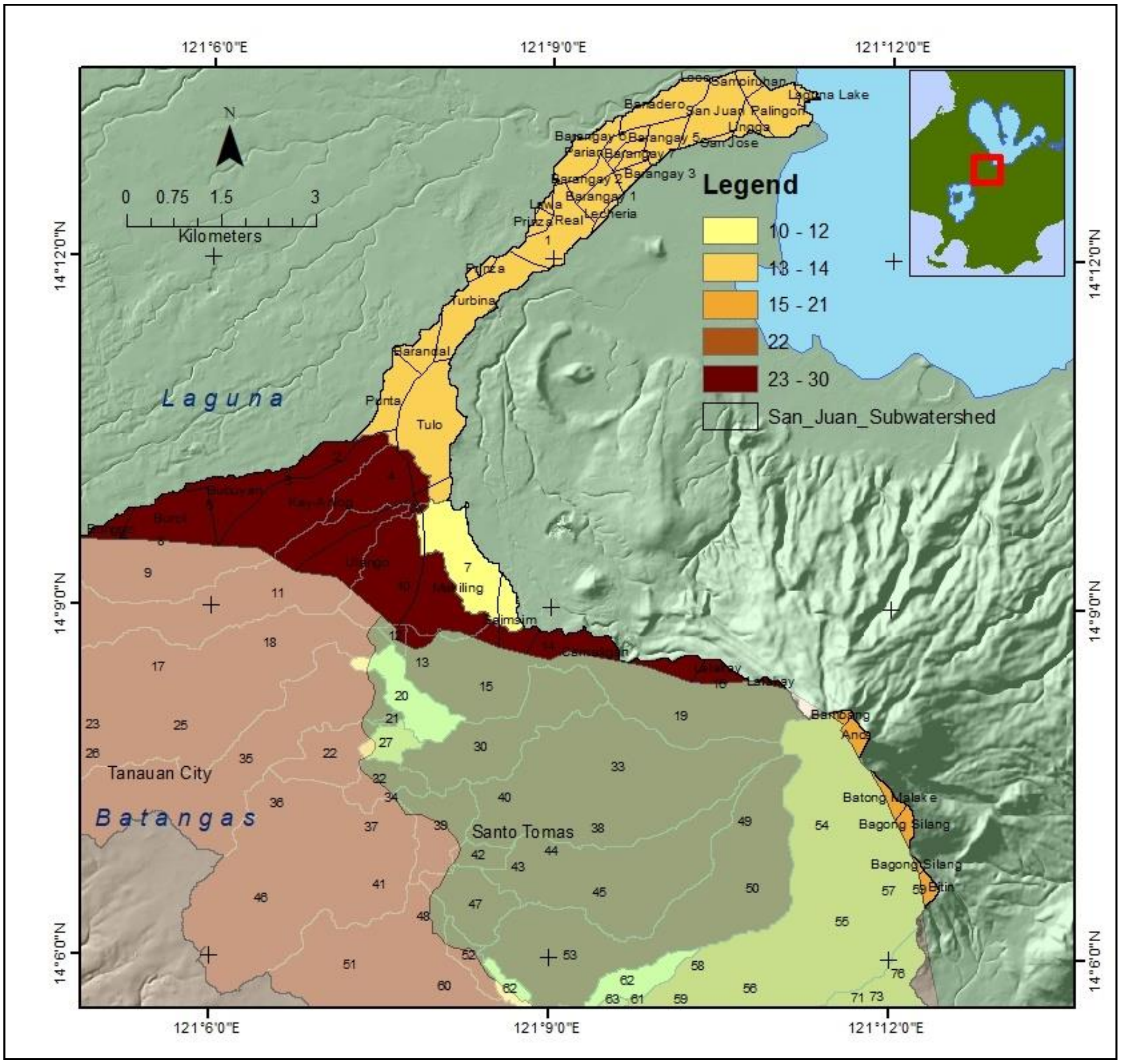

Figure 102. Rate of organic nitrogen yield was transported with sediment into the reach during the time step.

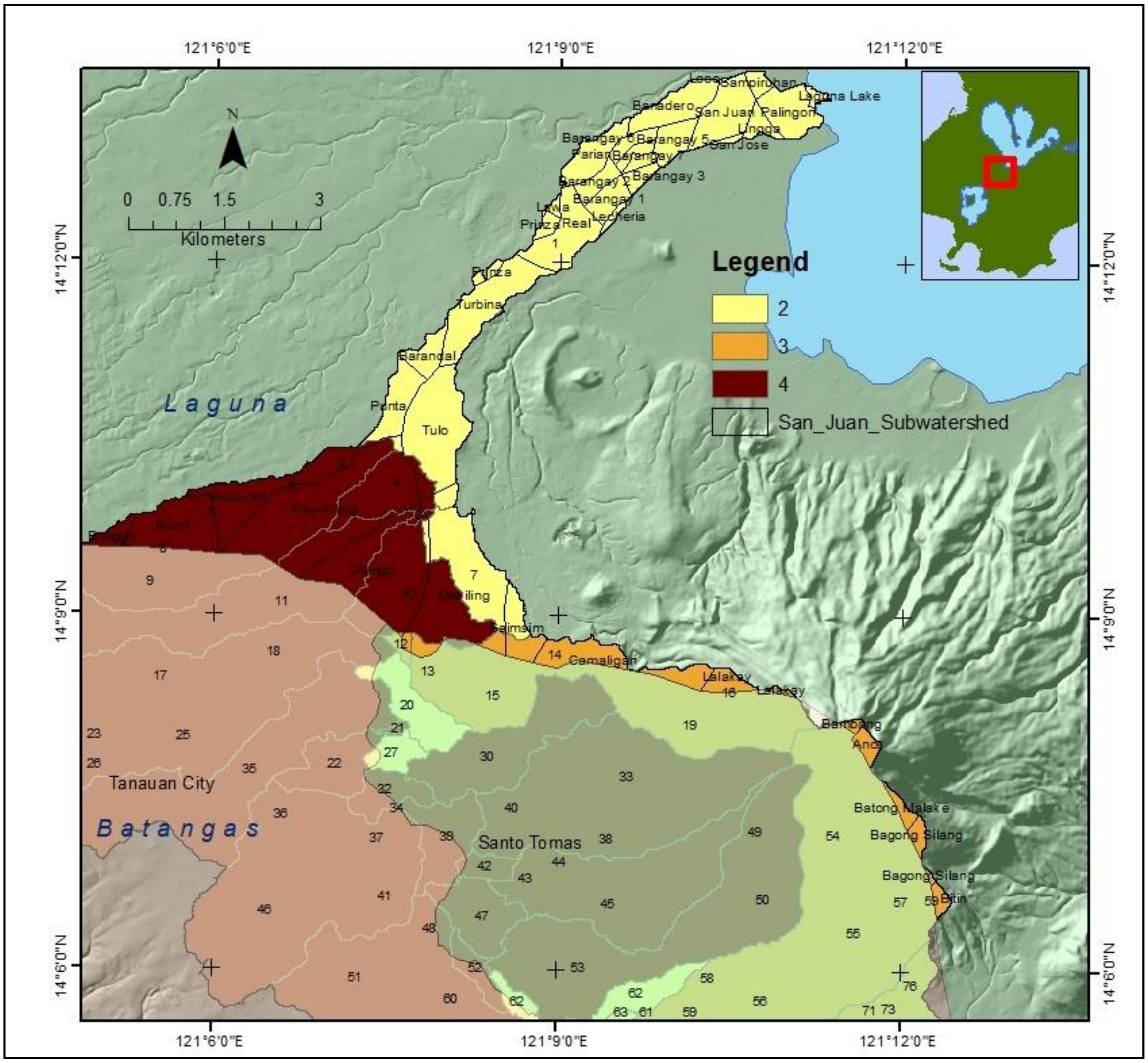

Figure 103. Rate of organic Phosphorus yield transported with sediment into the reach during the time step.

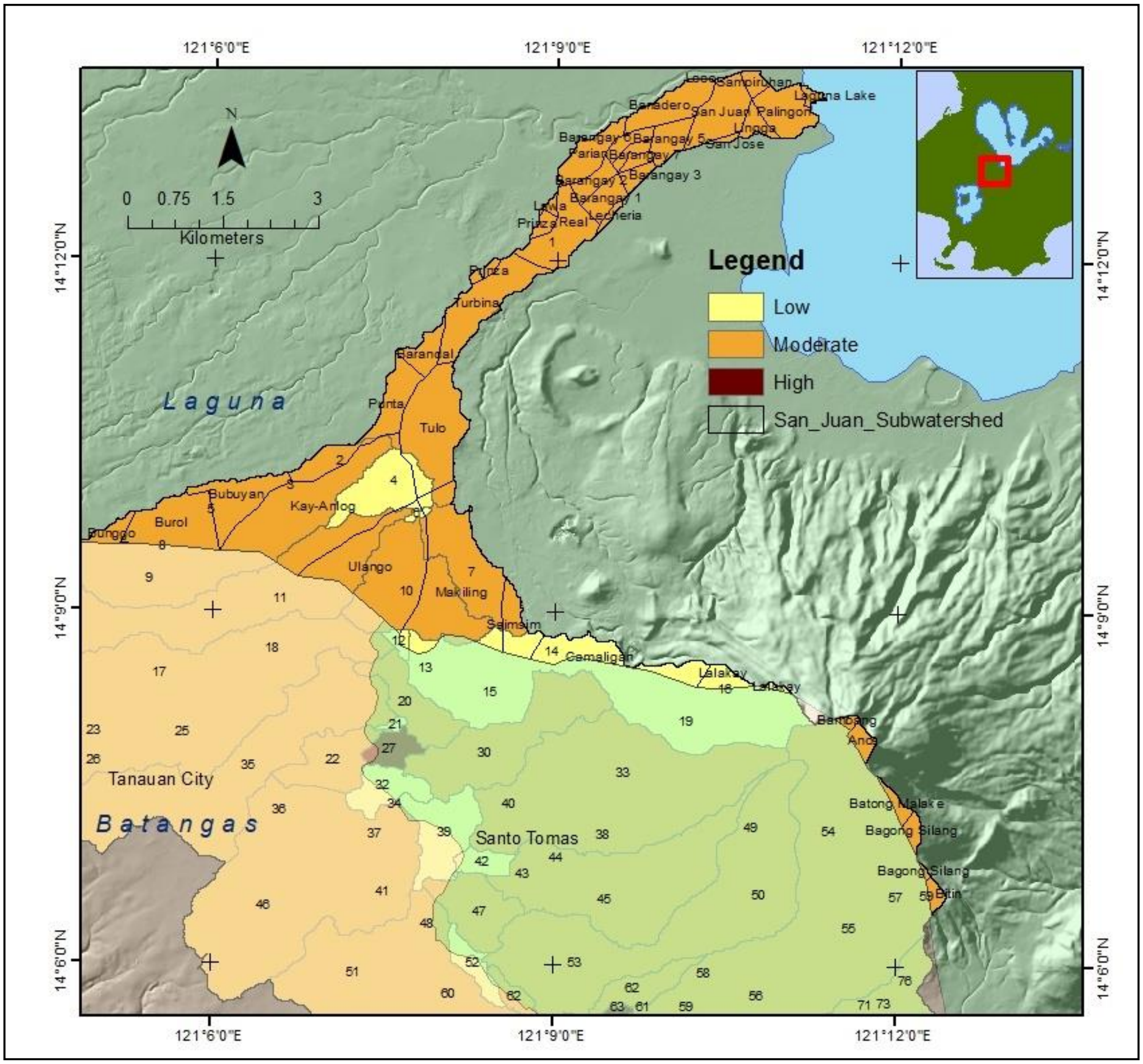

Figure 104. Rate of NO3 in surface runoff (kg N/ha) with San Juan River catchment in Laguna Province.

A. San Juan River

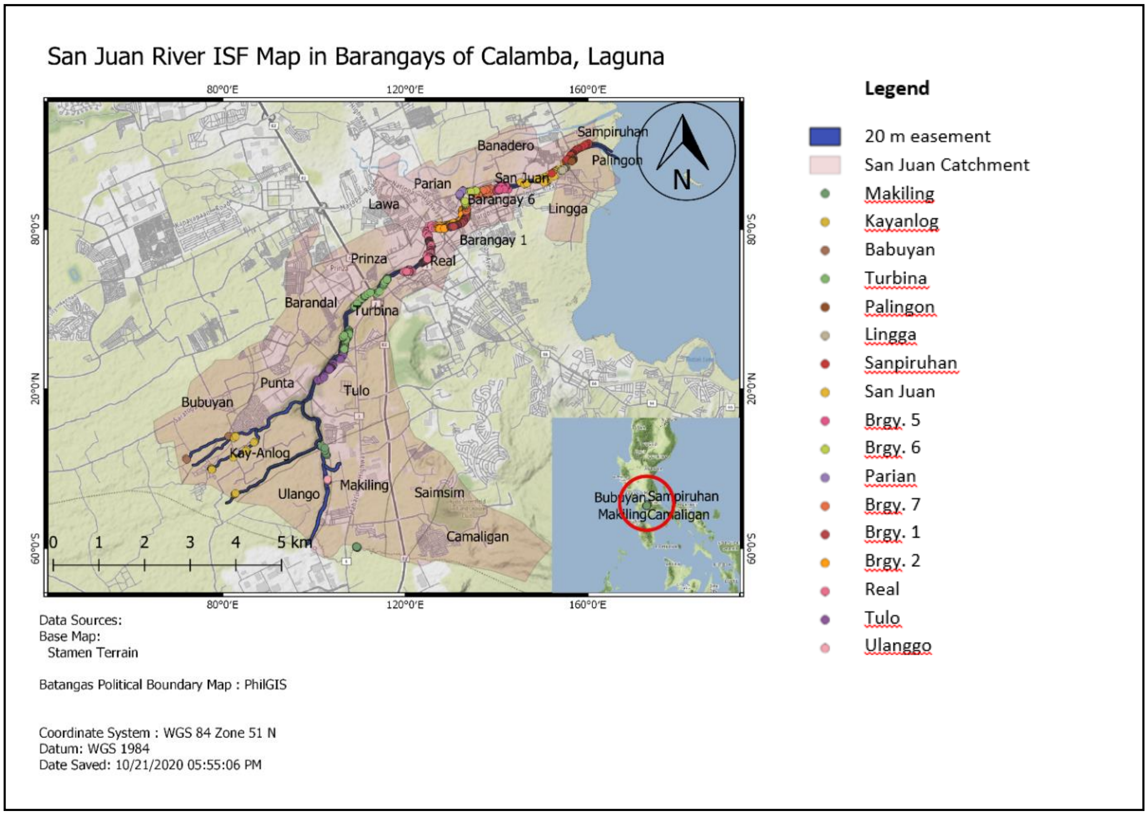

Figure 105. ISF Maps along San Juan River in Laguna Province

B. San Cristobal River

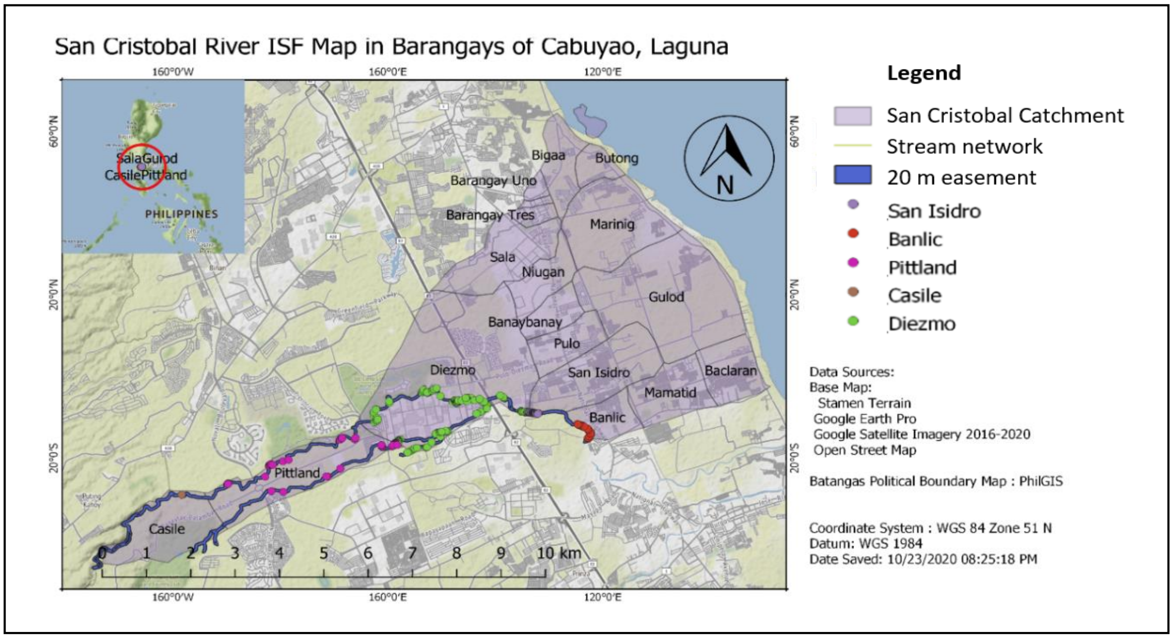

Figure 106. ISF distribution along the San Cristobal River in Cabuyao Laguna.

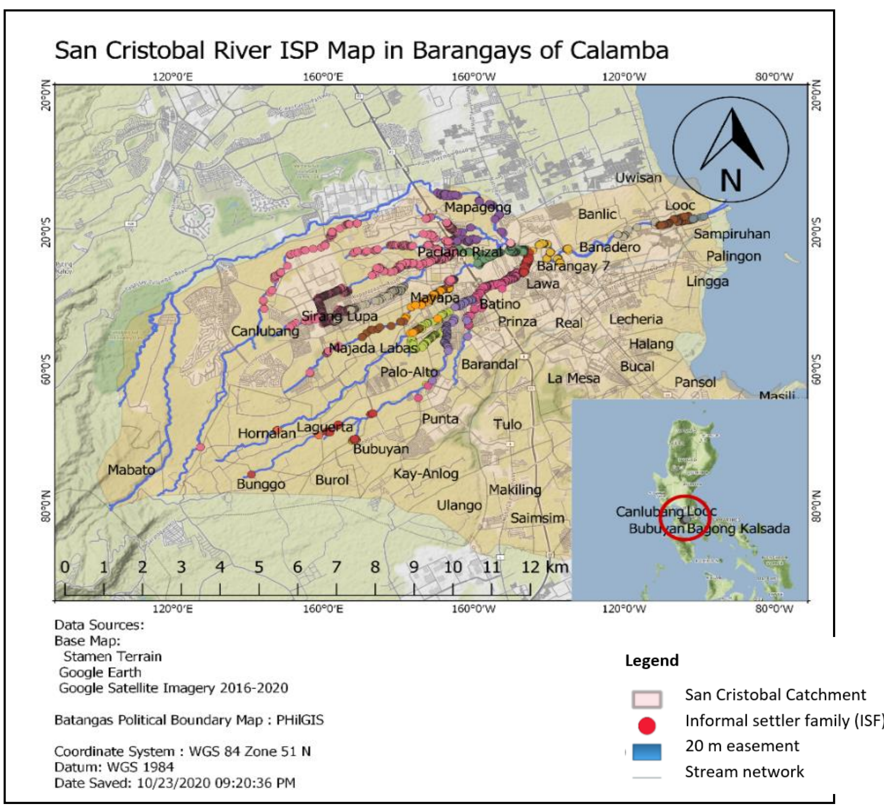

Figure 107. ISF distribution along the San Cristobal River in Calamba City, Laguna.

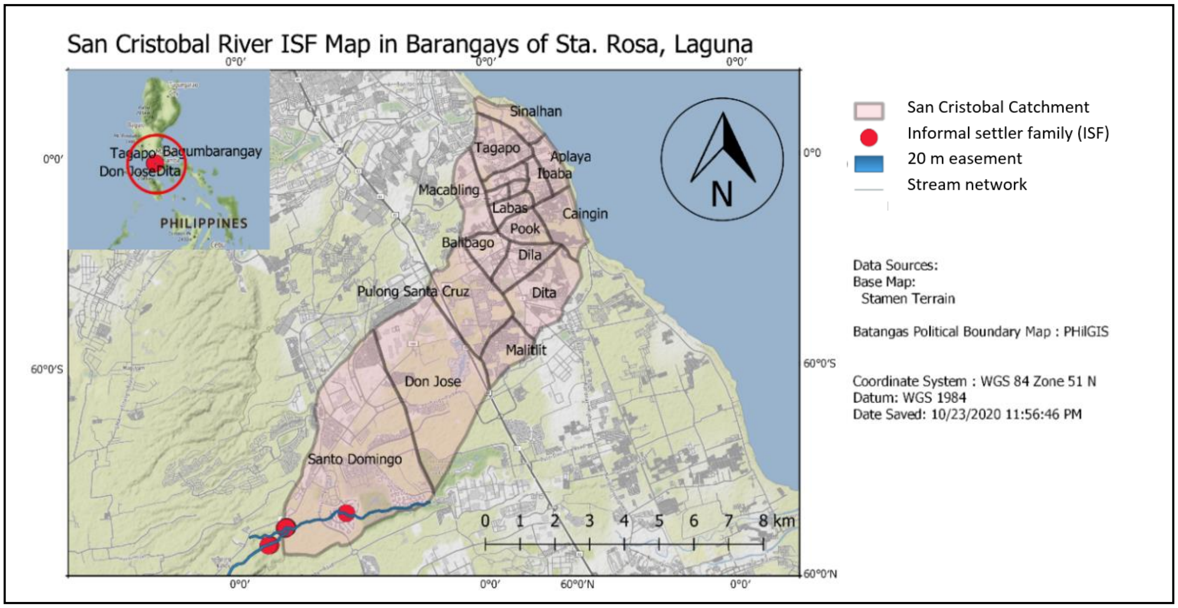

Figure 108. ISF distribution along the San Cristobal River in Sta. Rosa City, Laguna.

B. Non-point source pollution maps

Sediment Yield Map in San Cristobal River in Cabuyao, Laguna

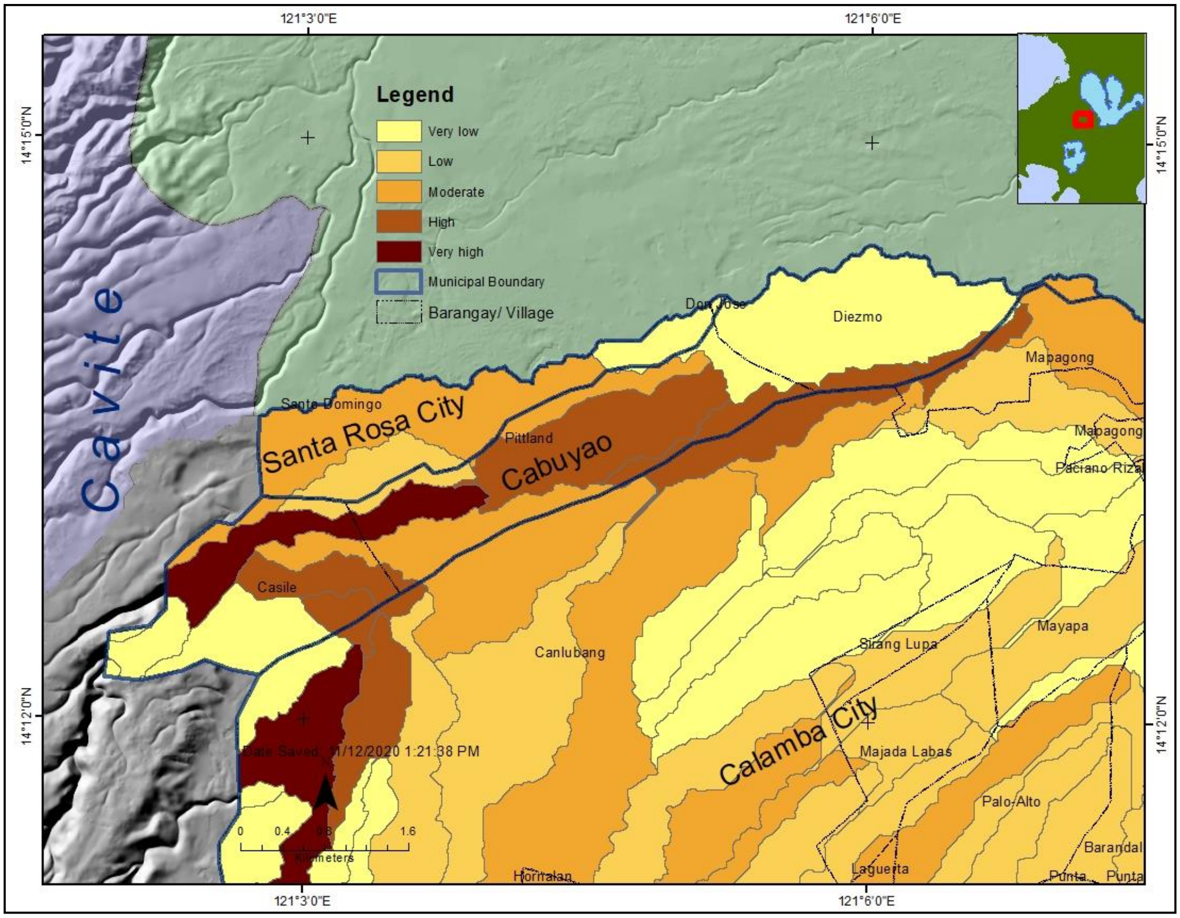

Figure 109. Spatial variation of average annual sediment yield in the catchment of San Cristobal River in Cabuyao, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover.

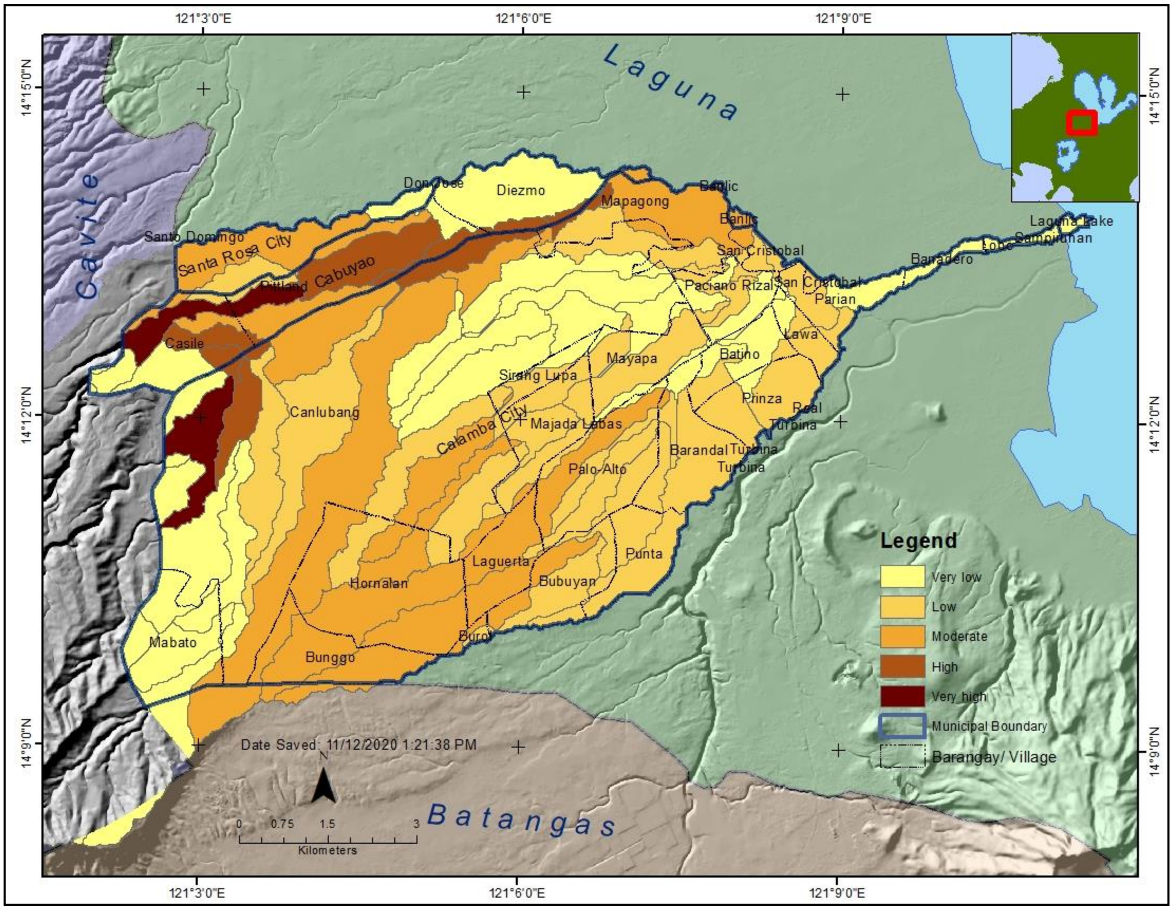

Figure 110. Spatial variation of average annual sediment yield in the catchment of San Cristobal River in Calamba City, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover.

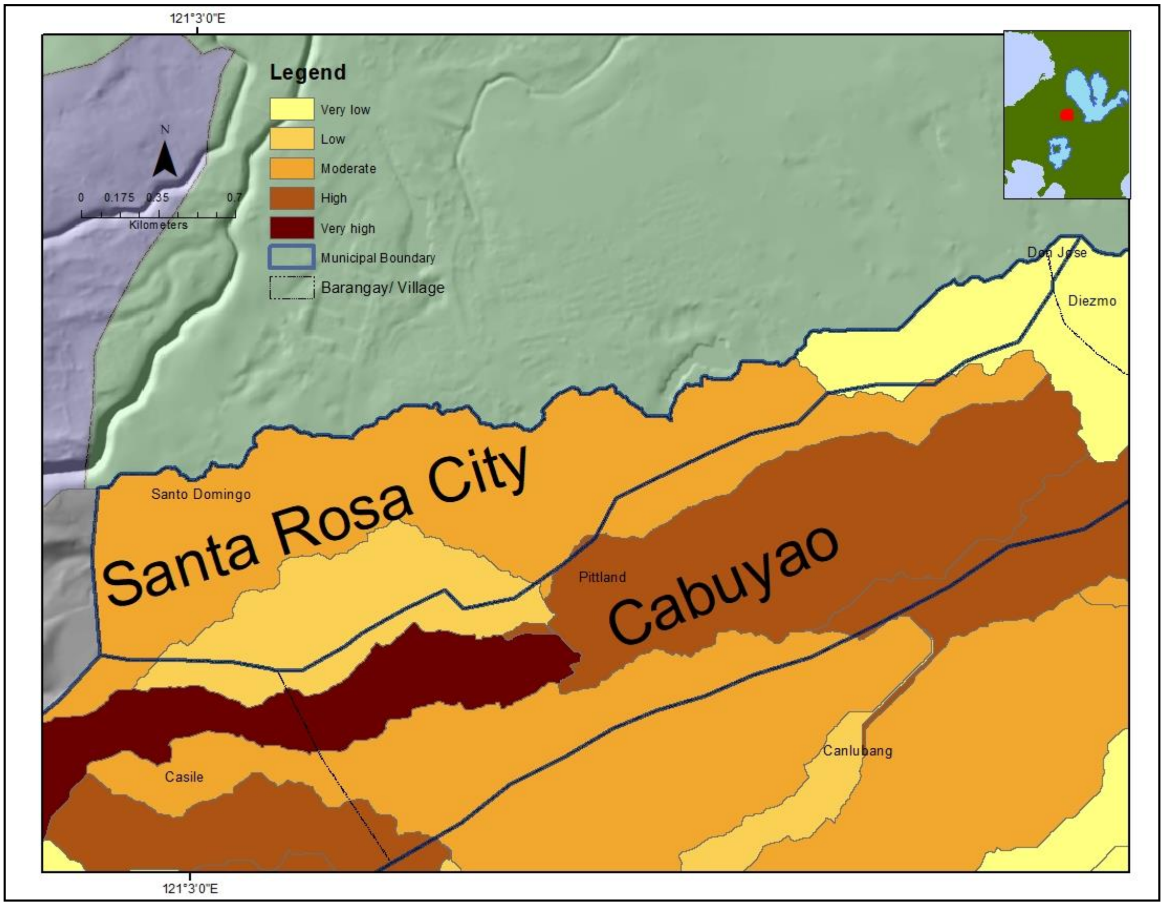

Figure 111. Spatial variation of average annual sediment yield in the catchment of San Cristobal River in Sta. Rosa City, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover

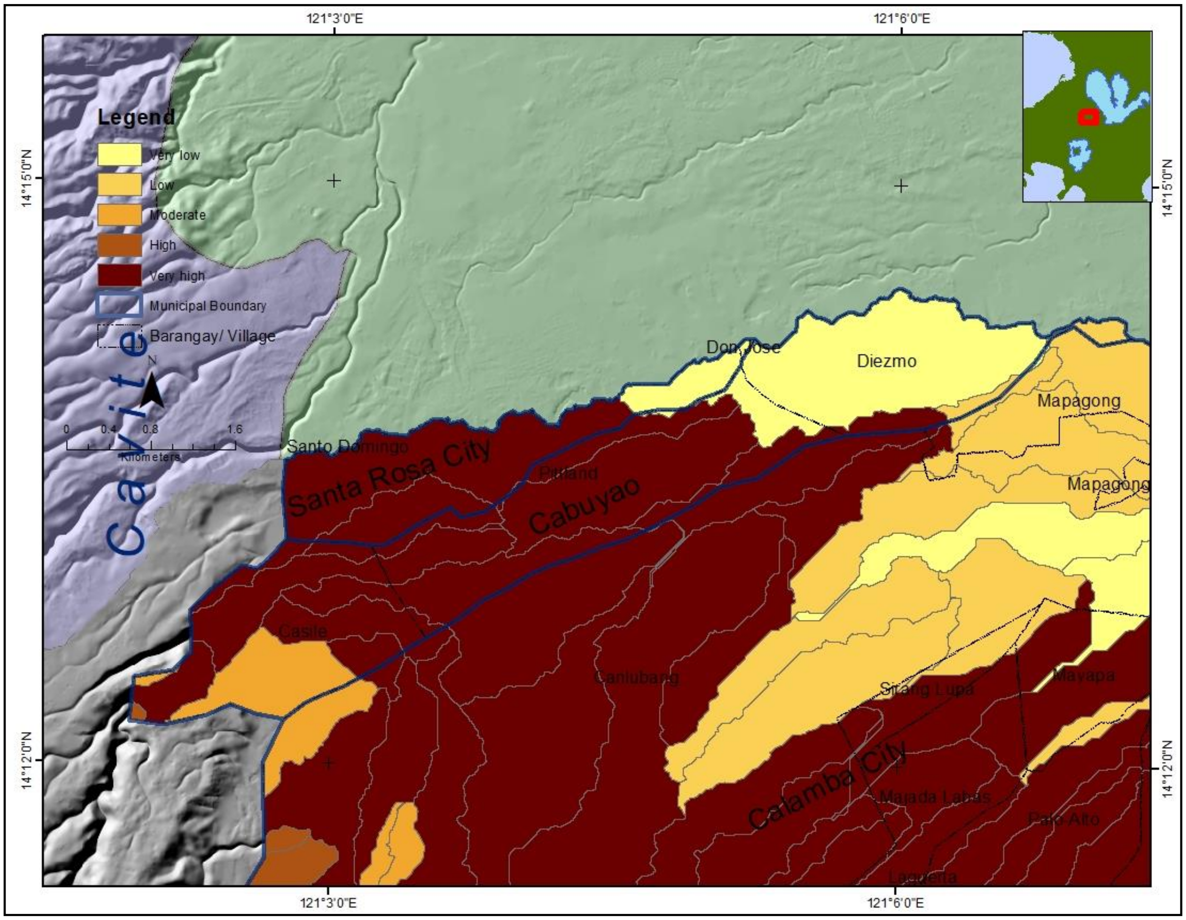

Figure 112. Spatial variation of average annual organic nitrogen in the catchment of San Cristobal River in Cabuyao, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover.

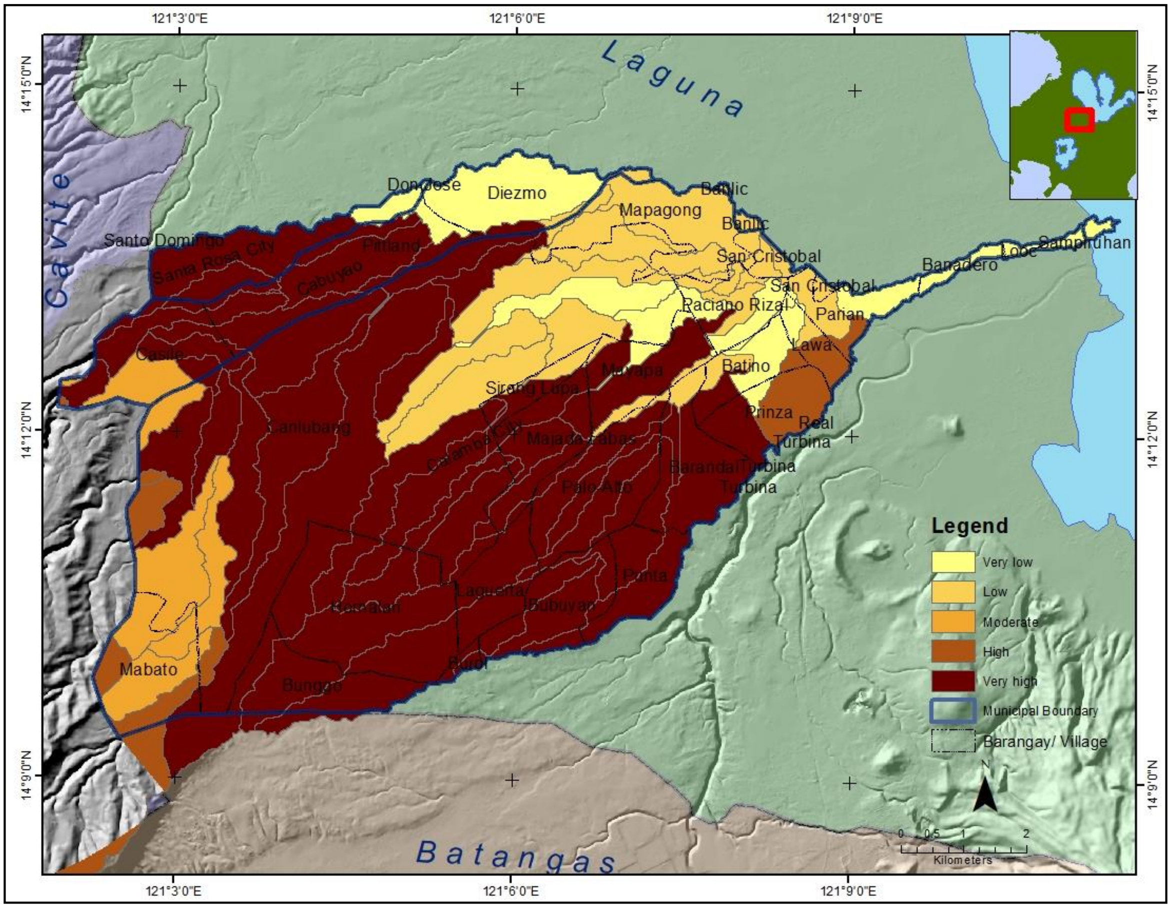

Figure 113. Spatial variation of average annual organic nitrogen in the catchment of San Cristobal River in Calamba City, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover

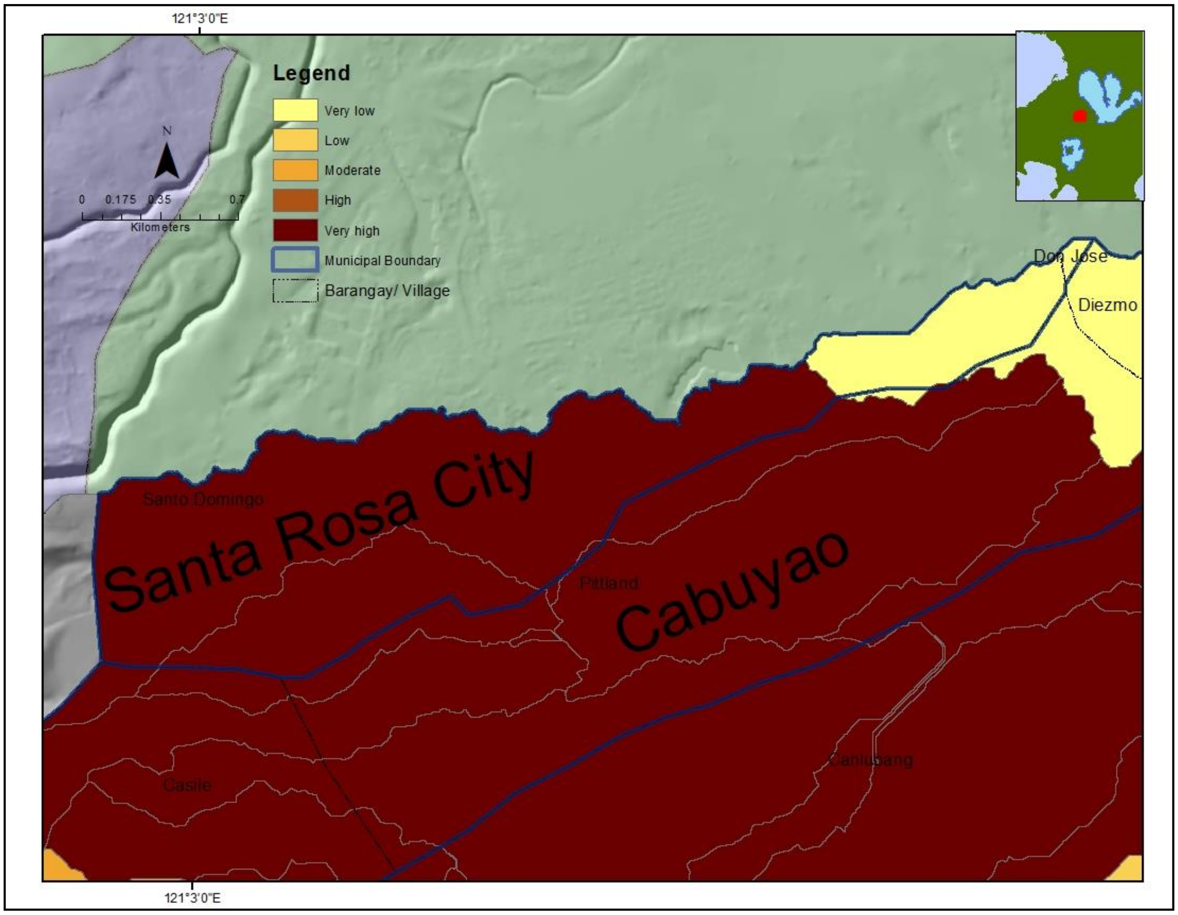

Figure 114. Spatial variation of average annual organic nitrogen in the catchment of San Cristobal River in Sta. Rosa City, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover.

Organic Phosphorous Map in San Cristobal River in Cabuyao, Laguna

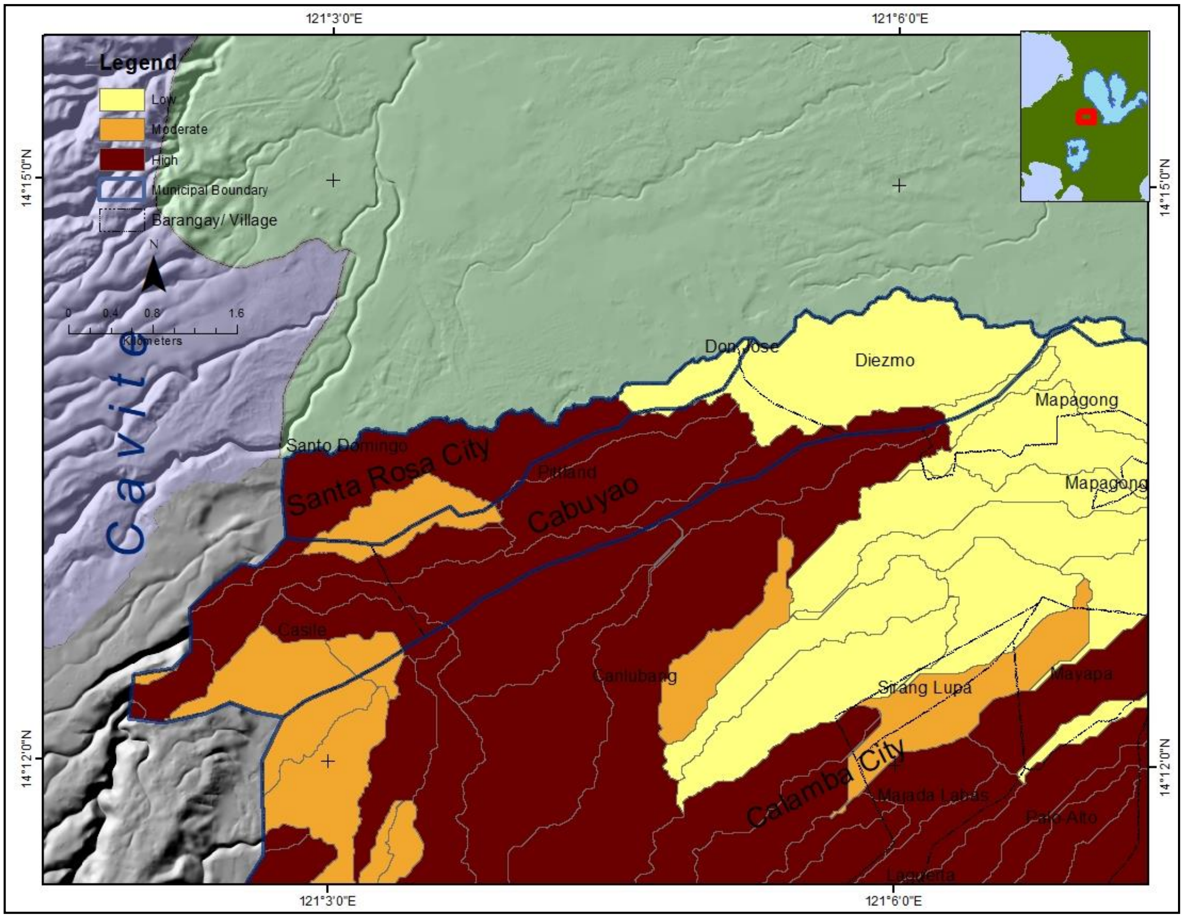

Figure 115. Spatial variation of average annual organic phosphorus in the catchment of San Cristobal River in Cabuyao, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover.

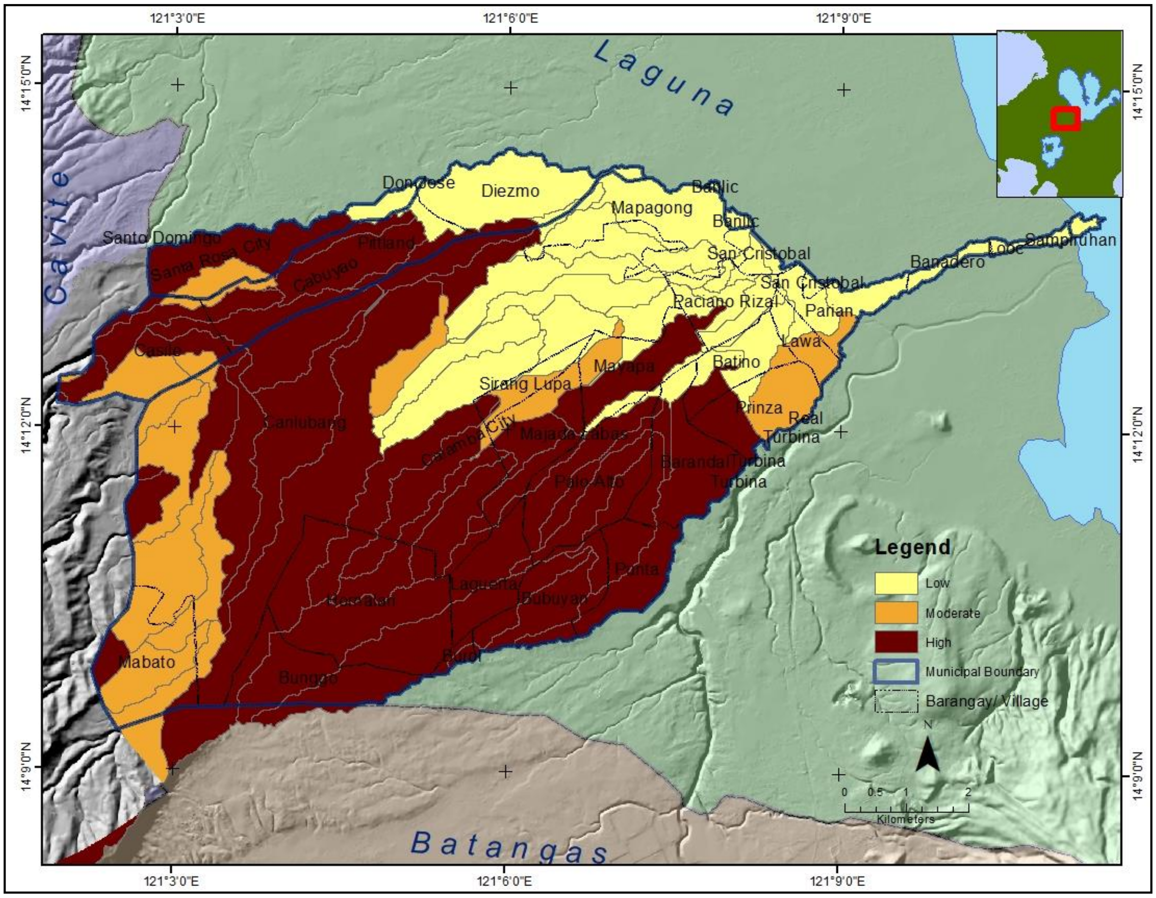

Figure 116. Spatial variation of average annual organic phosphorus in the catchment of San Cristobal River in Calamba City, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover

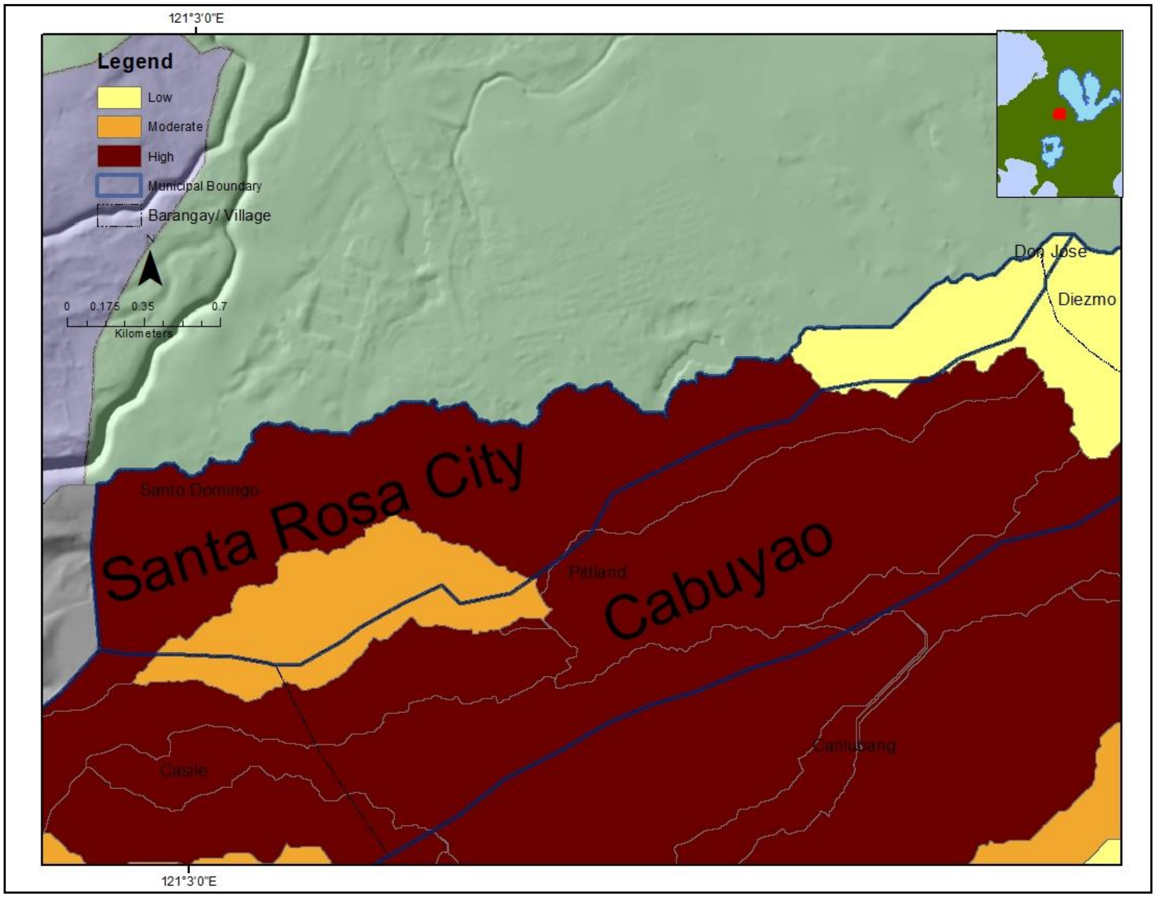

Figure 117. Spatial variation of average annual organic phosphorus in the catchment of San Cristobal River in Sta. Rosa City, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover

Saran River

Sediment Yield Map in Saran River Subwatershed

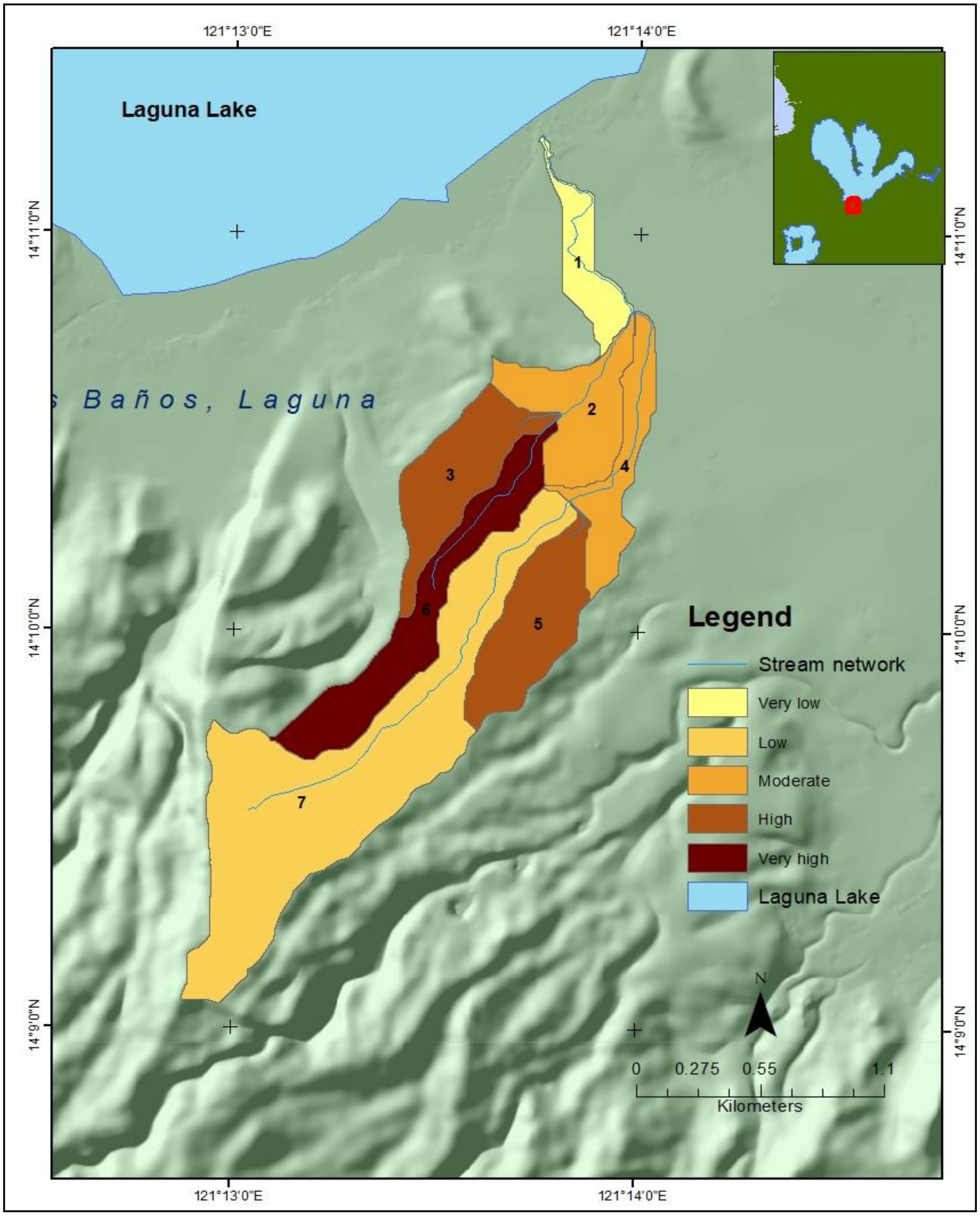

Figure 118. Spatial variation of average annual sediment yield in the catchment of Saran River in Los Baños, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover.

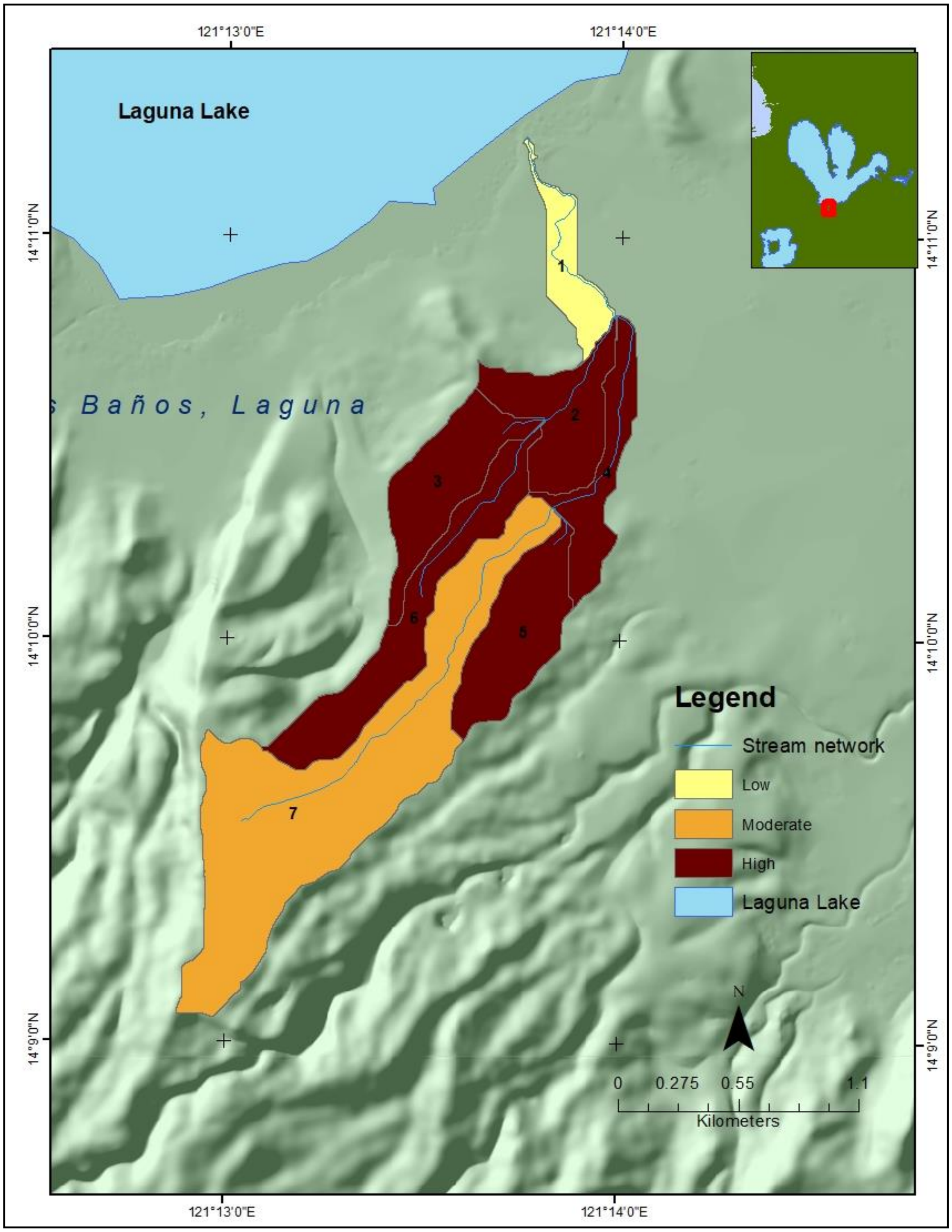

Figure 119. Spatial variation of average annual organic nitrogen yield in the catchment of Saran River in Los Baños, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover.

Organic Nitrogen Yield Map in Saran River Subwatershed

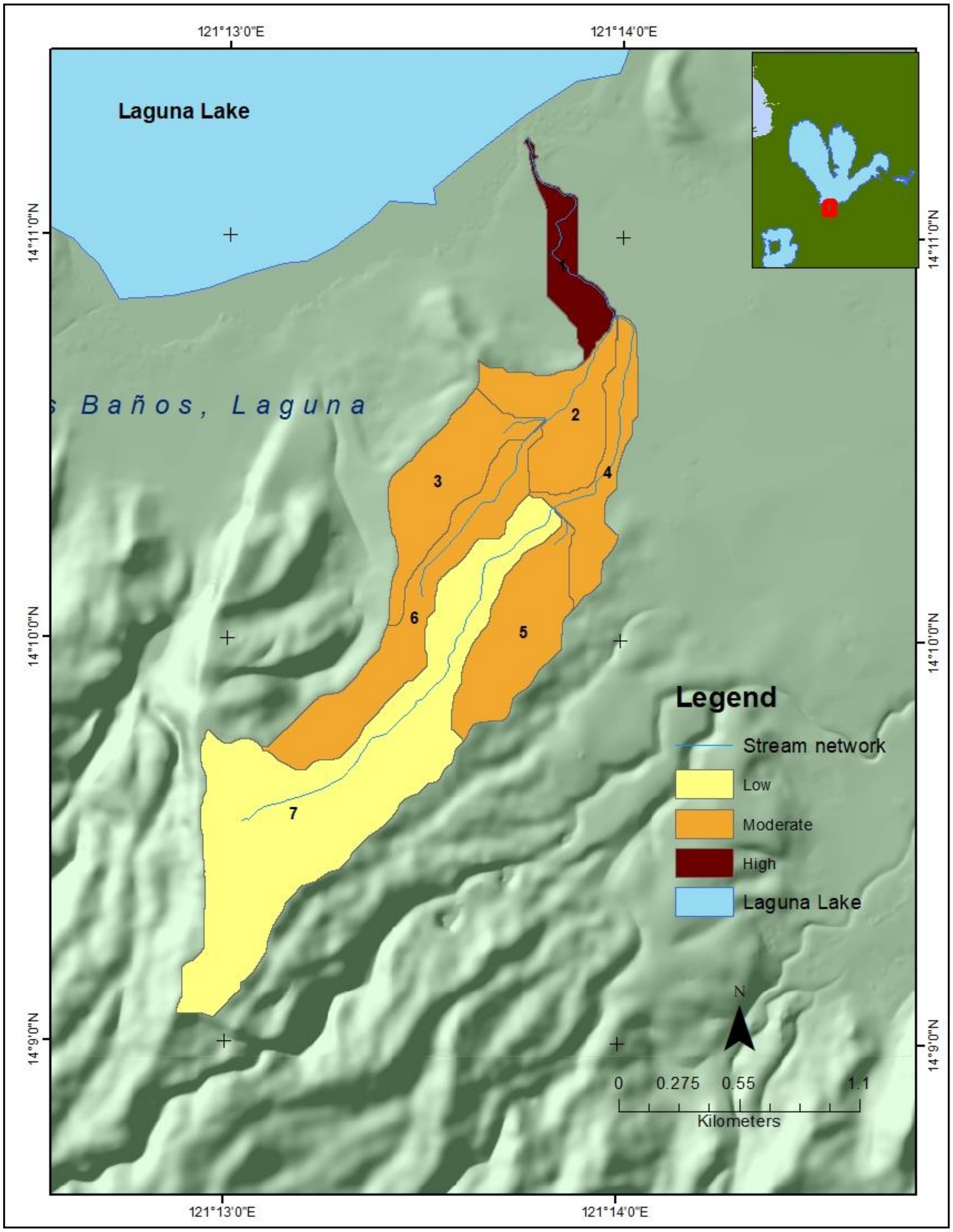

Figure 120. Spatial variation of average annual organic nitrogen yield carried through surface runoff in the catchment of Saran River in Los Baños, Laguna based on the 2010-2019 precipitation patterns and 2015 landcover.

Phosphorous Yield Map in Saran River Subwatershed

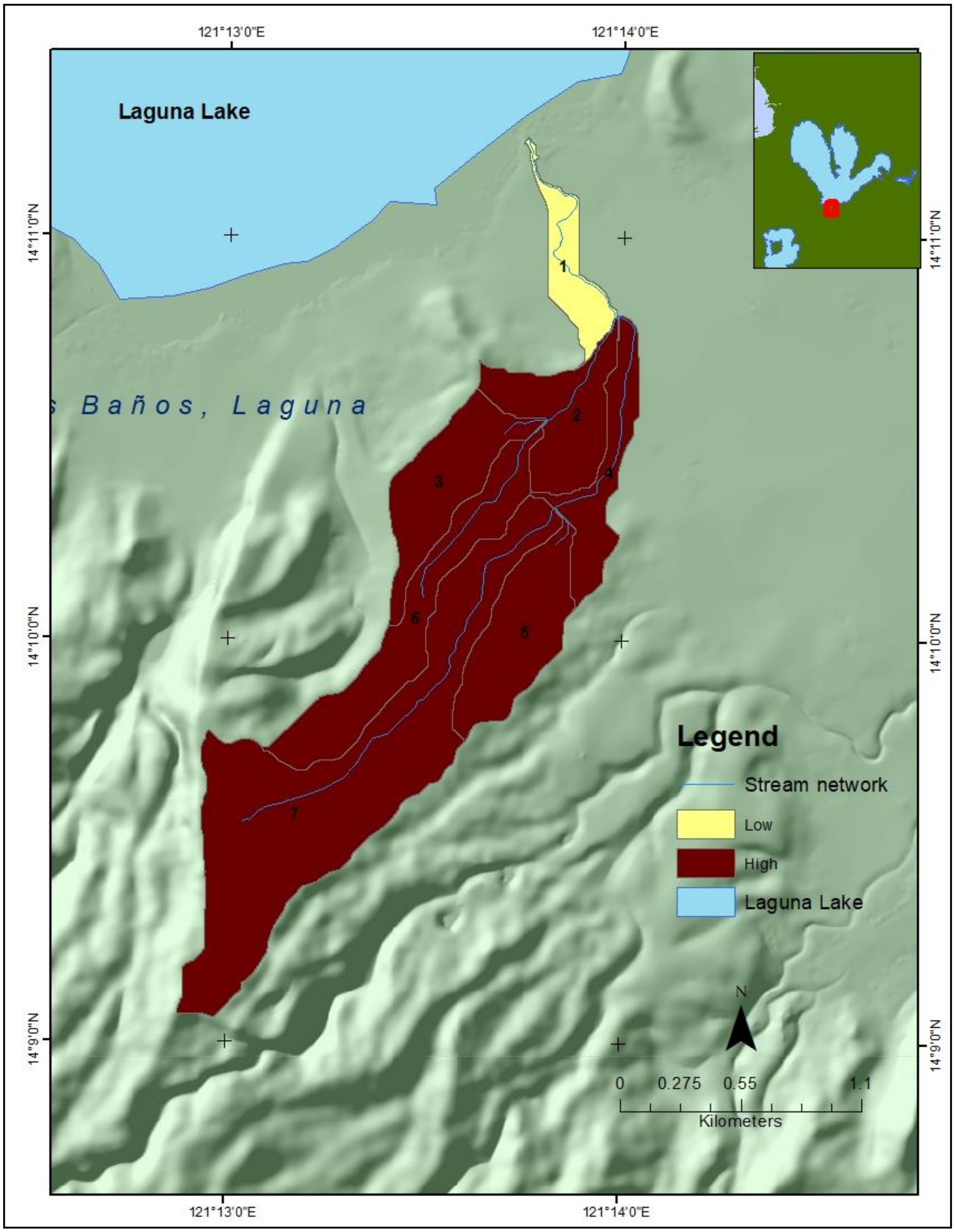

Figure 121. Spatial variation of average annual organic phosphorus yield in the catchment of Saran River in Los Baños Laguna based on the 2010-2019 precipitation patterns and 2015 landcover.

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