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A STUDY ON WATER SUSTAINABILITY IN TAHITI

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ABSTRACT

With an overall huge amount of water available in Tahiti, we might think that future generations have no reason to worry; however, this is not reflecting the real aspect of water availability in each district. By analysing the situation and the spatial distribution of the current water available, problematic areas have been identified. The methodology considers the major current characteristics, such as geographical variations for rainfall patterns and water distribution, but also demographic variations and distribution over the area.

There are 3 types of situation identified: In Papenoo: where water is available in a really huge amount with about 200 millions of cubic meter discharged per year, which is way higher than water demand in that area; In Afaahiti: where they are actually having sufficient water discharged by the AOMA's river, but are likely to experience water shortage in the future, with a minimum storage required volume of 2,300,000 m³ by 2050; -In Papara: where the most critical situation is found, especially during the dry seasons, with an actual water deficit requiring a minimum storage volume of 760,000 m³. Also infiltration volume of about 730,000,000 cubic meters recharging the underground reservoirs per year is found for the whole island.

Keywords: River discharge, rainfall

1. INTRODUCTION

1.1 Overview

Tahiti is an island of French-Polynesia, an overseas country of French-Republic, located at 4,300 kilometres North-East of New-Zealand. With an actual population of 183,645 and a 1,042 kilometre square surface area, the island of Tahiti is the most populous, accounting about 70% of total French-Polynesian population, and the largest one of the country.

The main water sources used in French-Polynesia are surface water, through river catchments, and underground water, through drilling well.

1.2 Aim and objectives

Rivers flow discharge differs considerably from a district to another, which is directly related to the average rainfall and exposition to the prevailing winds of the area; therefore, water available varies also from a district to another. In parallel to that, population keeps growing, leading to an increasing water demand over the years.

The objective of this study is to identify the current water availability from the main river basins located around the island, and by including variations in

population distribution and consumption, identify the areas that have water issues but also identify the areas likely to have water issues in the future.

2. METHODOLOGY

The methodology used for this study is essentially based on the analysis of the current characteristics such as: geographical variations of the major parameters, water balance, rainfall patterns, water distribution, demographic variations and distributions, and, individual characteristics of the districts.

2.1 Water balance

Rainfall pattern is used to calculate the water balance, together with predefined figures for Evaporation, Infiltration and flow discharge from the main river basins, from which volume is determined.

This is mainly to assess the reliability of the flow discharges that will also be used for the assessment of the sustainability of water consumption in each district determined later.

2.1.1 Rainfall patterns

Rainfall patterns and average depths are established from the rainfall data collected over the last 50 years from 5 different stations on the island with the help of the Thiessen Polygon method. Then Rainfall Volumes are calculated.

2.1.2 Evaporation

A predefined value is used for the evaporation and distributed proportionally to each catchment area defined with the Thiessen method:

$$\frac{\text{CatchmentArea}}{\text{TotalArea}} \times \text{TotalVolume}$$

2.1.3 Infiltration

A predefined infiltration figure is also used, however, unlike the evaporation, infiltration is not constant and depends on the average number of rain days recorded at each rainfall stations.

$$\frac{(\text{Area}\% \times \text{RainDays}\%)}{\sum(\text{Area}\% \times \text{RainDays}\%)} = \text{Infiltration}\%$$

Then this infiltration ratio is thereafter used to distribute the total volume of infiltration to each section:

$$(\text{Infiltration}\%) \times \text{TotalVolume}$$

2.1.4 Rivers discharge

Once again predefined values for the main river basins flow discharge are used.

2.1.5 Water balance calculation

Water balance for each section is thereafter determined, by making the sum of the evaporation, the infiltration and the rivers discharge volume per catchment area, and deducting it from rainfall volume in each of these sections:

$$\text{RainfallVolume} - (\text{Evaporation} + \text{Infiltration} + \text{DischargeVolume})$$

2.2 Population projection for 2050

A population projection for 2050 is established for each district, based on the last census made in 2012 and the growth trends observed during the period 1971-2012.

In parallel to that, estimations of water consumption per person per day would be established for the districts where water consumption pattern could not have been collected.

2.3 Water consumption patterns

By using the water consumption estimations and population data, both current and projected population, actual water demand volume per district is calculated as well as future water demand in 2050.

2.4 Sustainability of Water consumption

2.4.1 Cumulative river discharge

Cumulative values for volume of rivers discharges per catchment area are calculated per month for a period of one year by taking into account both low flow and average flow for the dry and humid seasons. Therefore, according to the general rainfall pattern analysis, temporal variation of precipitation will be defined and flow discharges will be distributed according to that.

2.4.2 Cumulative population and water demand

Cumulative values for volume of water demand per catchment area per month are calculated for a period of one year, for 2012 and 2050.

2.4.3 Correlation of cumulative values

By showing both cumulative population and water demand on the same graph would give a neat representation of the situation in each specific area. Three types of situations can be expected, the situation where:

1. There is sufficient water in the area for future generations;
2. Water available is actually meeting the demand but by 2050 there would be water issues;
3. There is actually a lack of water in the area and it will get worse in the future if no alternative is found.

3. RESULTS

3.1 Water Balance calculation

3.1.1 Rainfall patterns

3.1.1.1 General rainfall pattern

From the rainfall pattern established from the total average rainfall for the last twelve years, two distinct seasons are identified:

- An austral summer, from November to April, during which occurs the peak rainfall; and
- An austral winter, from May to October, the driest months of the year.

3.1.1.2 Average Rainfall Depth and Volumes

They are as indicated in the table below.

3.1.2 Evaporation

The Average evaporation in Tahiti is 1072.50 mm/year

$$\frac{\text{Evaporation / year}}{365 \text{ days}} = \frac{1072.5}{365} = 2.94 \text{ mm / day}$$

It is as presented below.

	Area km ²	Rainfall mm	Rainfall m ³
Catchment 1	293.50	6.07	1,781,545.00
Catchment 2	108.70	4.91	533,717.00
Catchment 3	370.90	7.93	2,941,237.00
Catchment 4	145.60	9.23	1,343,888.00
Catchment 5	123.30	9.62	1,186,146.00
TOTAL	1,042.00		7,786,533.00

	Area km ²	Evaporation mm/d	Evaporation m ³ /d	Area × <u>E.depth</u> E.Volume
Catchment 1	293.50	2.94	862,407.53	
Catchment 2	108.70	2.94	319,399.32	
Catchment 3	370.90	2.94	1,089,836.30	
Catchment 4	145.60	2.94	427,824.66	
Catchment 5	123.30	2.94	362,299.32	
TOTAL	1,042.00		3,061,767.12	

3.1.3 Infiltration

The Average Infiltration in Tahiti is 700mm/year.

	Area	Ratio A	Rain d/y	Ratio rain days/y	Combi ned ratio	New ratio	Total Infiltration (for 1042km ²)	Infiltration m ³
Catchment 1	293.50	0.28	110.36	0.12	0.032	16%	1,998,356.16	329,030.07
Catchment 2	108.70	0.10	138.78	0.15	0.015	8%	1,998,356.16	153,240.02
Catchment 3	370.90	0.36	228.74	0.24	0.085	43%	1,998,356.16	861,816.37
Catchment 4	145.60	0.14	257.38	0.27	0.038	19%	1,998,356.16	380,672.90
Catchment 5	123.30	0.12	218.44	0.23	0.027	14%	1,998,356.16	273,596.81
TOTAL	1,042	1.00	953.7	1.00	0.198	100%	1,998,356.16	1,998,356.16

3.1.4 Rivers discharge

There are 15 main river basins on the island of Tahiti, with flow discharge varying spatially from 13,046.40 m³ to 770,688.00 m³ per day.

Water balances in catchment areas 1, 2 and 3 are negative, due to excess rivers discharge, on the other hand, Catchment areas 4 and 5, Water balances are positive.

3.1.5 Water balance per catchment area

There are 5 different rainfall stations, 5 different catchment areas, which means that there are 5 different Water Balance equations.

What is interesting, is that when analysed spatially, negative water balance values are located on the bigger part of the island (Tahiti Nui), whereas positive

	Rainfall (R) m ³	Infiltration (I) m ³	Evaporation (E) m ³	Discharge (D) m ³	Water balance m ³	Excess	
Catchment 1	1,781,545	329,030.07	862,407.53	1,019,520.00	-429,412.60	D	24%
Catchment 2	533,717	153,240.02	319,399.32	235,440.00	-174,362.34	D	33%
Catchment 3	2,941,237	861,816.37	1,089,836.30	1,210,723.20	-221,138.87	D	7.5%
Catchment 4	1,343,888	380,672.90	427,824.66	17,107.20	518,283.24	R	39%
Catchment 5	1,186,146	273,596.81	362,299.32	479,865.60	70,384.27	R	6%
TOTAL	7,786,533	1,998,356	3,061,767	2,962,656	-236,246		

water balance are observed on the smaller part of the island (Tahiti Iti).

There is a supposition of an aquifer flowing South-east to North-west of the island.

According to the calculations, total water balance is negative, with an excess discharge of 236,246.29 m³ per day, which represents 3% of the total rainfall volume. A 3% excess water is acceptable, however, the discharge volumes taken in account are only from the main river basins. Therefore, the excess water discharge volumes would be higher if smaller streams and rivers were included in the study.

3.2 Sustainability of Water consumption

3.2.1 Overall Population projection and Water Consumption

With an actual population of 183,645, it is estimated to reach 287,480 people in 2050, which is equal to an increase of about 57%.

Population water consumption in 2012 is about 234,630.91 m³/month and it is estimated to reach 355,789.10 m³/month, representing an increase of about 52% of the actual consumption.

3.2.2 Study per districts

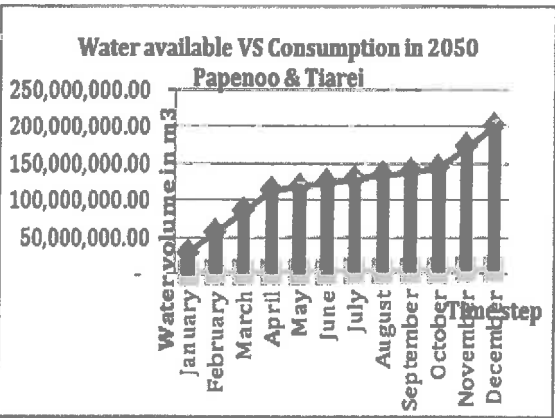
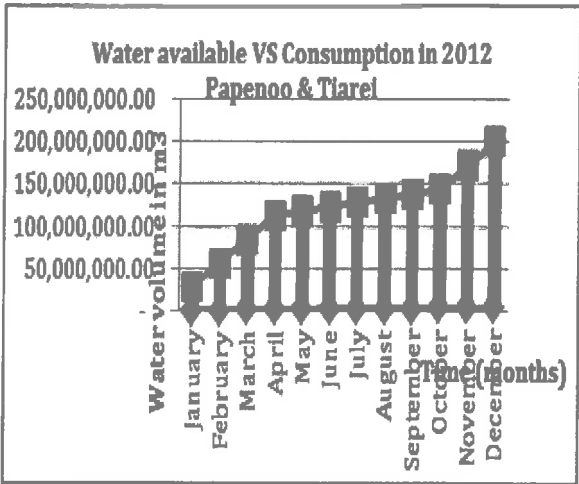
The Study per district is mostly highlighting 3 areas.

3.2.2.1 Study on water consumption sustainability in Papenoo and Tiarei

Papenoo and Tiarei, two rural, have a total population of 6,535 and an estimated population of 10,975 in 2050. A consumption estimation of 1.5 cubic meters per person per day leads to a total water demand of 9,802.5 cubic meters per day.

In order to meet the population water demand, these districts are taking water from the Papenoo river, which is the longest and the largest of the island.

The amount of water discharged per month by the PAPANOO river is, as can be seen on both figures, really huge. Cumulative discharge is 200,310,000 cubic meters per year and total consumption is accounting for only 2 and 3% of this total in 2012 and 2050. Therefore, population in these areas can be sure they will have sufficient water for future generations.

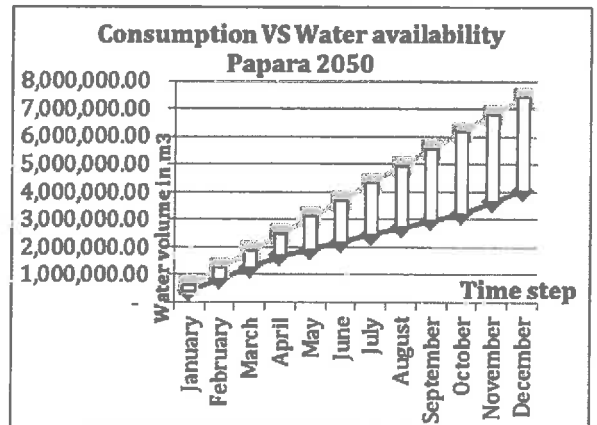
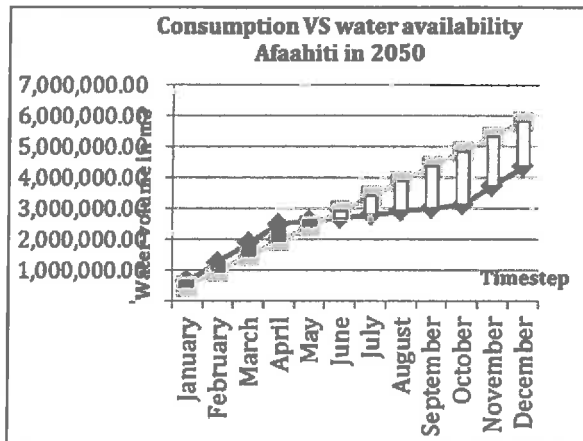
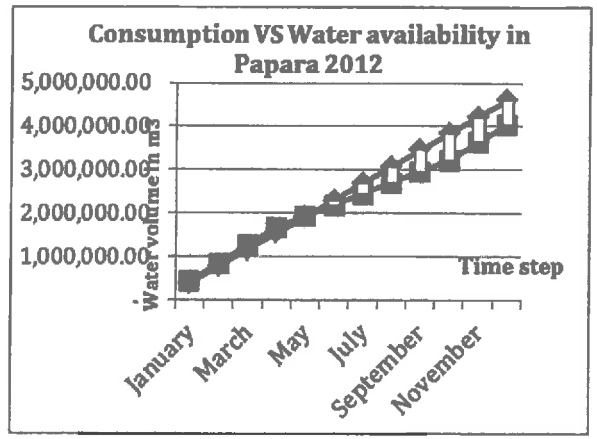
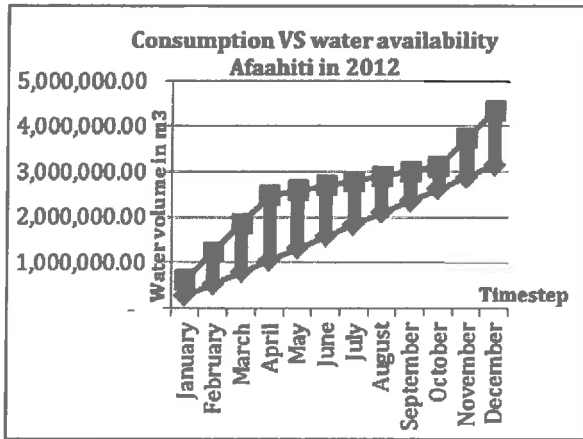


3.2.2.2 Study on water consumption sustainability in Afaahiti

Afaahiti, rural district, has an actual population of 5,815 which is estimated to reach 10,785 in 2050 (+85%) according to the actual trends.

Population consumption is 1.5m³/person/day, and source used is the AOMA's river.

As the population tends to increase considerably, water demand will increase proportionally and therefore water taken from the Aoma source would no longer be sufficient to meet the population water needs. Indeed from the analysis made, a minimum storage of 2.3 millions cubic meters might be required by then.



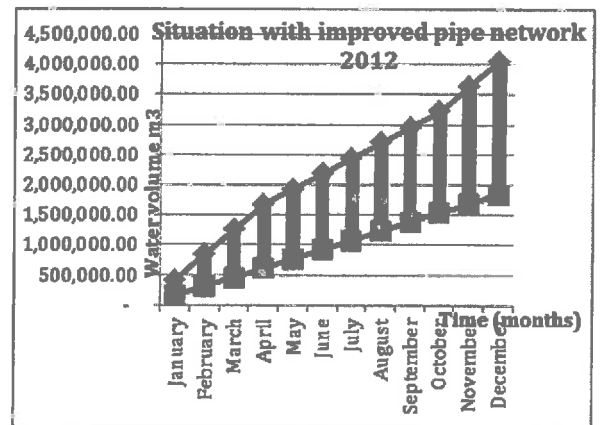
3.2.2.3 Study on water consumption sustainability in Papara

With a total population of 11,143 and an estimated consumption of 1.148 m³/person/day, the district of Papara is actually experiencing critical water shortages, especially during dry season (August being the worst period).

The first graph below, is only confirming the situation in the area at the moment, as it representing, from the second third until the end of the year, cumulative population water demand starts to be higher than cumulative water discharged which is to get worst by 2050 with a projected population of 20,165.

From the calculations made, a minimum storage of 760,000 cubic meters would actually be required. What is interesting to know is that this actual water issue population of Papara is having is not related to the insufficiency of water sources, but due to the poor distribution of the municipality. Indeed, about 60% of the total water distributed is in reality lost through piping. The graph below is showing how would the situation be with a better pipe network.

By saving these 60% of water lost in pipes, water distributed would be lessened from 380,000 to 150,000 cubic meters per month, which is a considerable amount of water.



4. CONCLUSION

To put it in a nutshell, most of the districts on Tahiti have a good situation in terms of water available to the population and there are 3 types of situation identified:

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In Papenoo: where water is available in a really huge amount with about 200 millions of cubic meter discharged per year, which is way higher than water demand in that area;

In Afaahiti: where they are actually having sufficient water discharged by the AOMA's river, but are likely to experience water shortage in the future, with a minimum storage required volume of 2,300,000 m³ by 2050;

In Papara: where the most critical situation is found, especially during the dry seasons, with an actual water deficit requiring a minimum storage volume of 760,000 m³.

Also, from the water balance calculations, an average infiltration volume of about 730,000,000 cubic meters recharging the underground reservoirs per year is found for the whole island. In these days, an estimation of only 8% of underground water is used. In other words, underground reservoirs could be reliable sources of water as well in quantity as in quality.

REFERENCES

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