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Analysis of water consumption in community based water service surrounding Wan Abdul Rachman Forest Park, Lampung province

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Abstract

The issue of providing clean water services is fundamental and an important part of the strategy to improve community welfare. Clean water facilities are generally provided by the government, but others are developed and managed by village communities. This research aims to: (1) analyse the supply and consumption of clean water in communities around Wan Abdul Rahman Forest Park (WARFP), (2) identify factors that determine household clean water consumption. This research employs a case study method in a community-based clean water management model around WARFP, in Gedong Tataan Sub-District, Pesawaran District. This research involved 90 households receiving clean water services. To answer objective 1, data tabulation analysis was used. To answer objective 2 multiple linear regression analysis was used. The study suggests that the clean water received by the community is very abundant, as indicated by the supply of clean water that exceeds household needs. The result also shows that: (1) the average water consumption of people in the study area *per capita* per day is 189 L with the lowest consumption being 40 L and the highest average consumption being 708 L. There are 29 respondents (32 %) who consume clean water less than the Ministry of Public Works and Housing (MPWPH) standard which is 121 L *per capita* per day. (2) Factors that influence clean water consumption are water supply, and household revenues. Number of family member and education did not have strong influence on water consumption.

Key words: clean water, consumption, multiple linear regression.

Introduction

Sufficient consumption of clean water is a basic right of society. In Sustainable Development Goals (SDGs), access to clean water along with sanitation aspects for the entire community is listed in Goal 6. (UNDP 2015). Bearing in mind that the Indonesian Government is committed to the SDGs, it is therefore mandatory for the government to fulfil them. Access to safe, clean water is a prerequisite for creating

a sustainable society so that providing access to clean water service will assist achieving that commitment (Dong et al. 2018). Clean water services also have dimensions in the context of efforts to reduce poverty because affordable clean water really helps poor communities. World Bank considered that providing affordable clean water for poor people in rural areas is strategic. The development of clean water in rural areas will encourage inclusive development (The World Bank 2019). In areas around forests, water services are part of efforts to protect water sources because local communities will protect water sources that provide the basic needs. This community-based water service potentially could fill the gap of water needs in rural area considering a lack of government support for clean water services.

A study by Ministry of Public Works and Public Housing (MPWPH) in 2016 showed that the minimum water requirement for urban communities was 121 L per day *per capita*, while survey results showed that water consumption for urban communities was 144 L per day *per capita*. The largest portion of water consumption (45 %) is for bathing (MPWPH 2017). Yet similar study for rural community has not available.

According to Indonesian National Standard or SNI (2002), the need for clean water *per capita* per day for urban communities is ranging from 150 to 250 L and the water needs of rural communities is 100 L. The water needed is for bathing, washing, drinking, hygiene, and other purposes. However, not all rural areas have been reached by the government's investment in clean water due to budget limitations and technical obstacles. As a result, the level of accessibility of village communities to affordable clean water is still not optimal. According to report of Central Bureau of Statistics (BPS 2023), the proportion of Indonesian people with clean, healthy water was only 44.5 % in 2022. This achievement is still far from other ASEAN countries achieved which reached above 91 % in 2016 (ASEAN 2017).

The Indonesian government's efforts to accelerate access to clean water for the community by encouraging Program for Provisioning Community Based Clean Water and Sanitation (PCWCBS) did not achieve optimal results and in 2021 the program was halted. One of the efforts made by the community to meet water needs is to utilize springs located in or surrounding forest area. Models like this are found quite a lot in the forests of Bukit Barisan National Park, areas around the forests of West Lampung, Tanggamus, and Pesawaran Districts, Lampung province. Community-based water management is an effort, an independent community initiative to fulfil the family's basic needs, namely water, by utilizing the resources from the environment around them (Abidin 2011). It was further explained that models like this also receive support from the government or other institutions that care about clean water services. However, the characteristics of such models have similarities, namely: (1) using local resources, (2) community initiative, (3) the organization is not uniform (some have organizations, some do not), (4) rely on community's volunteer, (5) local participation, (6) water quality not monitored regularly.

Due to the low accessibility of village communities to clean water, community efforts to obtain clean water are generally not recorded in government data. Meanwhile, clean water services that are built independently are generally not recorded. Thus, there is a problem in the form of not identifying the role of community-based

water management in meeting clean water needs as well as community access to water resources and how clean water is managed by the community.

Research on clean water provision is generally for urban or semi-urban areas. In Sidoarjo, East Java, Marsono and Nirwisaya (2020) evaluated that 2 of the 13 PCWCBS groups developed by the government were no longer operating. Meanwhile, the biggest challenge is public doubts about water quality and limited-service networks. This research was carried out in urban areas with deep well water sources. Other research in China performed by Dong et al. (2018) also focused on urban or city area. In several other studies in Indonesia, the relationship between forests and water services is starting to receive a lot of attention with various analyses used such as water and environmental services in National Park of Meru Betiri, East Java (Webliana et al. 2023). Others include (Alam and Hajawa 2007, Abidin et al. 2023) to investigate water services as environmental services in Java and Lampung. However, study on analysing water consumption of community residing nearby forest is still rare which encourages team to investigate.

According to Regional Technical Implementation Unit (RTIU) of Wan Abdul Rahman Forest Park (WARFP) (RTIU WARFP 2009, 2020), the forest park area is divided into several management blocks including: (a) the plant collection block which is used for collecting native and non-native plants; (b) protection block as an area to protect flora, animals, forest management together with the community, and (c) utilization block where community surrounding area allow to get access to the forest and obtain benefit of resources as long as keeping the forest maintained. This research was carried out in the utilization blocks, namely Wiyono and Kebagusan villages, Gedung Tataan Sub-district, Pesawaran District. This research aims to analyse: (1) community consumption of clean water and (2) factors that influence water consumption.

Object and Methods

Study area

The research was carried out in utilization block of WARFP. The research locations were in 2 villages, namely Wiyono (5°23’48.3” S, 105°08’35.3” E) and Kebagusan (5°24’18.3” S, 105°07’32.4” E) Villages, Gedung Tataan Sub-District, Pesawaran District, Lampung Province. The research was purposely selected these villages considering that the source of clean water is accessed directly from the utilisation zone area and they can represent villages located around north part of WARFP.

The site is located around 25 km west of the capital of Lampung province, Bandar Lampung city. The population of Gedung Tataan District in 2021 was 107,371 with population growth at 2.16 %, far above the national average. Population density is quite high too, namely 1106.3 people per km^2 (BPS Pesawaran District 2022). In terms of gender, male population is higher than the male one with sex ration at 107, which means that for every 100 female residents there are 107 male residents (BPS Pesawaran District 2021).

Wiyono and Kebagusan villages directly border to WARFP and have relatively large population, i.e. 14,200. The people rely on water sources from WARFP area. Wiyono Village has an area of 7 km^2 or around 7 % of the area of Gedong Tataan district. Meanwhile, Kebagusan village has

an area of around 4 km^2 or 4.12 %. Each has 8 hamlets. Respondents in Wiyono village are in 3 hamlets, namely Hamlet 5, 3 and Dam C. Meanwhile for Kebagusan village, the study was carried out in 2 hamlets, namely Hamlet 4 and 5. The following is a map of the research area.

From the map (Fig. 1), it can be seen that WARFP is on upstream of both villages.

The research was carried out from May to August 2023, which are months when rainfall is very low. Even in June-August 2023, Lampung is in a dry month and starting the El Niño of 2023.

Respondents

Respondents are households that receive clean water services and live in two research villages. The sample size was determined using the approach Isaac and Michael (1995) by formula (1):

$$n = \frac{N \cdot Z^2 \cdot \sigma^2}{N \cdot u^2 + Z^2 \cdot \sigma^2}, \quad (1)$$

where: N – population of people received water services in two villages, i.e. 250 households; n – sample size; Z is Z value at 95% confident level, i.e. Z = 1.96; σ – assumed standard deviation at 0.25; u – error estimate at 5%, i.e. u = 0.05.

With formula (1), the sample/respondent size is 77 families. However, this research increased the size of respondents to 90 respondents, spread across three clean water management groups, namely: (1) 2 independent clean water management groups in Wiyono and Kebagusan villages and (2) 1 clean water

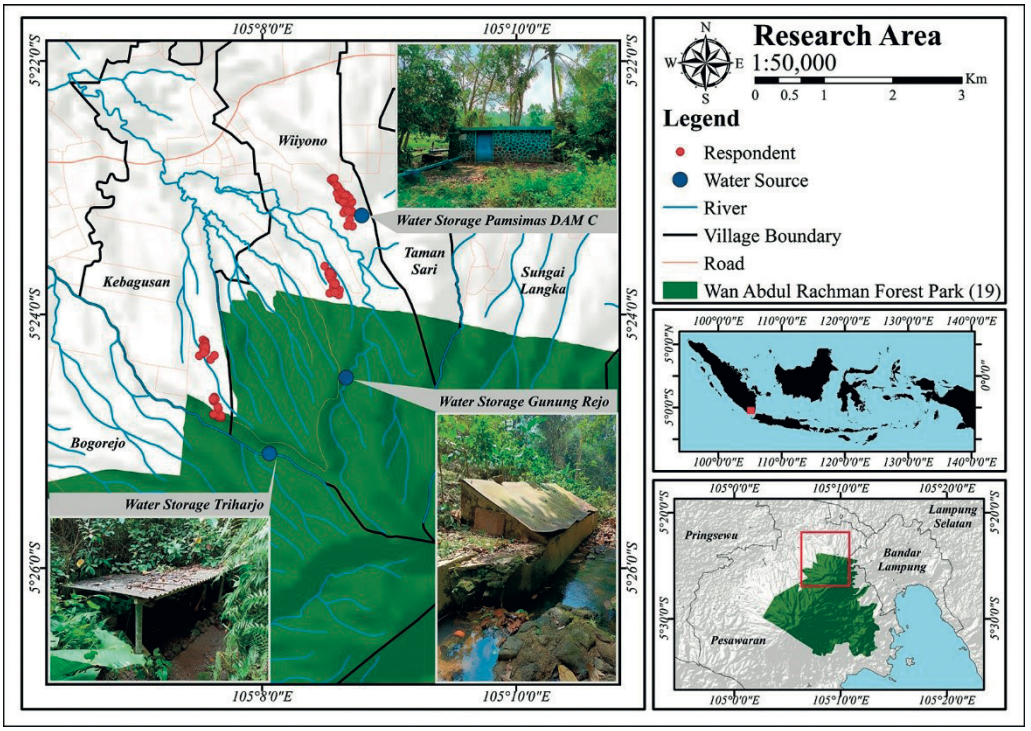

Fig. 1. Map of research site.

management group supported by Regional Company for Drinking Water (RCDW) in Dam C Hamlet of Wiyono village. Each group was represented by 30 households receiver of clean water, so in total there were 90 respondents. The use of disproportionate sampling is because assuming that respondents are relatively homogenous in terms of where they live, socio economic and social conditions.

Method of analysis

To answer objective No 1, the study employs descriptive analysis by tabulating and relating the data to benchmark data of SNI and the MPWPH. To answer objective 2, multiple linear regression analysis is used with the model equation (2) as follows (Baltagi 2008, Wooldridge 2013):

$$Y = \beta_o + \beta_1 \cdot X_1 + \ldots + \beta_n \cdot X_n + \mu, \qquad (2)$$

where: Y – average monthly water consumption, L per month; β_o – constant; β_o ... β_n – regression coefficient; μ – error term.

The variables were determined based on field observation and some researches relevant with this study. For example, a study by Fan et al. (2013) used correlation analysis for domestic consumption in rural area in China. The study suggested that water supply, age, educational attainment, household income, net family size, vegetable garden area, and solar water heater had strong correlation with water consumtion. Other relevant study done by Irianti et al. (2016), using regression analysis revealed some factors including family size, education, household wealth and some other variables inclined to use improved Drinking Water Supply (DWS). From previous studies combined with field observation, the study proposed the following independent variables, i.e.: X_1 = water supply per month, L per month; X_2 – education, year; X_3 – household revenue, IDR permonth; X_4 – Number of family member, person.

Results and Discussion

Characteristics of respondents

Characteristics of respondents described in this report include: (1) age, (2) education, (3) number of family members, (4) gender, and (5) family revenues. The distribution of respondents is presented in Table 1.

From the table above, the average age of respondents is 46 years with the youngest being 22 years and the oldest being 74. Therefore, the age difference is quite wide, reaching 53 years. The average age and media age is 46 years, indicating that respondents in the study location are still relatively of productive age. In terms of gender, 21 % respondent was female and 79 % was male.

In terms of education, there is also a wide difference between respondents with the highest education and those with the lowest level who have a difference of 13 years of education. The lowest level of education is only 3 years and the highest is 16 years (college completion). The average length of education is 9.3 years or the

Table 1. Characteristics of respondents.

Characteristics	Lowest	Highest	Average	Stdev	Median
Age, year	22	74	46.33	11.41	46.5
Education, year	3	16	9.27	2.92	9
Number of family members, person	3	6	4.5	0.73	5

equivalent of graduating from junior high school. Meanwhile, the median education is also equivalent to junior high school education, namely 9 years.

In terms of number of family members, the average number is 4.5 with the lowest being 3 people, namely a husband, a wife and a child. The highest is 6 with a median of 5 family members. So the it is the typical number of families in Indonesia, namely husband + wife + several children and siblings.

In terms of household revenue, the study results show that the average household revenues per year is IDR 28.9 million (Indonesian Rupiah; 1 IDR = 60,085,037·10[12] € and 1 € = 16,645.3 IDR). This revenue comes from agriculture (on farm) worth IDR 14.5 million (50 %). Followed by revenues from off-farm, namely activities related to agriculture such as farm labour, processing of agricultural products, and agricultural-related commerce which contributes IDR 6 million per year (21 %). The third source of income is non-farm, namely IDR 8.4 million (19 %). Revenue from agriculture comes from various agricultural activities such as cocoa farming which contributes 53 % of on-farm revenue sources (Fig. 2).

Governance of water service

The concept of water governance is related to the conditions that enable management to function in managing water (FAO 2023). Rogers and Hall (2003) stated that water governance is related to a series of political, social, economic processes and administrative systems to develop and manage water resources and the delivery of water services to various community groups. Therefore, water governance is designed to ensure that water service could perform for today and future needs.

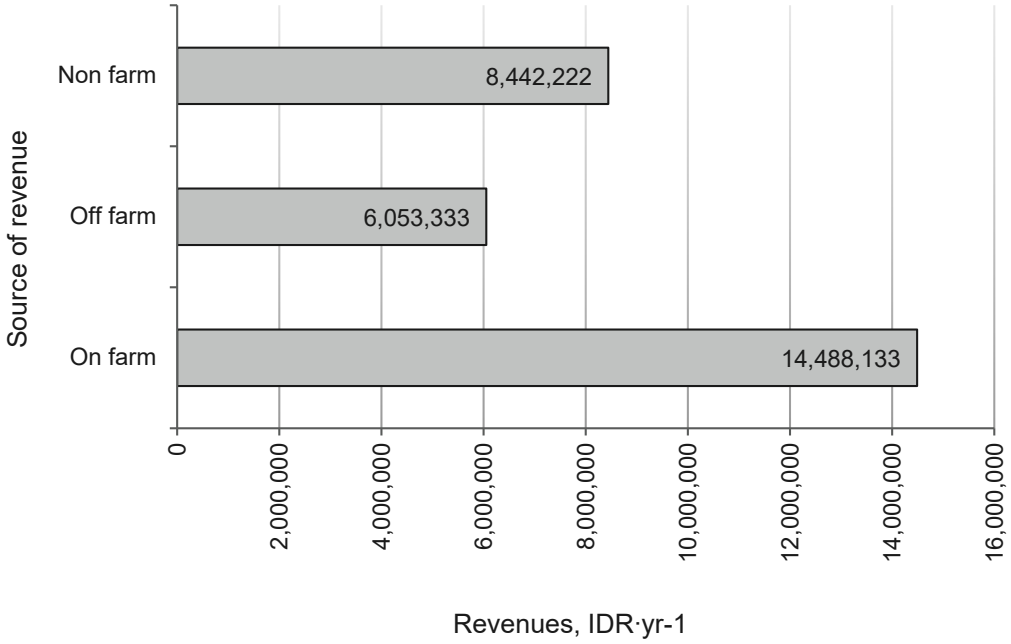

Fig. 2. Sources of household revenues.

In study site, sources of water are located in state property or public good, i.e. national park area. According to Mankiw (2018), public good property belongs to government or public and can be used for the benefit of people. The people in the study area are benefitting from public good of WARFP including the use of water resource. Since water is for public, not private, therefore the government do not apply environmental services fee. There are several reasons the government not to apply fee for environmental service: (1) it is not for commercial use, (2) beneficiaries are living nearby forest with less access to economy, (3) environmental service fee may lessen community participation, (4) installation of water is designed and funded by community with no government support.

Management of community based clean water service is done using community's volunteerism. According to Flood et al. (2005), volunteering is at the core and cannot be separated from service activities in both small and large organizations. Ideologically, volunteers play an important role in: (1) building society, (2) strengthening civil society, (3) developing equal relations between parties, (4) building public support, and (5) increasing public participation and accountability (Lingkar LSM 2023). In science and water research, volunteerism helps improve monitoring water and also data science collected by community (Church et al. 2019).

With volunteerism principle, (1) the price of clean water services is set not to make a profit, but only to cover operational costs, (2) officers do not receive a salary but rather want to help the community, and (3) no written rules prepared by the officers. With this principle, cost of getting water service is minimal and the commercial aspect of clean water is not applied, hence volunteerism improves the welfare of communities.

There are two models of water management in the study area. The following Table 2 is describing some characteristics of the two models, community based and community with RCDW.

Service fee is usually discussed and set by community. The fee was greatly influenced by how farming (coffee and cocoa) performed on that year. Therefore, performance of farming determines water service fee.

Cost of maintenance of community based with support RCWS is more expensive as this model require electricity to pump water to the households. While community-based model use gravitational system, no need for electricity.

Table 2. Characteristic of local community water service.

Characteristics	Community Based	Community with RCDW support
Organization	Not yet formalized	Not yet formalized
Method of determining service fee	Community discussion	Refer to RCDW rate
Maintenance	Voluntary	In cooperation with RCDW and community
Water distribution	Gravitation	Electric pump
Community participation	High	Medium
Maintenance fee	IDR 60,000 per year	IDR 120,000 per year
Sanction/penalty	Not available	Not available

Water consumption

According to SNI (2002) standard of using clean water *per capita* per day for urban communities is from 150 to 250 L and the water needs of rural communities is 100 L. The water needed is for bathing, washing, drinking, cleaning, etc. While according to MPWPH (2017), the minimum water requirement for urban communities is 121 L *per capita* per day, while survey results show that urban communities' water consumption is 144 L *per capita* per day. The biggest allocation of water use for family was for bathing, i.e. 45 % of daily water consumption. The study suggests that the average daily water consumption *per capita* of people is 189 L with the lowest consumption being 40 L and the highest being 708 L. The median amount of water consumption is 167 L *per capita* per day. There are around 26 % of respondent who use water less than 100 L *per capita* per day.

The data above shows that the water consumption of rural communities in the research location is partly below the SNI standard for clean water requirements and partly above the SNI. The number of respondents/communities who consume below the MPWPH's standard (121 L *per capita pe*r day) is quite high, that is 29 respondents (32 %). The causes of water consumption below the MPWPH's standard are: (1) lack of knowledge and (2) feeling that they already use enough water at home.

Meanwhile, the average daily water supply is 1994 L *per capita* per day. This figure shows that water supply exceeds average consumption. The minimum water discharge *per capita* is 240 L, which is above the consumption requirement. The median water discharge *per capita* is 1472 L. Meanwhile, the highest water discharge is 8100 L. From the data above, it appears that the water supply from WARFP exceeds household needs or consumption. This advantage is quite large and can be utilized by the community for other water uses.

The study shows that the majority of people (77 %) use excess water to irrigate fish ponds in their yards. The size of the fishpond varies with the smallest being 1.5×3×0.75 m up to 3×5×0.8 m.

Factors affecting water consumption

Factors affecting water consumption are estimated using multiple regression model (3) as stated in the followings:

$$Y = \beta_o + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \beta_3 \cdot X_3 + \beta_4 \cdot X_4 + \mu, \quad (3)$$

where: Y – household water consumption; β_o – constant; $\beta_1, \beta_2, \beta_3$ and β_4 – regression coefficients; X_1 – water supply per month; X_2 – education; X_3 – household revenue; X_4 – number of family member; μ – error.

Definitions of variables are explained in the Table 3.

The computation of multiple regression is using Microsoft Excel for Mac. The summary of the result is as follows.

Result of ANOVA in the following table suggests that all variables affect consumption of water as indicated by F test with p value lower than 0.05 (Table 4).

For measuring effect of each independent variable to dependent variable, t-test is generated, and the result is as stated in Table 5. It suggests that 2 variables significantly affect monthly household water consumption. If other factors assume *ceteris paribus*, then revenue of family per month (negative) and water supply per month have significant effect to water consumption. This result is a bit different from other study: Motho et al. (2022) suggested that there was weak

Table 3. Definition of variables.

Variables	Definition	Measurement	Units
Household water consumption (Y)	Household water consumption for a month which consists of water for: 1. Bathing and toilet 2. Laundry 3. Dishes 4. Washing vehicles 5. Others	Compute households daily water consumption and converted to a month	L per household per month
Water supply per month (X_1)	Volume of water supply received by housholds per month	Supply of water to households on daily basis and converted to a month	L per household per month
Education (X_2)	Length of time respondent took formal school	Length of education time	Year
Household Revenue (X_3)	All revenues obtained by family in one month	Revenues from farm, off-farm, and nonfarm activities in a month	IDR per month per household
Number of family members (X_4)	Number of persons living in one family which consists of parents, children, and relatives.	Number of family members in a house	Person

Table 4. Anova of factors affecting water consumption.

Indicators	*df*	Sum of squares	Mean square	*F*-ratio	*p*-value
Regression	4	4,545,080,677	1,136,270,169	14.51	4.5057E-09
Residual	85	6,655,629,523	78,301,523.79		
Total	89	11,200,710,200			

Table 5. Effect of each independent variable to dependent variable.

Indicators	Coefficients	Standard Error	t-stat	*p*-value
Intercept	-1640.60874	6180.523438	-0.265448187	0.79130695
Water supply per month***	0.828849957	0.202189482	4.099372269	9.43778E-05
Education*	456.7721467	336.5558919	1.357195514	0.178312024
Revenue per month***	-0.39144947	0.099545671	-3.932360561	0.000171057
Number of family member*	1269.834862	1294.283178	0.981110536	0.329322558

Regression Statistics	
Multiple *R*	0.637012593
R Square	0.405785044
Adjusted *R* Square	0.377821987
Standard Error	8848.814824
Observations	90

Note: *** – highly significant, * – significant.

relationship between family income and demand for water. Other study in rural China by Fan et al. (2013) suggested that water supply, education, age, household income, net family size, vegetable area, and use of water heater have strong correlation with domestic water consumption.

According to the model (3) of the factors affecting water consumption, the following equation (4) is obtained:

$$Y = -1640.61 + 0.83 \cdot X_1^{***} + 456.77 \cdot X_2^{*} - -0.39 \cdot X_3 + 1269.83 \cdot X_4 + \mu \; . \quad (4)$$

However, the result suggests that there is negative influence of family revenue and water consumption, that is the higher the revenues, the less family are going to use water service. It is probably because family with more revenues could afford more expensive option that is deep well water pump. The deep well water is perceived more secure in terms of quality than pipe water from open-source spring.

The regression model did not show robust to estimate water consumption as it shows that R^2 is 0.40 indicating 40 % of independent variables could explain the model. Study by Fan et al. (2013) in China, using step wise regression model, also suggested that R^2 was not high, only around 20 %. This means there is still possible additional variables that can be included in the model or using different model in estimating water consumption.

Conclusion

This research provides important lessons about how communities meet basic needs, how to manage and maintain spring water sources, and how they use them for life in simple and inexpensive ways. Forest resources provide convenience because the springs come from maintained forests. The research results concluded that:

1. There are family has used water above national standard. However, 26 % family consumes water less than SNI and around 32 % family consumes less than average consumption of national water consumption.

2. Factors affecting water consumption significantly include water supply to family. Family revenues influence negatively to family water consumption. The more revenues family obtained, the less they consume pipe water consumption. Water supply for family has positive influence to the consumption of water. But, years of education and number of family members have less strong influence to water consumption.

3. More education in water consumption is advised especially for families that still use water less than national standard.

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