Empirical analysis of Q&A websites and a sustainable solution to ensure water-security

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***Abstract*— In this paper, we present a novel empirical study of water-related questions from famous environment-related Q&A websites. Additionally, after a comprehensive evaluation, we explore solutions of global freshwater scarcity. Results show that in-spite of approximately constant number of water-related questions-posted from 2014-2017, the views on these questions are significantly decreasing. Prominent locations of water-related discussions are USA, Europe, Australia, and India. Most of the water-related questions discuss oceanography and water-management. Indian-users are observed to discuss solutions of their local water-related problems while no water-related discussion is observed from desalination-pioneers like Saudi-Arabia, Israel etc. Finite annual freshwater inventories are inadequate to meet stringently burgeoning human demand for water. To fathom desalination as a solution to water-scarcity by employing renewable energy, we draw a comparison of India and Saudi-Arabia and suggest desalination of sea-water as the sustainable solution for water-scarcity in regions with proximity to seas and oceans. This work also responds to myths that devoid of desalination and aims to formulate awareness in order to create a global freshwater security.**

Keywords—Earth Science; Sustainability Living; Desalination; Water Security; Water Scarcity.

I. INTRODUCTION

About 70.8% of Earth's surface is covered by saline Water. These Oceans accounts for 97.13% of water on Earth or 1.338 billion km³ [1, 2]. Total surface water reserves account for less than 2.26 %. It is evident and established from Seckler, D. (1994) [3] research that annual supply of freshwater on earth is finite. Due to increase in population, demands, and uncertainty of rainfall it is evident that these freshwater resources are becoming more and more-scarce [4]. So in order to fathom stand of global-community on water-related issues, and water-related trends all over the world, we conducted a five-year empirical investigation of water-related Questions and Users from popular community-based Q&A websites. We have selected Earth-Science (ES)[15] and Sustainability-Living (SL) [16] for this purpose.

The goal of this work is to obtain a deeper understanding of (i) composition of water-related questions and their trends and whether, (ii) there is any location-specific cues about water-related problems. Specifically, the questions we are trying to answer are:

RQ 1: How persuasive are trends of water-related questions on ES and SL over the years?

RQ 2: What is the percentage of successful, ordinary and unsuccessful questions?

RQ 3: What are the common tags of water-related Questions?

RQ 4: What are the most frequent-locations of the users posting water-related questions?

RQ 5: What are location specific concerns of the users posting water-related questions?

Additionally, from the findings of above RQs, we explore the solutions of global-freshwater scarcity.

II. RELATED WORKS AND RESEARCH CONTRIBUTION

In this section, we present the studies closely related to the work presented in this paper and the novel research contribution made by this work.

A. Related Work

Stack Exchange is a network of popular Q&A websites. These websites are analyzed in the past for various purposes. Lal et al. [7] analyze 42 technical websites from Stack Exchange network to find types of questions that are migrated from one site to another. Barua et al. [8] analyze Stack Overflow questions to find popular topics related to software development. Fu & Fan [9] analyze music related questions from music.stackexchange site to find real-life music information needs and uses. Pinto et al. [10] analyze questions related to energy consumption on Stack Overflow studies. Authors in [11] studied source-code logging questions on Stack Overflow website. In contrast to these studies, we have analyzed water-related questions from Earth Science and Sustainability Living websites.

Carter et al. [12] studied the present water and sanitation problems faced by communities. Whittingtona et al. [13] work on identifying the performance of community-managed rural water supply systems in developing countries. They conducted a multi-country research project and collected data from households, village water committees, focus groups of village residents, system operators and key informants. They report that in Peru and Bolivia, 95% of the houses included in sample

had operational taps. In Ghana 90% of the villages all the taps were working. In Ghana, 38% of households reported that use unprotected source of water for drinking and/or cooking. The 'sense of ownership' is a found to be a critical factor for infrastructure sustainability in developing countries. Marks et al. [14] present a novel measure of sense of ownership for piped water systems. They conducted their study on empirical data collected from 1140 households in 50 rural villages from Kenya. Parameswari & Moses [15] worked on developing an SMS based system for water quality measurement reporting. The work presented in this paper is complementary to these studies as in it we study the questions posted on Q&A websites from people across the world and hence, it can be beneficial in identifying main water-related concerns.

B. Research Contribution

In this work, we systematically analyze the water-related questions from two popular Stack Exchange sites. To the best of our knowledge, this work presented in this paper is the first step towards analyzing water-related questions from Q&A websites. Based upon the results of our empirical analysis we have also suggested usage of desalination of sea-water using renewable energy as a sustainable solution towards water-scarcity.

III. RESULTS AND DISCUSSIONS

A. RQ 1: How persuasive are trends of water-related questions on ES and SL over the years?

In this RQ, we compute a trend of number of water-related questions. We aim to derive whether there is any interest toward the water-related problem, if so, how this interest is changing over the years.

We have answered this question from the two perspectives, first, number of water-related questions posted in a year, and second, trends associated with number of views on water-related questions. To answer this question we aggregated results of water-related tags from ES and SL. Selected water-related tags are depicted in Table-I.

TABLE I. CLASSIFICATION OF WATER-RELATED TAGS AND TOTAL NUMBER OF QUESTIONS ON ES AND SL.

Classification	Tags	ES	SL
Water	Seawater, water, ocean.	298	77
Groundwater	groundwater, underground-water.	53	0
Water-Conservation	Water-conservation, water-management.	0	27
Others	Sea-level, water-vapor, water-table, sea-ice.	96	0
Total Questions		**447**	**104**

It is evident from the Fig.1 that number of water-related questions are constant between 2014 and 2017. Note, complete data of 2018 is not available as this study is conducted in March of 2018.

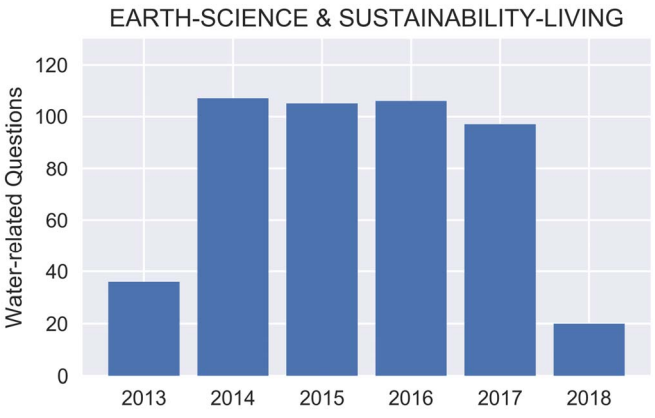

Fig. 1. Trends of number of water-related questions over the years.

Further, our analysis includes an illustration of Box-plots of number of views on water-related questions after removing outliers. Although, number of questions posted from 2014-2017 is approximately-constant but on both ES and SL a similar downtrend is observed that is both thought-provoking and saddening shown in Fig.2 and Fig.3. It can be observed that the number of views on water-related questions are decreasing from the year 2014 in terms of mean, median, quartiles and maximum.

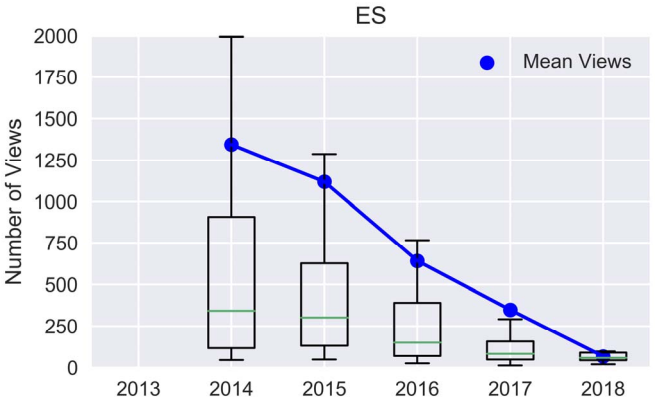

Fig. 2. Box-plot of views on water-related questions on ES over the years.

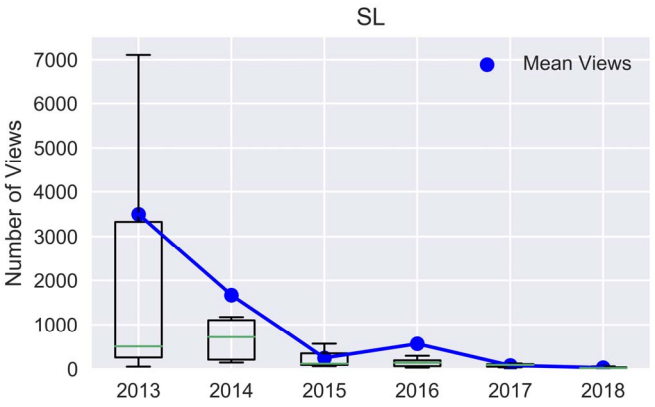

Fig. 3. Box-plot of views on water-related questions on SL over the years.

B. *RQ 2: What is the percentage of successful, ordinary and unsuccessful questions?*

To answer this question we observed the fate of water-related questions on ES and SL. The user who asks the question can review all the answers in the discussion. If one of these answers satisfies the user's query, then he can accept that answer. However, if none of the answers satisfies the user then user has a prerogative to not select any of these answers as accepted. Questions with accepted answers are considered successful while if no one answers the asked number then it is considered unsuccessful [10].

Fig.4 and 5 depict the distribution of ordinary, successful and unsuccessful questions on ES and SL respectively. The ratio of Successful to Unsuccessful questions or SU Ratio is continuously decreasing over the years from 10.4 in 2014 to 1.18 in 2017 for ES while SU ratio turned upside down for the case of SL from infinite in 2013 to 0.25 in 2017.

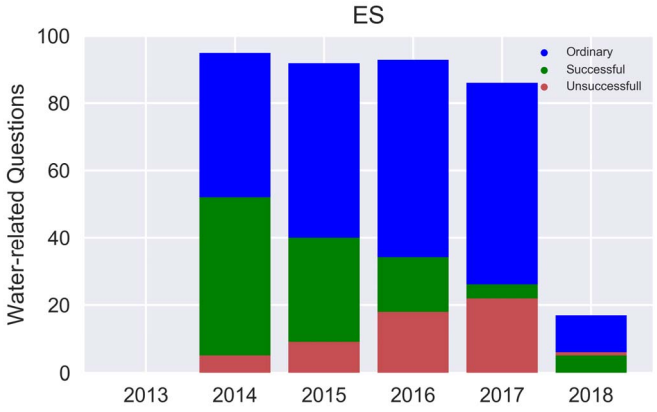

Fig. 4. Distribution of successful, ordinary and unsuccessful water-related questions on ES over the years.

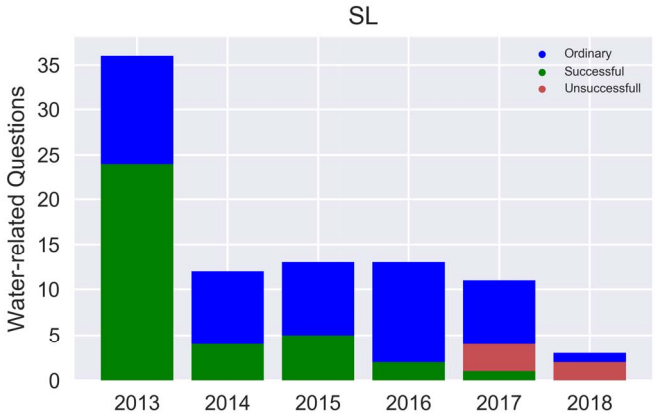

Fig. 5. Distribution of successful, ordinary, and unsuccessful water-related questions on SL over the years.

C. *RQ 3: What are the common tags of water-related Questions?*

Each question on these websites is associated with a tag. This tag describes the general nature of questions and helps to categorize questions. This part of the study involves investigation of tags of water-related questions in order to determine the general composition of water-related questions over these websites.

Fig.6 and 7 depict observed word clouds of ES and SL. Most of the water-related discussion on ES is focused on oceanography and geochemistry while most of the discussion on SL is composed of water-management and conservation related-topics.

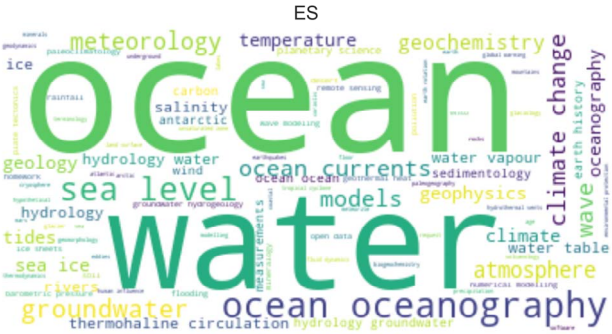

Fig. 6. Word Cloud of water-related tags on ES.

Fig. 7. Word Cloud of water-related tags on SL.

D. *RQ 4: What are the most frequent-locations of the users posting water-related questions?*

The motivation behind this question is a mere curiosity of the origin locations of water-related queries and this result can be useful to understand common problems that are faced by people in these regions. We have mapped the locations of user those were involved in posting-water related queries. Table-II and III depict the locations and number of users posting water-related questions. Indeterminable and less-frequent locations are categories as 'others'. Fig. 8 illustrates the region-wise aggregated results. For better visualization results of multiple European-countries were clubbed and represented as Europe. Results were surprising due to unavailability of Middle-Eastern countries those are pioneer in desalination like Israel, Saudi Arabia, and Dubai etc.

TABLE II. CLASSIFICATION OF LOCATIONS OF USERS POSTING WATER-RELATED QUESTIONS ON ES.

Locations	User Addresses	Count
USA and Canada	Seattle- WA, United States, Playa del Rey- Los Angeles- CA- United States, New York- NY- United States, Massachusetts- USA, Urbana- IL, Washington, Chicago, British Columbia, Peterborough- Canada, Ann Arbor- MI, St. Petersburg- Florida- United States, Syracuse- NY, Connecticut, Bay Area- CA, Arizona- United States. Dallas Tx, California, Monterey- CA- USA, Florida, Canada, Burlington- VT, Missouri, San Francisco, DC, San Francisco Bay Area- CA- United States, Atlanta- GA, Illinois- United States, Laramie- WY- United States, British Columbia- Canada	35
Europe	Reading- England, Europe, UK, Pécs- Hungary, Stockholm- Sweden, Berlin- Germany, Prague- Czech Republic; Paris- France, Szczecin- Poland, Netherlands, Germany, Strasbourg- France, Madrid, Alphen aan Den Rijn- The Netherlands, Lisbon- Portugal, Scandinavia, Flanders, London- United Kingdom, London, Norway, Breda- Netherlands, Milan- Italy, Cambridge- United Kingdom, Bavaria- Germany, Munich- Germany	27
India	India, Delhi- India, Hyderabad, Nagpur- India, Noida- India, Nagpur- Maharashtra- India, Chennai, Tamil Nadu- India	10
Australia and New Zealand	Australia, Canberra- Australia, Hawkes Bay- New Zealand	4
Others	Thailand, The Pillars of Creation- NGC 6611, Uruguay, 127.0.0.1, Probably not that infinite plane of uniform density you physicists go on about, Earth- TX, Sandy Eggo, A small planet somewhere in the vicinity of Betelgeuse, Southern Hemisphere, Lima District- Lima Region- Peru, Campina Grande- Brazil picturanosaurus land fr, Adelaide- South Australia- or at work anywhere in the world, Al Jizah- Egypt, Quito- Ecuador, Taipei- Earth, Colombo, Green Island- TW, Moscow- Russia, South-Africa	20

TABLE III. CLASSIFICATION OF LOCATIONS OF USERS POSTING WATER-RELATED QUESTIONS ON SL.

Locations	User Addresses	Count
USA and Canada	United States, Bloomington- IN, Pittsburgh- PA, Houston- TX,US, Dallas- TX,California, Falls Church- VA, New York- United States,Atlanta- GA- USA, Montpelier- VT- USA, Long Island, Columbus- Ohio, Denver- CO- United States, Berkeley- CA- United States	18
Europe	Antwerpen- België, Netherlands, London- Europe, London, Malvern- United Kingdom,United States / Germany, Sarajevo- Bosnia and Herzegovina, Guildford- United Kingdom, Norway, Galway- Ireland	11
India	India, Bangalore	3
Australia and New Zealand	Napier- New Zealand, Brisbane- Queensland- Australia, Australia	3
Others	Czech Republic, Earth, Mexico City, Bangladesh, On Internet, Brazil	6

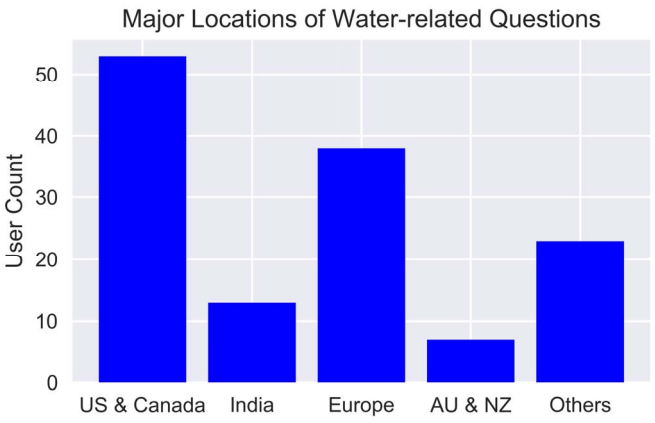

Fig. 8. Locations of users posting water-related questions.

E. What are location specific concerns of the users posting water-related questions?

We further focused on the context of the water-related question asked by users of locations illustrated in Figure-3. Some of the interesting and relevant questions are selected from these locations and discussed.

Some of the interesting questions by American and Canadian users are depicted in Table-IV. The context of most of the questions is water-knowledge, water-usage, and global warming. For an instance, the question with id 4747, discuss, *how much land does it take to support New York City?* User is concerned about the population density of New York City and wants to know how much land outside NYC is effectively dedicated to supports city's food and freshwater demands [16].

TABLE IV. SOME OF THE DISCUSSED QUESTIONS BY AMERICAN/CANADIAN USERS.

Question Title	Id	Region	Web
How much land does it take to support New York City?	4747	US	ES
Sudden Localized Surface Water Temperature Increase In Eastern Lake Superior, Canada	4324	US	ES
Ocean level rising, or the floor getting higher?	8837	US	ES
How to build a waterfall powered electric generator?	1223	US	SL
Analysis of Water Usage by Family Demographics	2319	US	SL
Regarding the melting glaciers and icebergs, why isn't the extra water vapor in the atmosphere mentioned in discussions of global warming?	2455	Canada	ES

Most interesting Questions by European users are depicted in Table-V. The context of questions is mostly knowledge-based, Sea-level rising and comparison of water on Earth and Mars.

TABLE V. SOME OF THE DISCUSSED QUESTIONS BY EUROPEAN USERS.

Question Title	Id	Region	Web
Water on Mars and Earth	13366	Germany	ES
Why deep ocean didn't freeze during snowball Earth?	4315	Poland	ES
Where does the water from rain in rain forests come from?	4326	Netherlands	ES
Dataset for expected sea level rise in case of massive meltdowns (Greenland/Antarctica)	9607	Netherlands	ES
How can people afford to be self-sufficient and sustainable?	4659	UK	SL

Some of the relevant questions by Indian users are discussed in Table-VI. The context of questions are local problems as well as knowledge-based. For an instance, ES Question with id 9810, *Do Hydro-Carbon extraction units pollute groundwater?* The user is concerned about the installation of Hydro-Carbon extraction unit by Government of India in his home state Tamil-Nadu. User suspect ill-effects of this Hydro-Carbon extraction unit on groundwater and production of rice as people of this region are completely reliable on groundwater due to the uncertainty of rain from decades. Another SL-Question with id 5198 discusses ways of *how can a family save water in day-to-day housework?* And *how can an individual contribute to increase ground water level?* User seemed to be concerned about Deforestation and Global-Warming. Additionally, SL-question with Id 4541 deals with a serious issue as regular water supply in the area is hard-water. User discusses the sustainability of water-purifiers considering hard-water supply in his/her apartment.

TABLE VI. SOME OF THE DISCUSSED QUESTIONS BY INDIAN USERS.

Question Title	Id	Region	Web
How to protect underground tank water from insects and Algae?	1158	India	SL
Saving water in day-to-day life	5198	India	SL
Are there hard water purifiers for the main water pipe into an apartment?	4541	India	SL
Do Hydro-Carbon extraction units pollute ground water?	9810	India	ES

Most interesting Questions by Australian/NZ users are depicted in Table-VII. The context of questions is mostly knowledge-based, treating harvested water and recycling.

TABLE VII. SOME OF THE DISCUSSED QUESTIONS BY AUSTRALIAN/NZ USERS.

Questions	Id	Region	Web
Historically, how has the fraction of Earth covered by water changed?	990	Australia	ES
Whole-of-life impact of liquid soap vs solid bars of soap	4353	New Zealand	SL
Is it worth washing a plastic bag to reuse it?	6233	Australia	SL
Maintaining or treating harvested water for animal consumption	103	Australia	SL

Code of the complete analysis is publically available at GitHub repository (https://github.com/newtein/Desalination).

IV. SUSTAINABLE SOLUTION

Most interesting and tempting question that came across in our study is**, *Why is there so much scarcity of water?*** *Even there is plenty of seawater present,* the user heard on the radio that only 1 liters of water will be available per person by year 2090. He is concerned about a global water crisis and perplexed by the origin of water-scarcity even if there are processes like desalination and distillation for making seawater usable/drinkable [17]. **Thus, user proposes a valid question that needs to be further discussed deeply.**

With a limited and scarce freshwater supply and burgeoning demand, it is a pressing need of the hour to welcome processes like desalination. Desalination is the process of removing salt and other impurities from saline water to make it fit for drinking purpose.

Iran is surrounded by the Caspian Sea in the North, the Persian Gulf and Gulf of Oman in the South. *"Water-Water everywhere not a single drop to drink".* This accurately describes the dilemma of drought-affected areas all over the world with proximity to seas and oceans. Gorjian & Ghobadian (2015) discusses desalination as a sustainable solution to water-scarcity in Iran, they focus on using solar-desalination techniques considering the geographical location of Iran [18].

Major finding of above analysis are

- In-spite of approximately constant number of questions posted from 2014 to 2017, views on Water-related questions are decreasing on Environment related-popular Q&A Websites.
- Popular topics/tags of Environment related Q&A Websites deals with Oceanography and Water Conservation but there is no mention of Desalination related tag.
- Most of the water-related Questions are being posted from USA/Canada, Europe, India and Australia/New Zealand. No mention of Middle-east Desalination Pioneers like Israel, Saudi Arabia.
- Some interesting Questions by Indian-users discuss their local water-related problems while most of the questions from other parts of the world are knowledge-based.

This analysis formulated the premise of further work to understand the global status and aspects of desalination. Saudi Arabia is originally a desert country with no permanent rivers and it transformed into a global pioneer in desalination. Before implementing desalination, the country depends solely on rainfall and groundwater resources that are already depleted due to the climate changes and high demands. Now Saudi Arabia is self-sufficient and water secured after implementing more than 28 desalination plants throughout two decades.

In 2016, the Supreme Court of India declared that one-fourth of Indian Population is affected by the drought that accounts 330 million population across 254 of the total 676 districts [19]. SC's 53-page verdict quotes "lack of will" shown by the Centre and States in combating drought and saving lives. Moreover, blamed the Centre guilty of "washing its

hands of" a national disaster that affected one-fourth of the population. About 5,000 farmers committed suicide in last 5 years due to the consecutive failure of crops.

Even having such enormous water scarcity, Only Chennai in India emerged as water-secured city after chronic droughts of 2002. In last decade Chennai developed two operational desalination plants. In India, we propose Nuclear and Solar driven desalination plant because of their null maintenance value, sustainable nature and renewable form of energy. Moreover, we suggest the use of a small-scale solar desalination plant invented in Pakistan as a solution to water-scarcity in India and across the globe.

The Indian government has already spent and still spending multi-billion dollars on various water security schemes like Ganga Action Plan, Interlinking of River (ILR), Namami Gange, Jal Kranti Abhiyan etc. For an instance, since 1985, Rs 4000 crores are already spent on Ganga rejuvenation, moreover, under Namami Gange Scheme Rs 20,000 crores to be spent in another five years and Rs 5,60,000 crores to be spent for Interlinking of rivers that account for around $100 billion dollars [20-22]. Studies show that 70% of Himalayan Glaciers will be lost till 2100 [23] that accounts for the disappearance of Himalayan rivers and all programs such that Namami Gange and interlinking of rivers will go in vain.

While if we act up now desalination and it's pipelining from peninsular region to Indian mainland can act as a savior. Desalination plants in Chennai cost around $5.3 billion each while due to vast R&D in this field, technology is getting cheaper and a significant amount of profit is earned from sales of water that goes to the State. We are not proposing the complete shift of budget from River Rejuvenation to Desalination but we propose an effective planning in this field, keeping in mind current scenario and future prospects. We also propose Nuclear, Solar, and Small Scale Solar Desalination plants that will uphold a clean and sustainable model of development.

V. ADDRESSING A MYTH

Many Environmentalist fears that if humans started drinking sea water then the sea will vanish one day. We hereby present a legitimate fact to disprove this Myth.

TABLE VIII. WATER TRANSACTIONS TO DISPROVE DEPLETION OF SEAS AND OCEANS BY DESALINATION

Water Transactions	Volume of water
Volume of Sea/Ocean water	1.33 Billion km^3
Global annual continental freshwater discharge (excluding Antarctica) from 931 major rivers	37288 km^3/year
Freshwater discharge from Antarctica	2613 km^3/year
Total Discharge per year	39901 km^3
Average human drinks 3L of water per day that account for 1095 litres per year and 7000 million humans (7 Billion) consumes	7665000 million litres or 7.6 km^3/year
Hence, Total consumption is far less than total freshwater discharge with enormous volume of seas and oceans.	7.6 km^3/year << 39901 km^3

Table-VIII depicts the mathematical calculations to disprove this classical myth. Total drinking consumption of freshwater is far very less and nearly insignificant in comparison with yearly freshwater discharge in oceans i.e. 39901 km^3 along with oceans volume of 1.33 billion km^3 [24]. Along with drinking, water can be used for agriculture, domestic and industrial purposes comfortably that will add more water to freshwater discharge, thereby completing water cycle again in the sea.

VI. CONCLUSION

Our empirical analysis on popular environment-related Q&A websites involves a comprehensive investigation of water-related questions, their nature, and their origin. Several interesting perspectives were unraveled during the study. Firstly, Trends in the number of water-related questions is constant from 2014 to 2017, while views on water-related questions are significantly decreasing. Ostensibly, the interest of the community in this regard is decreasing over the time. Secondly, we further analyzed, distribution of questions (successful, unsuccessful and ordinary), it is observed that the percentage of successful to ordinary questions is decreasing over the time. Thirdly, in order to analyze nature of questions, we investigated water-related tags on these websites. Most of questions concerns oceanography (ES) and water-management (SL). Fourthly, we analyzed if there are any cues about region-specific water-related issues. Most of the questions asked concerned knowledge-based general information while some questions from Indian users were based upon local water-related issues. We have encountered interesting questions and research studies, those propose desalination as a solution towards water-scarcity. It was also interesting to note that there were no questions from middle-eastern desalination pioneers like Saudi Arabia, Israel etc. We further analyzed desalination as a sustainable solution in the context of India and Saudi Arabia.

Desalination by employing renewable energy can be the permanent solution towards water security, this is evident from the journey of Saudi Arabia from a desert country with no reliable water sources to a water secured nation. Chennai, India also follows common success model through the steps of desalination. In Spite of success models all over the globe, due to lack of awareness and policy paralysis, one-fourth of Indian population suffers from drought in 2016. Desalination is not being extensively implemented that accounts for the sufferings and suicides of farmers all over globe. High infrastructure cost of desalination can be easily broken-even with happy, secure and productive human lives and improvement in the economy due to the increased agricultural yield from well-irrigated crops. Further, using clean and renewable energy for desalination will contribute in the building of a sustainable model that will ensure a healthy environment and secured human lives.

REFERENCES

[1] H.E. Thomas (1965), Water problems, Water Resources commentary, Water Resources Research Vol. 1,No. 3, Table-1. https://doi.org/10.1029/WR001i003p00435

[2] U.S. Geological Survey's (USGS), Official Website, https://water.usgs.gov/edu/earthhowmuch.html

[3] Seckler, D. (1994). Water resources strategy for the 21st century. Environment and agriculture: Rethinking development issues for the 21st century, 70-107.

[4] Rock, M. T. (1998). Freshwater use, freshwater scarcity, and socioeconomic development. The Journal of Environment & Development, 7(3), 278-301.

[5] Earth Science, https://earthscience.stackexchange.com/ [accessed on 12th Jan, 2018]

[6] Sustainability-Living, https://sustainability.stackexchange.com/ [accessed on 12th Jan, 2018]

[7] Lal, S., Correa, D., & Sureka, A. (2014). Miqs: Characterization and prediction of migrated questions on stackexchange. In In Proceedings of the 21st Asia-Pacific Software Engineering Conference (p. 9).

[8] Barua, A., Thomas, S. W., & Hassan, A. E. (2014). What are developers talking about? an analysis of topics and trends in stack overflow. Empirical Software Engineering, 19(3), 619-654.

[9] Fu, H., & Fan, Y. (2016, June). Music information seeking via social Q&A: An analysis of questions in music StackExchange community. In Digital Libraries (JCDL), 2016 IEEE/ACM Joint Conference on (pp. 139-142). IEEE.

[10] Pinto, G., Castor, F., & Liu, Y. D. (2014, May). Mining questions about software energy consumption. In Proceedings of the 11th Working Conference on Mining Software Repositories (pp. 22-31). ACM.

[11] Gujral, H., Sharma, A., Lal, S., Kaur, A., Kumar, A. & Sureka, A. (2018). Empirical Analysis of the Logging Questions on the Stack Overflow Website. In 2018 Conference On Software Engineering & Data Sciences (CoSEDS) (in-press).

[12] Carter, R. C., Tyrrel, S. F., & Howsam, P. (1999). The impact and sustainability of community water supply and sanitation programmes in developing countries. Water and Environment Journal, 13(4), 292-296.

[13] Whittington, D., Davis, J., Prokopy, L., Komives, K., Thorsten, R., Lukacs, H., ... & Wakeman, W. (2009). How well is the demand-driven, community management model for rural water supply systems doing? Evidence from Bolivia, Peru and Ghana. Water Policy, 11(6), 696-718.

[14] Marks, S. J., & Davis, J. (2012). Does user participation lead to sense of ownership for rural water systems? Evidence from Kenya. World Development, 40(8), 1569-1576.

[15] Parameswari, M., & Moses, M. B. (2018). Efficient analysis of water quality measurement reporting system using IOT based system in WSN. Cluster Computing, 1-9.

[16] Chris Mueller (2015), how much land does it take to support New York City?, https://earthscience.stackexchange.com/q/4747 , Retrieved on 14 March 2018.

[17] Jasmeet singh (2016), Why is there so much scarcity of water?, https://sustainability.stackexchange.com/q/5440/, Retrieved on 14 March 2018.

[18] Gorjian, S., & Ghobadian, B. (2015). Solar desalination: A sustainable solution to water crisis in Iran. Renewable and Sustainable Energy Reviews, 48, 571-584.

[19] PIL by Swaraj Abhiyan (NGO) (2016), 53-page verdict, Bench of Justices Madan B. Lokur and N.V. Ramana, Judgment by Supreme Court of India

[20] The Hindu (May, 2015), Centre okays Rs. 20,000-crore budget for Namami Gange scheme, http://www.thehindu.com/news/national/rs-20000crore-budget-for-namami-gange-scheme/article7201467.ece . Retrieved on 17, December, 2017.

[21] Namami Gange, Minister's Corner, Ministry of Water Resources, River Development and Ganga Rejuvenation Website, http://wrmin.nic.in/forms/contentpage.aspx?lid=1299 . Retrieved on 17, December, 2017.

[22] Interlinking of rivers (August, 2016), Press Information Bureau, Government of India, Ministry of Water Resources

[23] Shea, J. M., Immerzeel, W. W., Wagnon, P., Vincent, C., & Bajracharya, S. (2014). Modelling glacier change in the Everest region, Nepal Himalaya. The Cryosphere Discussions, 8, 5375-5432.

[24] Aiguo Dai & Kevin E. Trenberth (2002), "Estimates of Freshwater Discharge from Continents: Latitudinal and Seasonal Variations", National Centre for Atmospheric Research, vol 3.