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Diffusion of Innovative Water Atomization Technology to Conserve Water in Water Stress Countries

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Abstract

Clean water is a challenge in water stress semi-arid country like Botswana. All the perennial rivers are shared with river basins of neighbouring countries. Some of the ground water in aquifers are of fossil nature and remain without any recharge. The low rainfall and the increasing temperature increase further the scarcity of water. With the Adaptation at Scale in Semi-Arid Regions (ASSAR), the impact of climate change due to Global warming for Botswana, it is estimated that the Limpopo Catchment (runoff) would decrease 26%, 36%, 46% and 56% under the global warming 1.5°C, 2°C, 2.5°C, and 3°C respectively. Hence water management is imperative in Botswana

In managing water, demand management with price and non-price strategies, is the most abundantly used approach. In this respect, a recently emerged strategy is the application of water atomization technology. This research investigates the effectiveness of using water atomization technology at Botho University, as a large size consumer in Botswana and envisage further to scale up to a macro level in Botswana.

At Botho University, having studied this as a case study project, it was found that the application of water atomization technology at micro level enables us to save 75% of water that was previously consumed. The installation of technology is a simple process and the payback period is shorter. Further, it was found that the projection for the application of the technology at macro level reflects that there would be a saving of water by 36 million kilolitres. Hence, it was recommended to have a marketing strategy based on principles of persuasion for diffusion of innovative technology to attract adopters, within a budgeted period of ten years. These findings and recommendations are significant not only for micro level application but also macro level application in the country for fulfilling the pledge taken by the country and corporate citizens with SDG 06: Clean Water for all and Sanitation & SDG 12: Responsible Consumption of 2030 Agenda for 17 Sustainable Development Goals(SDGs). However, the study is subject to the limitation that assessing water savings expected from the water technology among various types of customers at macro level is dependent on high resolution water consumption data which is not publicly available.

Keywords: Water Conservation, Water Atomization, Technology, Sustainable Development Goals (SDGs), Diffusion of Innovation, Principles of Persuasion, Adopters.

Introduction

Clean water is a global challenge aggravated by rapid social and economic development, population growth and climate change. As a result, water is becoming a scarce commodity in water stress countries in particular. Botswana is a water stress country which has fresh water resources between 1000-1700m^3 per person per year [1-3]. The whole country suffered from droughts in 1981-87, 1991-1999, 2001-2005, 2007-2008, 2012 and 2014 [4]. The Semi-arid country with low rain fall and increasing temperature increase the intensity of water scarcity. The average minimum temperature has increased from 12.60^{0}C during 1971-2000 to 14.7^{0}C in 2016. The rainfall is another critical factor for water scarcity. The national average precipitation per annum is between 250mm to 550mm but the national average rainfall follows a downward trend from 463.7mm during the period of 1971-2001 and 216mm in 2016/17 [5, 6].

The water sources of Botswana consist of surface water and underground water. The surface water from rivers, pans and dams is affected by the rainfall and temperature. All the perennial rivers are shared with river basins of neighbouring countries, Okavango, Zambezi, Orange-Senqu and Shashe-Limpopo. Some of the ground water in aquifers is of fossil nature without recharge [7]. They are also subject to the adverse impact of climate change. Hence, water management is imperative in Botswana.

In water management, demand management is the most abundantly used strategy for water conservation. There are many strategies for water conservation available for water utility authorities under demand management. Some are price strategies. Some are non-price strategies. Increasing block tariff system is a powerful pricing

strategy than a uniform pricing system [8]. Non-price strategies such as awareness programmes enable to conserve water not only among permanent residents but also among non-permanent residents, for example, hotel guests who have no direct pecuniary benefits [9]. Innovations of water technology is a non-price strategy but it is different from some of non-price strategy such as awareness programmes because innovative technology provides mutual pecuniary benefits to all stakeholders of water, water utility authority, consumers and the society at large. Water atomization technology is an innovative technology which could be applied at micro level and even macro level in a country, however, the said water technology has not yet diffused in Botswana, for example, the water project studied here as a case study was an experience of a senior manager from outside the country.

Accordingly, there is a research gap to find the application of water atomization technology at micro and macro level. Hence, this investigation is carried out to ascertain the effectiveness of the application of water atomization technology at Botho University in Botswana. The research strategy is primarily a case study. Research questions are posed for two social phenomena. One of the social phenomenons under the investigation is how water atomization technology is effective at micro level in terms of pecuniary benefits together with the acceptance of technology among the community. The second phenomenon is to ascertain by projecting how the application of water atomization technology is effective at macro level in Botswana. The findings for these social phenomena enable to meet the purpose of the research is to motivate water consumers, domestic, government, councils and business for the application of the technology and to convince water authorities to diffuse the technology with the principles of persuasion latter which persuade the various types of adopters, innovators, early adopters, early majority, late majority, laggards and sceptics, beyond the voluntary responsible behaviour but not cohesive. Findings are significant for both water authorities and consumers because of mutual pecuniary and non-pecuniary benefits. However, the study is subject to the limitation that assessing water savings expected from the water technology among various types of customers and factors are dependent on high resolution water consumption data is not publicly available [10].

The remaining parts for the paper are dealt with as follows. Immediately after the introduction, Part 2:Literature review is dealt with the supporting theoretical background under which it is discussed demarketing strategy to conserve water with water atomizing technology as a social innovation. Further it is discussed theoretical support of diffusion of innovation with principles of persuasion. Part 3: Materials and Methods deals with the research methodology that the study is a case study under mixed method research. Part 4: Findings deal with the findings of the research. Part 5: Discussion elaborates how findings are met. Part 6: Conclusion summarizes the study and further indicates managerial and policy implications together with the necessity of future researches.

Literature Review

Water conservation is inevitable for water stress countries. Demand management of water is the most open aspect for water conservation than the supply management. There are various strategies embedded with technology are available for the purpose in the market. A recent innovation to conserve water by atomizing water available in the market now and the technology boast to save up-to 98% but the empirical evidence in this case study leveraged to save water by 75%. The application of water atomization technology is a demarketing strategy to conserve water. Demarketing means unselling or marketing in reverse [11]. In the context of water, demarketing means the marketing efforts taken for attracting water customers to limit the consumption of water because water is a scarce commodity in a water stress country. Limiting the consumption means reducing the waste of water and sells them to others who desperately need. The awareness programmes for water conservation is a de-marketing strategy [12]. Pricing strategy, block tariff system are also demarketing strategies [13].

Application/adoption of water atomization technology is a demarketing strategy with social innovation. The term social innovation includes various organizational and inter-organizational activities which are used to address the most deep-rooted 'problems' of society, such as poverty, inequality and environmental degradation [36]. It is defined social innovation as "new ideas that simultaneously meet social needs and create new social relationships or collaborations". It is pointed out that positive socioeconomics changes required for sustainable development can be brought by the application of social innovations [14, 15]. Hence, water atomization technology can be treated as social innovation to solve social problems such as clean water for community [16]. Since the water market is not deregulated in many countries and under the direct control of parastatal organizations, the adoption of water technology for water conservation is within the water authorities. They enable to use water in their business as a social entrepreneurship and extrapreneurship. The objective of social entrepreneurship with profit motive or not is to address a particular social problem and extrapreneurship as a partnership which goes beyond the business to customer (B2C) relationship creating network and leveraging greater impact in resolving social problems for sustainable development [39].

In the endeavour of resolving social problem of water scarcity with water atomization technology, the social science model called Diffusion of Innovation (DOI) developed by E.M. Rogers in 1962 outlines how new technology is adopted (Figure 01). Accordingly

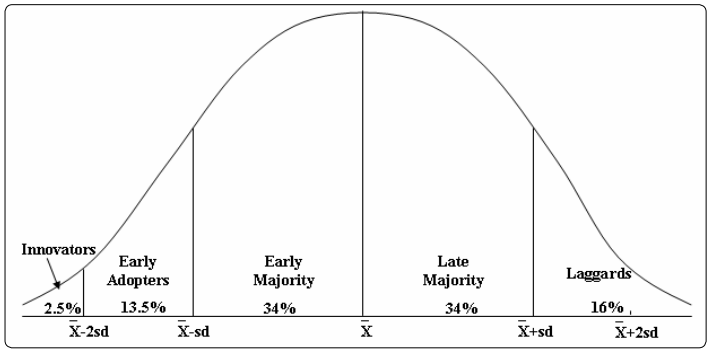

Figure 01: Adopter Categorization on the Basis of Innovativeness

Source: *Diffusion of Innovations, fifth edition* by Everett M. Rogers (2003) [17].

In this bell shaped diffusion of innovation, innovators are those who are quick to adopt the technology such as water atomization technology because they experiment the new ideas even taking a risk of failure. Early adopters are those who learn from innovators

and active to find ways to improve their lives with the innovation. Further, they share their experiences with others. Early majority are those who are pragmatists take decisions for their commitment with the new technology after analysing feedback obtained from innovators and early adopters. Late majority are those who are inescapable of adopting the technology otherwise there would be risks and additional cost to be incurred in the absence of adoption. Laggards are those who are struggling to adopt the new technology and sceptics are those who are suspicious always for adoption of new technology [18].

The adoption of technology for water conservation can be achieved by persuasion. Persuasion is a psychological process to persuade the recipient (water customers) by the persuader using communication channels to change the behaviour of recipient for the purpose of adoption of the technology [19, 20]. Persuasion enables to shape the attitudes or behaviour of the customers without coercion or deception [21]. In other words, persuasion system enables to change the attitudes and resultant behaviour for voluntary responsible behaviour for the conservation of water as stipulated by national regional and international legal policy framework of water management.

The adoption of water atomization technology by consumers for water conservation in a water stress country can be persuaded by the principles of persuasion [22]. There are seven principles in this marketing strategy which could be used to tailor made for making persuasive adopters who are assertively and confidently committed for water conservation. The principle, reciprocity means give a little to something to get a little something in return from consumers. The principle, commitment means consumers are committed when their beliefs are consistent with their values. The principle, social proof means consumers are committed when they feel that they are validated by others. Authority means the consumers are subject to authority. The principle, Liking means when consumers like others they tend to follow them. The principle, scarcity means consumers want to commit more when the commodity is scarce. The principle, unity means consumers want to be a part of group or community rather than to individualistic. These principles have evolved and were used in profit motive and non-profit motive marketing campaigns [23].

Materials and Methods

Water conservation through water atomization technology is a project implemented in a large scale at Botho University in Botswana. The social phenomenon under the study is to ascertain the effectiveness of the project at micro level and projection of effectiveness at macro level. Due to the nature of availability of primary and secondary data the interpretivist approach was chosen in a part of the research. The lens of interpretivist philosophy is methodologically consistent with qualitative research methodology for uncovering shared meanings for the social phenomenon studied here. Primary and secondary data were obtained from three sources, interviews, project document analysis and observations. Hence, this investigation is a multimethod study. The strategy used in the study is therefore a case study. A case study is an in-depth inquiry of a social phenomenon in a real life setting [24]. The case study strategy was supported with grounded theory by comparative comparison with the same source and different sources for validation by triangulation [25]. The validation was further strengthened by peer examination and member check. Reliability of the research was strengthened by engaging two researches including the project manager. Both researches are participant observers as well. The data so collected were analysed qualitatively and theory was developed inductively. However, quantitative data not statistical but financial data were also collected for ascertaining the effectiveness of the project at micro level and macro level. The quantitative data so collected were used to develop theory by deduction without developing shared meanings, for example, payback period. Since the data were collected at a particular time, the study is a cross sectional study. Since quantitative data was collected from the project report directly, the face validity and internal validity is ensured. The combination of interpretation of both qualitative data and quantitative data pave the way for a mixed method research.

Findings

The water atomization technology boasts that the water comes through the tap bounces on the surface which results in use only a 2% and waste 98%. The technology claims the saving of 98% in their theoretical design. Botho University, a large size business consumer adopted the technology for saving water and found in this study that the university enables to save water by 75%.

It was further found out that the investment for replacing the conventional faucets with specially designed high speed, heavy misty and shooting out nozzle of the faucets which atomize water, has a shorter payback period of one year and the installation is a simple process for replacing the conventional faucets.

The community of the users of water, students, academic and non-academic staff and others have embraced the technological change for nearly two years. However, they were sought their feedback after installation of the technology and adjusted the faucets to increase the water flow thereby now enable to save 75% of the water consumption.

When considering the application of water atomization technology at macro level, it was projected that approximately 36 million of kilolitres would be saved at an overall saving of 50% at macro level in Botswana.

Discussion

Background

Water is a part and parcel of day today life of all beings in particular human beings. It plays a major role in health and sanitation of people. United Nations in their Sustainable Development Goals Knowledge platform expresses their scepticism for reaching the full implementation of integrated water resources management by 2030 with Sustainable Development Goals 6 “Ensure availability and Sustainable Management of water and sanitation for all ” pointing out inter alia that 785 million of people lack even for basic drinking water despite the fact that there is an increased access for safely managed drinking water services from 61 to 71% in 2015 but remained unchanged in 2017 [26]. They further point out that 701 million people still participate in open defecation despite the fact that there is an increased safely managed sanitation services from 28% to 43% in 2015 and 45% in 2017.

The above scepticism reminds to have a strategy in water stress countries so that those countries enable to ensure water and sanitation for all. Botswana is a water stress country caused by semi-arid nature that has characteristics such as low rain fall, unreliable rain fall,

constant drought and high rate of evaporation. As result, there is limited ground water. In addition, the country extracts surface water from four foreign river basins Okavango, Zambezi, Orange-Senqu and Shashe-Limpopo flowing from neighbouring southern African countries (Department of Water Affairs- Ministry of Minerals, Energy & Water Resources, 2013) [27].

Adaptation at Scale in Semi-Arid Regions *(*ASSAR) analysed what Global warming of 1.5° C and Higher means for Botswana and estimated impacts under projected climate change (Table 01)

Table 01: what Global warming of 1.5° C and Higher means for Botswana

Local Impacts in Botswana			Global Warming above Preindustrial Level			
			1.5° C	2° C	2.5° C	3° C
Projected Climate Change	Climate	Mean Temperature (°C)	Increase By 2.2	Increase By 2.8	Increase By 3.5	Increase By 4.2
		Heat Waves (days)	Increase By 43	Increase By 72	Increase By 105	Increase By 136
		Annual Rainfall	Decrease By 5	Decrease By 9	Decrease By 10	Decrease By 11
		Heavy rainfall (days)	Decrease By 2	Decrease By 3	Decrease By 4	Decrease By 4
		Dry days	Increase By 10	Increase By 17	Increase By 24	Increase By 28
Estimated Impact	Water	Okavango River (Stream Flow)	Decrease By 6%	Decrease By 12%	Decrease By 18%	Decrease By 24%
		Limpopo Catchment (runoff)	Decrease By 26%	Decrease By 36%	Decrease By 46%	Decrease By 56%
	Agriculture	Maize (yield)	Decrease By 23%	Decrease By 35%	Decrease By 46%	Decrease By 58%
		Sorghum (yield)	Decrease By 11%	Decrease By 17%	Decrease By 23%	Decrease By 29%
		Water for Lives Stock (Cost of Pumping)	Increase By 15%	Increase By 19%	Increase By 22%	Increase By 24%
	Health	Malaria (Malaria months of risk)	Decrease By 12%	Decrease By 16%	Decrease By 29%	Decrease By 29%
		Heat Stress (No of Days of Exposure)	Increase By 20	Increase By 20	Increase By 40	Increase By 40

Source (CDKN, 2018; African Portal, 2018) [28, 29].

Accordingly, water management is imperative in Botswana. There are two ways for water management. One of them is the supply management and the other way is the demand management [30]. In the presence of limited ground water and surface water, supply management is subject to many constraints. One of the limiting factors of supply management is the intensive capital investment in building dams, purifying plants etc. The most abundant way of water management is the demand management by conservation of water [31]. There are several strategies for water conservation by demand management, namely, government regulation, plumbing standards, water conservation awareness programmes, water technology for efficient use of water smart metering and water rates reflected true social cost [30, 32, 33].

Micro Level Application of Water Efficient Technology in Botswana

Botho university in Botswana under this study installed a simple water technology system under which the conventional water system was replaced by dual flush toilets, water efficient shower heads and faucets with a specially designed high speed, heavy misty and shooting out nozzle of the faucets. The advantage of the water efficient appliances is that the old system releases a large volume of water which bounce on the surface and use only a small fraction, for example, use only 2% and waste 98% (as promoters of the technology explains in their theoretical design) because these faucets atomize water breaking millions of tiny droplets which enable to increase the surface area of the water by contacting almost all water coming through the faucets. In support of the claim of waste of water, a study of waste water narrates how water is wasted "for brushing, washing hands, shavings by running tap for 9 min require 81 litres of water while using mug and tumbler require meagre 3 litres [34]. Similarly, shower (shower flower open all the time during shower), flushing traditional toilet consumes 104 litres, while with modified adaptation of wet down, tap off, soap up, rinse off method and using modern dual flush system in toilet needed 25 litres of water. Besides, watering plants, washing floor, and washing car by running hose for 20 min may exhaust 720 litres water, while water can, mop or bucket and two buckets car washing method may require 41liters of water [34].

The new system is acceptable by the students and staff community of the university and it is in successful operation for the past two years. The savings of the new water efficient system enables to recover the investment within one year, the payback period. There are many other advantages conferred by the new system. Among them, the community of the university receives continuous flow of water, the investment for replacing faucets, dual flush system and head showers and labour is an affordable investment which is a best alternative for capital intensive infrastructure investments for changing old plumbing system, retrofitting buildings and installing new plumbing and fixtures [35]. Easy installation and reducing water foot print are also other advantages. Water foot print is an indicator of water conservation [36]. Carbon footprints are global whereas water foot prints are local indicator for conservation of water [37].

When considering the challenges of the project, there was a passive resistance to change the habit to conserve water in the beginning was natural and tolerable. All the communities of the university, students, academic and non-academic staff and the management act mutually to understand the challenges of the project and later the faucets were leveraged to increase the flow by 25% use and 75% saving of water in practical application of the technology. The awareness of the fact that the country is water

stressed motivates the acceptance of the new water efficient technology. The water atomization project is in successful operation nearly two years. The strategic plan of the university, Sustainable Growth Strategy 2018-2022, had provided the necessary policy background providing inter alia that "Environmental sustainability is also critical to ensuring that the world as we know it exists; environmental degradation symptomatically felt through higher temperatures, water shortages, harsh weather and food shortages affect the growth of any organisation and its community. Sustainability alludes to a sense of responsibility that any large organization like Botho University has for its People, society and the environment".

Macro Level Application of Water Efficient Technology

The micro level application of water technology at the university, a large size organization above discussed enlightens water authorities for macro level application. Water Utilities Corporation is the parastatal organization owned by the Botswana Government responsible for the provision of water and waste water across the country since 2009. Its water infrastructure includes 900 boreholes 9 dams in Gaborone, Nnywane, Bokaa, Shashe, Letsibogo, Ntimbale, Dikgatlhong, Lotsane and Thune as well as 365km long pipeline, water treatment plants and associated pump stations together with a duplicate North South Carrier in progress. The customer base has increased from 80,000 in 2009 to 355,000 in 2019.

The customer base for portable water consists of four types of customers, domestic customers. Governments, Councils and Business. They are largely service organization. They consume water for drinking, outside use, washing clothes, washing dishes, flushing the toilets, showers and bath in general. In general, Institutional customers are willing to save water with different strategies than domestic customers who consume water at a low level at domestic level [38, 39]. The water consumers of governmental organizations and Councils can be persuaded for water conservation in particular, Botswana is a signatory for 2030 Agenda for 17 Sustainable Development Goals and Paris Climate Agreement. With a view to commit for the above two universal agreements entered in 2016, multiple ministries and connected institutions have been formed into a structural team. Their mission includes, The SDG 06: Clean Water and Sanitation & SDG 12: Responsible Consumption and Production. In this respect, the water authorities are also mandated for making clean water available for all Batswana by 2030. Regional and national level water policy framework also mandate water conservation. The framework includes Botswana National Water Policy, Botswana Integrated Water Resources Management & Water Efficiency Plan, Water Utilities Corporation Act of 1970, SADC Protocol on Shared Watercourses [29].

There is only one decade for meeting the target. Hence, it is recommended here to adopt water atomization technology at macro level taking this case study into consideration. The water conservation is projected below for 10 years with Diffusion of Innovation Model (DOI).

The four types of customers are billed by Water Utilities Corporation under water management centres on meter readings and estimations. There are 16 water management centres out of which seven centres are identified as southern water management centres and the remaining nine are under northern water management centres. These 16 centres have billed 72 million kilolitres approximately in 2016/17.

As per the Diffusion of Innovation (DOI), there are six types of adopters, namely, innovators, early adopters, early majority, late majority. Laggards and Sceptics. 10 years' time span has been allocated as 1, 2, 2, 2, 2, and 1 years respectively. Savings of the water is projected accordingly. In this projection, it is assumed that 50% of the water (as a variable) can be saved by adoption of water atomization technology as an attainable target even-though this case study's empirical data reflects 75% saving. The projected savings of water is based on billed customers in 2016/17. The projected savings are displayed in Table 2 and 3. Table 2 for billed customers under Southern Management Centres which would be able to save 19.4 million of kilolitres approximately. Table 3 for billed customers under Northern Management Centres which would be able to save 16.5 million of kilolitres. Both together enables to save 36 million of kilolitres without increasing purifying centres for new water market even with a premium price.

Table 02: Southern Management Centres

Assumed Savings	50%	**Intended Savings by Application of Water Efficient Technology in Kilo Litres**					
Budgeted time period		2021	2022-2023	2024-2025	2026-2027	2028-2029	2030
Type of Consumers		Innovators	Early Adopters	Early Majority	Late Majority	Laggards	Laggards
Adoption rate		2.50%	13.50%	34.00%	34.00%	13.50%	2.50%
Gaborone	23 980 590	299 757	1 618 690	4 076 700	4 076 700	1 618 689.83	299 757
Kanye	3 555 939	44 449	240 026	604 510	604 510	240 025.88	44 449
Lobatse	3 547 346	44 342	239 446	603 049	603 049	239 445.86	44 342
Molepolole	3 258 863	40 736	219 973	554 007	554 007	219 973.25	40 736
Mochudi	2 488 821	31 110	167 995	423 100	423 100	167 995.42	31 110
Ghanzi	1 068 637	13 358	72 133	181 668	181 668	72 133.00	13 358
Tsabong	904 723	11 309	61 069	153 803	153 803	61 068.80	11 309
Total	38 804 919	485 061	2 619 332	6 596 836	6 596 836	2 619 332	485 061
Cumulative Savings		485 061	3 104 394	9 701 230	16 298 066	18 917 398	19 402 460

Source: Authours elaboration by using Statistics Botswana (2017b)

Table 03: Northern Management Centres

Assumed Savings	50%	Intended Savings by Application of Water Efficient Technology in Kilo Litres					
Budgeted time period		2021	2022-2023	2024-2025	2026-2027	2028-2029	2030
Type of Consumers		Innovators	Early Adopters	Early Majority	Late Majority	Laggards	Laggards
Adoption rate		2.50%	13.50%	34.00%	34.00%	13.50%	2.50%
Francistown	10 148 833	126 860	685046	1 725 302	1 725 302	685046	126860
Selibe Phikwe	6 386 006	79 825	431055	1 085 621	1 085 621	431055	79825
Serowe	3 308 364	41 355	223315	562 422	562 422	223315	41355
Palapye	3 155 979	39 450	213029	536 516	536 516	213029	39450
Masunga	2 726 562	34 082	184043	463 516	463 516	184043	34082
Mahalapye	2 535 658	31 696	171157	431 062	431 062	171157	31696
Maun	2 039 668	25 496	137678	346 744	346 744	137678	25496
Letlhakane	1 464 876	18 311	98879	249 029	249 029	98879	18311
Kasane	1 263 158	15 789	85263	214 737	214 737	85263	15789
Total	33 029 104	412 864	2 229 465	5 614 948	5 614 948	2 229 465	412 864
Cumulative Savings		412 864	2 642 328	8 257 276	13 872 224	16 101 688	16 514 552

Source: Authours elaboration by using Statistics Botswana (2017b)

Having being felt of successful application of the water technology in this case study, the participants of this water research is optimistic of macro level application of the technology. There are two important contributions from them. One of them is that the provision of technology under the water authorities and the communication of the necessity by persuasion than cohesion. The behavioural change for adoption of water technology by cohesion is not pragmatic because administration of the compliance of legal framework that imposes fines and penalties is a complex process which includes regulatory authorities for enforcement of the law. However, it does not exclude legal framework such as Water Act of 1968, Water Works Act of 1962, Water Utility Corporation Act of 1970 and Boreholes Act of 1956. In addition, there are nine more legislative enactments such as Environmental Impact Assessment. However, adoption of technology can be inspired by marketing techniques such as seven principles of persuasion because persuasions strengthen the voluntary responsible behaviour for adoption of water technology.

When analysing the responses of the participants of this investigation it is uncovered that all seven principles of persuasion are congruent with the adoption of water technology more fully summarized below. The principle of reciprocity is satisfied if the water authority facilitates to provide water technology by way of financial support, technical knowhow etc., by which the consumers enable to receive the pecuniary benefit by saving water. The principle of commitment is satisfied because many consumers, government, councils, business and even domestic customers appreciate sustainable values. The principle of social proof is satisfied because; clean water for all as mandated by 2030 Agenda for 17 SDGs is validated by others in the community. The principle of authority is satisfied because water market is not deregulated and the consumers are subject to the water authority. The principle of liking is satisfied because the adopters will follow from innovators, early adopters up to sceptics in a persuasion marketing campaign. The principle of scarcity is satisfied because water is scarce resource in a water stress country. The principle of unity is satisfied because they wish to be a part of community.

Conclusion

It is the need of the hour to conserve water in Botswana. The demand management is one of the most abundantly used approaches in this respect. There are price and non-price strategies available for water conservation. The adoption of innovative technology, water atomization is a non-price strategy for water conservation available for water consumers despite of their size and nature of the consumers. In other words, water atomization technology can be adopted by four types of consumers, domestic, government, councils and business customers to a very large extent in Botswana.

The installation of water atomization technology is a simple process. The adoption of this new technology at Botho University enabled us to save water by 75%. It was further found out that the investment for replacing the conventional faucets with specially designed high speed, heavy misty and shooting out nozzle of the faucets which atomize water, has a shorter payback period of one year. The community of the users of water, namely the students, academic and non-academic staff and others have embraced the technological change.

The application of water atomization technology when considered at macro level in Botswana, it was projected that approximately 36 million of kilolitres would be saved at an overall saving rate of 50%. The water utility Corporation (WUC) as the sole authority in regulating water supply within Botswana, can provide a conducive environment for adoption of this newly emerging technology. Hence, to take it to a macro level, it is recommended to have a marketing strategy based on principles of persuasion for diffusion of innovation and attract adopters, innovators, early adopters, early majority, laggards and sceptics during a period of next 10 years.

Managerial implication of the study is that the findings of the study enlighten water consumers, government, councils, business and domestic consumers to adopt water atomization technology. Policy implication is that the policy makers are brought to the attention that the current policy and institutional framework could,

by financial and nonfinancial motivational scheme, be strengthened for adoption of water atomization technology among consumers. However, many future researches are required from each segment of water consumers.

References

1. Wang X, Zhang J, Shahid S, Yu L, Xie C, (2018) Domestic water demand forecasting in the Yellow River basin under changing environment. International Journal of Climate Change Strategies and Management 3: 379-388.
2. United Nations Environmental Programme UNEP (1999) Global environmental outlook 2000, Earthscan Publications.
3. Rowntree K (2013) Water resources in Botswana with particular reference to the Savanna regions. The South African geographical journal 85: 42-49.
4. Statistics Botswana (2016) Botswana Environment Statistics: Natural Disasters Digest 2015.http://www.statsbots.org.bw/sites/default/files/publications/Botswana%20Environment%20Statistics%20Water%20%20climate%20Digest%202017.pdf
5. Statistics Botswana (2017) Botswana Environment Statistics: Natural disasters Digest 2017.http://www.statsbots.org.bw/sites/default/files/publications/Botswana%20Environment%20Natural%20Disaster%20Digest_2017.pdf
6. Statistics Botswana (2017). Botswana Environment Statistics: Water and Climate Digest 2017. http://www.statsbots.org.bw/sites/default/files/publications/Botswana%20Environment%20Statistics%20Water%20%20climate%20Digest%202017.pdf
7. UNDP (2012) Reflecting on the Challenges of Attaining a Green Economy. Botswana Water Sector Policy Brief 2012: 1-9.
8. Ratnasiri S, Wilson C, Athukorala W, Garcia-valin MA (2018) Use and conservation : a quasi-experimental. Environ Econ Policy Stud. 20: 547-560
9. Reiley D, Jung S, Saijo T, Eco K R, National S, et al. (2018) Every Drop Counts : A Water Conservation Experiment With Hotel Guests. Economic Inquiry *56*: 1788-1808.
10. Wang XJ, Zhang JY, Shahid S, He RM, Xia XH, et al. (2015) Potential impact of climate change on future water demand in Yulin city, Northwest China. Mitigation and Adaptation Strategies for Global Change 20: 1-19.
11. Kotler P (1973) The Major Tasks of Marketing Management. Journal of Marketing. 37: 42-49.
12. Yousif R (2014) Measuring the Effectiveness of Demarketing in Influencing Consumer Behavior of Individuals. International Journal of Business Management & Research 4: 31.
13. Lowe B, Lynch D, Lowe J (2015) Reducing Household Water Consumption: A Social Marketing Approach. Journal of Marketing Management 31**:** 378-408.
14. Murray R, Caulier Grice J, Mulgan G (2010) The Open Book of Social Innovation, National Endowment for Science, Technology and the Art, London.
15. Heiskala R, Hamalinen TJ (2007) Social innovation or hegemonic change? Rapid paradigm change in Finland in the 1980s and 1990s. Social Innovations, Institutional Change and Economic Performance.2007: 80-94.
16. Phills JA, Deiglmeier K, Miller DT (2008) Rediscovering social innovation. Stanford Social Innovation Review 6: 34-43.
17. Rogers EM (2003) Diffusion of innovations (5th Ed). New York: Free Press.
18. Dearing J, Cox J (2018) Diffusion of Innovations Theory, Principles. Health Affairs 37.
19. Lockton D, Harrison DJ, Stanton NA (2010) The Design with Intent Method: A design tool for influencing user behaviour. Applied Ergonomics 41: 382-392.
20. Shati A (2020) mhealth applications developed by the Ministry of health for public users inksa: A persuasive systems design evaluation. Health Informatics - An International Journal 9: 1-13.
21. Oinas Kukkonen H (2009) Persuasive Systems Design: Key Issues, Process Model, and System Features. Communications of the Association for Information Systems 24: 485-500.
22. Cialdini RB (1984) Influence: The Psychology of Persuasion. Journal of Marketing Research.
23. Seethaler R, Rose G (2006) Six Principles of Persuasion to Promote Community-Based Travel Behavior Change. Transportation Research Record 2006: 42-51.
24. Yin RK (2014) Case Study Research: Design and Method 5th Ed. Canadian Journal of Program Evaluation 30: 1-5.
25. Suddaby R (2006) From the Editors: What grounded theory is not. Academy of Management Journal 49: 633-642.
26. United Nations (2019) Sustainable Development Goals 6: Ensure Availability and Sustainable Management of Water and Sanitation for All. Progress & Info 2019.
27. Department of Water Affairs- Ministry of Minerals, Energy & Water Resources (2013) Botswana Integrated Water Resources Management & Water Efficiency Plan. (L. Dikobe, Ed.) Gaborone, Botswana: Government of Botswana.
28. CDKN: Climate & Development Knowledge Network (2018) Opinion: What global warming of 1.5°C and higher means for Botswana and Namibia. CDKN 2018.
29. Africa Portal (2018) What Global Warming of 1.50 C and Higher means for Botswana and Namibia. Mark New Brendon Bosworth.
30. Willis RM, Energy O, Stewart RA, Talebpour MR (2011) End use water consumption in households : impact of socio-demographic factors and efficient devices. Journal of Cleaner Production 60: 107-115.
31. Steg L, C Vlek (2009) Encouraging pro-environmental behaviour: An integrative review and research agenda. J Environ Psychol 29: 309-317.
32. Plappally A, Lienhard V (2012) Energy requirements for water production, treatment, end use, reclamation, and disposal. Journal of Renewable and Sustainable Energy Reviews 16: 4818-4848.

33. Ouda OKM, Shawesh A (2013) Review of domestic water conservation practices in Saudi Arabia. Applied Water Science3: 689-699.

34. Kurunthachalam SK (2014) Water Conservation and Sustainability : An Utmost Importance. Hydrol Current Res 5: 2-4.

35. Parker JM, Sams D, Manoylov K (2018) Water conservation behavior : is what we say what we do ? Journal of Consumer Marketing 6: 644-652.

36. Zanetti SS, Cecilio R (2020) Green Water Footprint and Sustainability for Espirito Santo State. Revista Engenharia na Agricultura 28: 24-36.

37. Perry CJ, & Researcher I (2019) Learning from Water Footprints who loses, who loses, who wins, and who cares? Agricultural Water Management journal 15: 70-74.

38. Goette L, Leong C, Qian N (2019) Motivating household water conservation: A field experiment in Singapore. PLoS ONE 14.

39. Tracey P, Stott N, Tracey P, Stott N (2016) Social innovation : a window on alternative ways of organizing and innovating. Innovation Organization & Management 19: 51-60.