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### **Dedication**

It is our pleasure and great privilege to present the fiftieth issue of the Academic Journal of Research and Scientific Publishing to all researchers and doctors who published their research in the issue, and we thanks and appreciate to all contributors and supporters of the academic journal and those involved in the production of this scientific knowledge edifice.

Academic Journal of Research and Scientific Publishing

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## Urban Big Data and Smart Cities through UTAUT Model (The Case of the Kingdom of Saudi Arabia)

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### Abstract:

The use of Information and Communication Technology (ICT) is the primary goal of the construction of a smart city, with the end goal being a more efficient management of urban resources such as electricity, public transportation, roadways, and wastewater management systems along with judicious use of resources and infrastructure. It is necessary for the technologies to make a contribution to the building of an inclusive society that has a high level of civic involvement and transparency. Therefore, it is vital to investigate the behavior of people, their motivation, incentives and the elements that impact the desire to use and the use of the communication technologies for the purpose of resolving day-to-day responsibilities and problems. We used the UTAUT model in addition to the structural equation modelling based on partial least squares (PLS-SEM). In the UTAUT model, these major contributors are Behavioral Intention and Use Behavior. The findings of this research will enable the authorities of Saudi Arabia to facilitate all of the processes of putting the smart city concept into action by increasing the population's involvement in the use of applications along with cybersecurity framework in all aspects of day-to-day life.

**Keywords:** Smart cities, UTAUT, Urban Big Data, Kingdom of Saudi Arabia.

## 1. Introduction:

The use of Information and Communication Technology (ICT) is the primary goal of the construction of a smart city, with the end goal being a more efficient management of urban resources such as electricity, public transportation, roadways, and wastewater management systems along with judicious use of resources and infrastructure. As per the definitions by (Nikitas et al., 2020) and (Toli & Murtagh, 2020), a metropolitan region is considered to be a smart city if it implements information, telecommunication, and digital technologies on conventional networks in order to improve the flexibility, efficiency, and sustainability of such networks. Components of a smart city include intelligent infrastructure, intelligent energy, intelligent transportation, intelligent government, intelligent healthcare, intelligent education, intelligent energy, intelligent buildings, intelligent technology, and intelligent residents. The quality of life in a smart city may be gauged by its residents' economic standing as well as their mental and emotional health. The Internet of Things (IoT) is at the center of every deployment of a smart city. A smart city should contain elements that depend on the Internet of Things (IoT), such as connectivity, intelligence, and instrumentation (Nikitas et al., 2020). The emergence of smart cities around the globe, particularly in the Middle East, Latin America, Asia, and Africa, represents a wave of entrepreneurial urbanism (Silva et al., 2018).

The Saudi Arabian Vision 2030 plan describes the nation's objective of having at least three cities listed among the top 100 most intelligent cities in the world by the year 2030. The goal of the smart aspiration is to increase the overall quality of life for all people and to fulfil the requirements of residents by ensuring that they have access to services and infrastructure of the highest possible standard. introduced the Riyadh and Neom smart city frameworks. This provides us with a beginning point for constructing a stronger framework towards a suitable e-government framework that does not contradict the social, economic, or cultural values of Saudi Arabia. Specifically, this gives us a starting point for establishing a suitable e-government framework.

In smart cities, the population occupies a unique and important role. People are assumed to be the driving force behind developments in smart cities, as well as the focus and primary concern of all activities, according to the presumption underlying the notion of smart cities. The term "smart city" refers to an area in which existing networks and services are made to operate more effectively via the use of digital and telecommunication technologies for the purpose of serving the needs of

the city's residents and companies (Das, 2020; Lim et al., 2019; Saba et al., 2020). There are a variety of elements that influence people's perspectives about information technology in a variety of contexts. Some residents of the city do not accept information technologies or have certain problems and concerns with their use due to a variety of reasons, such as personal characteristics, a lack of knowledge or technical resources, cyber security threats and so on (Habib et al., 2020; Soyata et al., 2019). Other residents of the city accept information technologies but have certain problems with their use. Because the use of information technology is a demand that smart cities put forth, it is possible that these individuals may have difficulties integrating into the activities of a smart city, which may, in turn, constitute a barrier to the functionality of a smart city (Razmjoo et al., 2021; Sharma et al., 2020). It is also inefficient from an economic standpoint, due to the fact that the non-use of technology leads in poor resource allocation and low effectiveness (Lee et al., 2014; Razmjoo et al., 2021; Yigitcanlar, 2015). The creation of smart city regions demands an integrated knowledge of the numerous aspects of services that impact the choice that people make about whether they will utilize these services. In the alternative, they have the potential to be the origin of new kinds of social exclusion owing to a lack of skills and competency in the use of technologies (Andone et al., 2014; Perätalo & Ahokangas, 2018), or a weak infrastructure or the absence of required equipment (Bomba et al., 2018). It is necessary for the technologies to make a contribution to the building of an inclusive society that has a high level of civic involvement and transparency (Preston et al., 2020; Robinson, 2020). Therefore, it is vital to investigate the behaviour of people, their motivation, incentives and the elements that impact the desire to use and the use of the communication technologies for the purpose of resolving day-to-day responsibilities and problems.

### **1.1 UTAUT Model:**

Because of their reliance on information and communication technology, the smart cities in Saudi Arabia are vulnerable to cyberattacks. The country needs to devise a cyber-security policy framework for its various programs, which then has to be tailored to the specifics of the local environment. This article examines how the nation may establish a cyber-security policy framework for its smart cities, how the framework can be customized to the country's local environment, and how the framework may have an influence on the country's people. According to the findings in pre-survey, Saudi Arabia ought to adopt an appropriate cyber security policy

framework for its smart city projects. This policy framework should include a digital trust platform, a cyber threat intelligence and analysis platform, a cyber competencies and awareness program, privacy by design, and cyber response and resilience. The research, on the other hand, will be centered on the creation of a cyber-competencies and awareness program that takes into account the customs, culture, society, and economics of the Kingdom. In addition, the research has a certain scientific value due to the fact that it applies the Unified Theory of Acceptance and Use of Technology (UTAUT) model. This model is typically utilized for the purpose of researching aspects; however, we applied it for the purpose of examining how people generally accept technological instruments. In addition, while this approach is often used when discussing technology, the writers will be focusing on web applications. This newness has the potential to contribute to the improvement of the techniques' implementation. the researchers suggested that the legislative framework for the country's cyber-security should be tailored to the country's specific local context. Issues that arise from the interoperability, convergence, and interconnection of urban processes and systems may be addressed by effectively synchronizing the framework with the Saudi Arabian smart cities strategy. In addition, the nation must do a comprehensive analysis of how its population are affected by the country's technological advancements and infrastructure. Following the conclusion of the research, a cyber-security policy framework that is well-suited for Saudi Arabia's smart cities will be produced.

In our research, we used the UTAUT model (Figure 1) in addition to the structural equation modelling based on partial least squares (PLS-SEM). PLS-SEM is a technique that is often used in the estimation of route models that include latent variables and the connections between them. The identification of the most important contributors to target constructs is a typical objective of PLS-SEM analysis. In the UTAUT model, these major contributors are Behavioral Intention and Use Behavior.

Performance Expectation (PE) (H1), Facilitating Conditions (FC) (H2), Social Influence (SI) (H3), Effort Expectation (EE) (H4), Behavioral Intention BI), Use Behavior (UB), Attractions towards the adoption of Cybersecurity Frameworks was used as the UTAUT con-structs. Age, Gender, Experience, Working Sector and Education were considered as moderators.

After making some minor modifications, the survey questions that were used to measure the UTAUT components were taken directly from the research. The evaluation of these statements in the questionnaire was done using a Likert scale of five points.



Two separated questionnaires were structured to collect the data from IT experts working in hubs and general public using any IT gadget and apps.

The following hypotheses were tested

**H1:** The lack of trust related to cyber infrastructure issues, services from governments and companies, cyber threats attacks and cyber based economy limit cybersecurity frameworks adoption in Saudi Arabia.

**H2:** The lack of developments related to shortage of cyber awareness programs and lack of trained personnel limit cybersecurity frameworks adoption in Saudi Arabia.

**H3:** Cultural influences, including use of social apps and influence Saudi Arabia's adoption of cybersecurity awareness methods.

**H4:** The lack of IT professionals in public sector (a shortage of local expertise) limits the implementation of cybersecurity frameworks in Saudi Arabia.

The data was collected by circulating the questionnaire among the participants and was analyzed by using SmartPLS 4.0 software. The UTAUT model was validated for all model fit parameters.

**Table 1: UTAUT Model components, General Public**

Hypothesis	UTAUT Model Component	Items/Questions Post Survey
Mediating component	<b>Attraction</b>	20.How well the program mode of delivery attracts public to give out their problems ATR1
		30.Do you think that the current IT infrastructure (internet speed, security and accessibility) is suitable for the success of the program? ATR2
Citizen's desire to live in smart cities	<b>Behavior Intention (Dependent Variable)</b>	10. After watching the induction video: how much do you want to register and take advantage of the program's features BI1
		11.Do you agree that the program will be a reliable awareness source instead of other unreliable sources? BI2

		24.Do you think the program will help promote e-commerce instead of traditional trade?	BI3
H4	<b>Effort Expectancy</b>	8. Does the program meet your expectation?	EE1
		14.Do you agree the proposed program will reduce your fears about online shopping?	EE2
		16.Do you agree the proposed program will reduce your fears about share your personal information with e-government services?	EE3
		19.I'm confident with the cyber security information I get from expertises via the program	EE4
		22.Do you think the program will increase your knowledge of the risks of cyber threats?	EE5
		25.To what extent were the society cyber issues will be solved with the program?	EE6
		28. Do you think the program will help you to attain gains ?	EE7
H2	<b>Facilitating Conditions</b>	12.It will be easy now to solve the cyber security issues when the program will be implemented.	FC1
		13.Do you agree the program will make smart cities safer and more aware?	FC2
		29.How much do you think the program will be easy to use?	FC3
H1	<b>Performance Expectancy</b>	7. In a range of 1-5 rate the proposed program.	PE1
		15. How much do you think the program will affect Saudi Arabia's move towards e-commerce and the digital economy?	PE2

		17. How confident are you in sharing your issues through the program?	PE3
		23. Are you ready to pay a small fee for the course if any?	PE4
H3	<b>Social Influence</b>	9. How much do you rate this idea: the program has several partnerships and sponsors as a parallel program to qualify recent graduates or non-specialists to be new members and to ensure the continuity of the program	SI1
		18. The proposed program will increase the public awareness of the cyber security	SI2
		26. Based on the previous survey result shows that culture of Saudi Arabia is affected by social apps. Analyzing the results, it has been observed that snapchat (51.4%) and Twitter (32.4%) are the two mostly used social media apps in the Saudi Arabia. Do you agree that awareness programs will reduce cyber threats through social media applications and how to deal with them?	SI3
Behavior towards cybersecurity frameworks adoption	<b>Use of Behavior (Dependent Variable)</b>	21. Has the video changed your viewpoint on the cyber security?	UOB 1
		31. Are you willing to adopt the program to your life or recommend it ?	UOB 2

**Table 2 UTAUT Model components, IT experts**

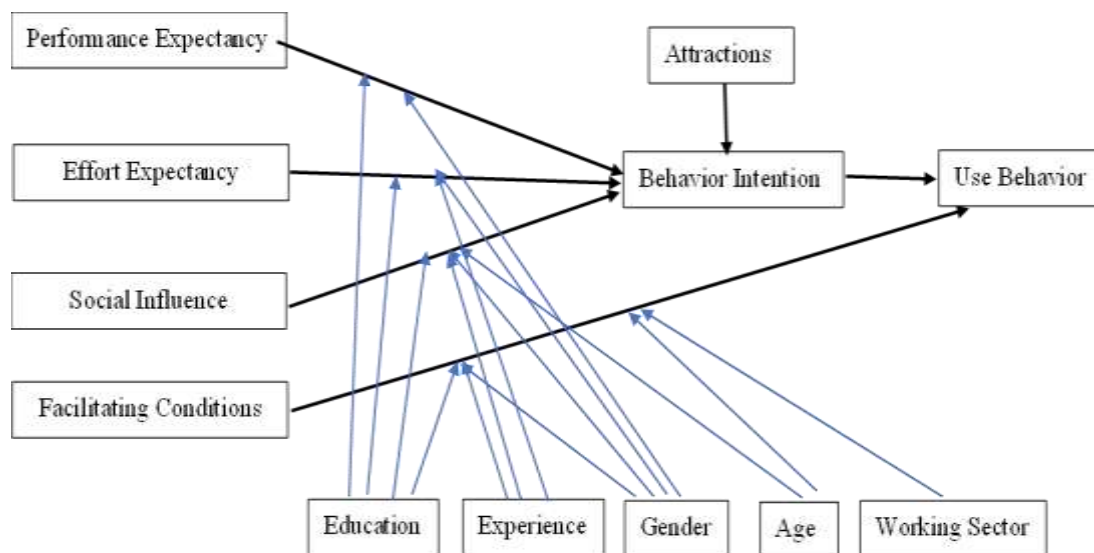
Hypothesis	UTAUT Model Component	Items/Questions Post Survey
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Mediating component	<b>Attraction</b>	20. How satisfied are you with the incentives and bonuses mentioned in the program?	ATR1
		24. Do you agree the program will attract the residents of villages to live in smart cities?	ATR2
Citizen's desire to live in smart cities	<b>Behavior Intention (Dependent Variable)</b>	10. After watching the induction video: how much do you want to register and take advantage of the program's features	BI1
		11. Do you agree that the program will be a reliable awareness source instead of other unreliable sources?	BI2
		27. With proposed program it is now beneficial to work in public sector than in private sector.	BI3
H4	<b>Effort Expectancy</b>	8. Does the program meet your expectation?	EE1
		16. Do you agree the program solve cyber security issues in public sector?	EE2
		18. The proposed program will enhance cyber awareness	EE3
		21. To what extent were the society cyber issues will be solved with the program?	EE4
		29. How much do you think the program will be easy to use?	EE5
H2	<b>Facilitating Conditions</b>	13. The smarter cities use modern and safe technologies, as the risk of cyber threats increases.	FC1
		14. Do you agree that the program is effectiveness in promoting smart cities?	FC2
		30. Do you think that the current IT infrastructure (internet speed, security and accessibility) is suitable for the success of the program?	FC3

H1	<b>Performance Expectancy</b>	12. The program promotes the knowledge on cyber security threats and appropriate practices to reduce risk for citizens living in smart cities in Saudi Arabia.	PE1
		15. Do you agree that the program is effective in promoting digital economic and use of eCommerce?	PE2
		19. Do you agree the program can help to improve your skills and knowledge?	PE3
		25. The program will solve the issue of shortage of ICT professionals in public sector and serving the society.	PE4
		28. Do you think the program will help you to attain gains?	PE5
H3	<b>Social Influence</b>	9. How much do you rate this idea: the program has several partnerships and sponsors as a parallel program to qualify recent graduates or non-specialists to be new members and to ensure the continuity of the program	SI1
		17. The proposed program will lead to mutual benefit both to the community and professionals in terms of cyber education	SI2
		22. How much do you agree in this phrase: Saudi society is characterized by great trust among its members such as friends and family, increasing awareness and safety in smart cities will reduce the threats of social engineering such as impersonation to penetrate privacy.	SI3

		23. Based on the previous survey result shows that culture of Saudi Arabia is affected by social apps. Analysing the results, it has been observed that snapchat (51.4%) and Twitter (32.4%) are the two mostly used social media apps in the Saudi Arabia. Do you agree that awareness programs will reduce cyber threats through social media applications and how to deal with them?	SI4
Behavior towards cybersecurity frameworks adoption	<b>Use of Behavior (Dependent Variable)</b>	26. Does the program increase the interest among professionals in ICT sector in working in the public sector?	UOB1
		32. Are you willing to adopt the program to your life or recommend it ? To what extent	UOB2

**Figure 1. Modified UTAUT Model plan:**



## 2. Methodology:

A particular developmental research methodological framework was developed to design and implement a proposed cybersecurity framework. Initially a cyber competence and awareness-based program was designed as a proposed one for Saudi Arabia.

The program was subdivided into one of two interrelated categories: a societal awareness program and a cyber-hub. The cyber hub is the part of the program where advanced knowledge on cyber security and actions that would increase the adoption and safe usage of smart cities is shared with other participants. Members often include those with advanced entry level participation, professionals working in ICT, and specialists in ICT. Members of the program will earn points in this level of the program that may be redeemed for awards that attest to the individual's growing level of expertise in matters pertaining to cyber security and industry standards. It is the members' willingness to teach members of the general public about cyber security and awareness that determines whether or not they get points for their efforts. The second level of the program is the one that raises social consciousness and focuses on the public by way of online seminars, conferences, and community centers.

At this stage of the program, participants will exchange knowledge about the safest cyber practices and the most effective ways to use smart infrastructure in smart cities. The process of developing the program architecture is the second phase in the research approach. This part of the research is going to be handled by experienced educators and programmers from the workforce.

The following step will consist of analyzing and designing the program. In order to collect data from industry professionals and to acquire insights and data that will serve as the foundation for the cyber-competency and awareness program, a survey has been developed. Following the development of the program, the further steps of the research would consist of putting the program into action and analyzing how well it performs its intended function. The gathering of feedback from participants is an essential step in determining where adjustments are required and identifying areas of weakness. The comments will also make it possible to further tailor the program so that it better reflects the social, cultural, and economic character of the country. In the subsequent part of this investigation, a greater level of depth will be devoted to the examination of significant facets of the cyber-competency and awareness program for Saudi Arabia and its smart cities.

## **2.1 Literature Review:**

As an integral component of the information security awareness campaign, informative videos play a significant role. There is no need for a proper classroom trainer, nor is it necessary to have personnel who cannot be reached with the use of software designed for online education. One concerning the most significant problems associated with traditional methods of dissemination of information among the challenges presented by techniques is keeping a trainee's attention and there

are required intensive efforts to explain your target and purpose of any program. Videos and other visuals adequate in length to convey an appropriate message are much effective especially when the trainees are difficult to approach them in person. Videos seen online give a number of benefits. The participants may see and learn from the videos as per their convenience. Visuals and graphics' interactive features contribute to the increased efficiency of the videos in comparison to non-interactive ways, although it is more costly. In addition, the videos can be watched and viewed again and again to enhance the understanding of the beneficiaries of any program.

(Abawajy, 2014) reported that In today's world, operating systems and programs are more secured, therefore hackers are focusing their efforts on breaking into organizations' information systems via vulnerabilities in its human workforce.

They focused on the analyses and assesses the impact of a variety of information security awareness distribution strategies that have been utilized to improve the information security awareness and behavior of end users. There is a broad variety of training delivery techniques available for information security awareness, such as training materials based on the internet, contextual training, and embedded training. A text-based approach, a game-based approach, and a video-based approach were the three modes of information security awareness training that they experimented with in order to ascertain which format was preferred by users. According to the findings of this research, a combination of several distribution strategies for security awareness is superior than using a single way. The videos and other visual methods of delivery were found to be most effective among all available sources of information dissemination. (Kruger & Kearney, 2006) reported a study based on the development of a prototype model for evaluating information security awareness in a multinational mining corporation. The results concluded that the prototypes had significant impact on awareness programs as compared to traditional methods of information dissemination.

(Abawajy & Kim, 2010) evaluated the effectiveness of various information security awareness delivery methods, such as interactive videos, internal training session classes, screen savers, emails, and social media. These methods were used to improve end-user awareness and behavior, particularly in relation to phishing attacks. They investigated the efficacy of approaches that were based on text, games, and videos respectively. The trials were carried out with sixty different individuals, and the results showed that the subjects' top choices for techniques were video, followed by texting in their order of preference. (Ahmed et al., 2017) employed both online and



offline polls of people in Bangladesh to determine the amount of cyber-security knowledge those individuals had. According to the findings of the survey, the current level of knowledge is unsatisfactory, and a significant proportion of the population is uneducated on the fundamentals of cybersecurity. However the videos and other prototypes enhanced the awareness level significantly.

The objective of the cyber-competency and awareness program being implemented in Saudi Arabia is to guarantee that the issues that are now being faced by smart cities and cyber security are met. The training will be divided into two halves, and participants will be ranked based on their degree of experience as either novices, professionals, or experts.

The social awareness program will be the component of the program that will get the greatest attention from the general public. In this component of the program, the goal will be to educate the general public about cybercrime, cybersecurity, and appropriate ways to engage with various forms of technology. During the first phase of the program's rollout, entry-level participants will be recruited. These participants might be students attending reputable educational institutions or members of the general public holding any kind of recognized credential. The participants will be asked to take part in online courses, seminars, community centers, and conferences that are intended to educate them about the dangers of cyberspace and the appropriate ways to use resources in smart cities. Awarding members 5 points for each hour spent offering their services to the community of spreading information and educating members on cyber awareness is one way to encourage active participation and increase competency in the field. This can also be done as a means of increasing members' cyber awareness. The curriculum will place an emphasis on fundamental knowledge and skills in the areas of cyber security and space, and participants will be evaluated regularly on their technical and human abilities. The societal awareness program provides its participants with the opportunity to obtain essential technical knowledge that will assist them in navigating the complex world of smart cities and interacting with others online in a more secure manner.

### **3. Results**

#### **3.1 Professional (IT Experts)**

By using Descriptive Statistics as show in table 3, the results of analysis, the frequency of male participants in the study was 87, while that of female participants were 23 with the frequency of

79% and 21% respectively. The results also explained that the frequency of public sector employees in the study were 38, while those belonging to private sector were 30, 7 were self-employed and 35 were students. 36 study participants had diploma, 52 participants had bachelor's level qualification, 17 had Master's level qualification, 2 had Post-graduation and 3 participants had phd level qualification, in the current survey project.

**Table 3** Frequency and Percentage of the Participants of the Study (N= 110)

<b>Age</b>				
	<b>Frequency</b>	<b>Percent</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
18-25 years	46	41.8	41.8	41.8
26-35	43	39.1	39.1	80.9
36-45 years	16	14.5	14.5	95.5
46-55 years	5	4.5	4.5	100.0
Total	110	100.0	100.0	
<b>Education</b>				
Diploma	36	32.7	32.7	32.7
bachelor's	52	47.3	47.3	80.0
Master's	17	15.5	15.5	95.5
Post-graduation	2	1.8	1.8	97.3
Phd	3	2.7	2.7	100.0
Total	110	100.0	100.0	
<b>Experience</b>				
no experience	18	16.4	16.4	16.4
less than 1 year	27	24.5	24.5	40.9
1-5 years	32	29.1	29.1	70.0
5-10 years	14	12.7	12.7	82.7
More than 10 years	19	17.3	17.3	100.0
Total	110	100.0	100.0	
<b>Gender</b>				
Male	87	79.1	79.1	79.1
Female	23	20.9	20.9	100.0
Total	110	100.0	100.0	
<b>Working Sector</b>				

public sector	38	34.5	34.5	34.5
private sector	30	27.3	27.3	61.8
self employed	7	6.4	6.4	68.2
Student	35	31.8	31.8	100.0
Total	110	100.0	100.0	

By applied the Scales Reliability and Validity of UTAUT components ( $N=147$ ) and applied Correlation Analysis ( $N= 110$ ) and T-test Analysis of Gender,:

- All the components of the UTAUT model have Cronbach's alpha value as above 0.7. This means that all the components are valid and reliable. Statistics Scale reliability ( $N=147$ )
- There is significant and positive relationship observed among different variables of the study. Results showed that effort expectancy is positively and strongly associated with attraction, while negatively associated with behavior intention. In addition to this it was also observed that behavior intention is also presenting positive and significant relationship with social influence.
- The overall results showed that there was no significant relationship among other variables of the study and participant's gender.

By applied the ANOVA Analysis for Working Sector, Work Experience, and Education The analysis revealed that:

- The participants belonging to public sector reported more facilitating conditions by presenting the p value at .002 and in term of social influence, by presenting p value .042. However, there was no significant analysis observed on anova in term of working sectors of the participants and other variables.
- The participants with 1-5 years of work experience show more facilitating conditions by presenting p value .000 and similar experience category also presented association with social influence by presenting the p value at .007. However, there was no significant analysis observed on anova with working experience of the participants and other variables of the study.

- The participants with bachelor's level of education show more significant association with facilitating conditions and social influence as well as use of behavior by presenting the p value significant at .000, .001. and .042 respectively.

### **3.2. IT experts' UTAUT Model Validation**

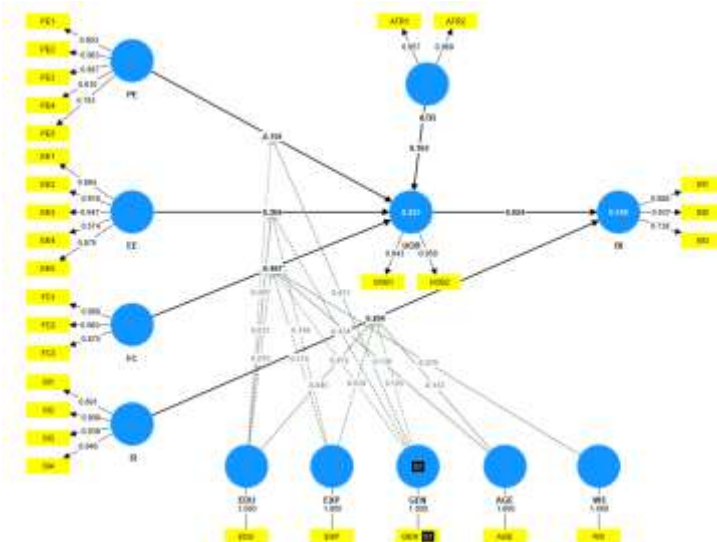
#### **3.2.1. Evaluation of Measurement Model**

All the twelve constructs in the model were measured reflectively. The composite reliability (CR) was calculated to measure the internal consistency of the constructs. The Cronbach's alpha is used to test the reliability of the data and all the calculated values of Cronbach's alpha against all 12 constructs of the model are above 0.7 which reflects the validity of model. The CR was greater than 0.7 for all the constructs. The outer loadings were significant and found to be higher than 0.7 for all constructs. Average variance extracted (AVE) which is a measure of convergent validity was found to be greater than 0.5 and significant at 95% level. The discriminant validity was established using the criteria of Heterotrait Monotrait (HTMT) ratio. This criterion is the strictest amongst the other two criteria for discriminant validity viz. cross loading criteria as compared to the Fornell and Larker criteria. The discriminant validity was established since all the values were below 0.85. Only between the constructs performance expectancy and gender (0.88) was higher than 0.85 which is still acceptable being close to 0.85 and therefore retained. All the factor loading in table 1 are above 0.7 and all factor weights are below 0.5 which confirm the model fit and validity of UTAUT Model adding Attraction as an independent variable.

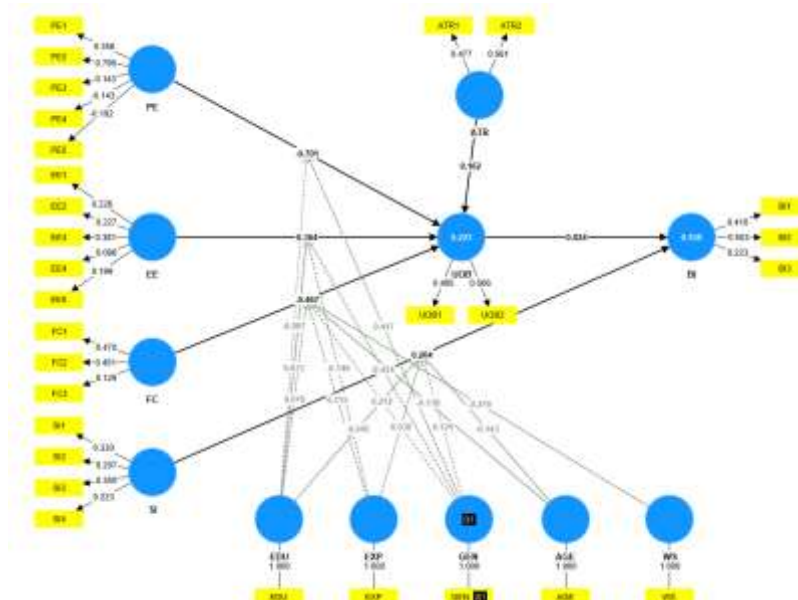
#### **3.2.2. Evaluation of Structural Model**

The path coefficients (Figure 2 and Figure 3) are ascertained after running the PLS algorithm. The algorithm is designed to reject a set of path specific null hypothesis of no effect. Also, the path coefficient from behavioral intention, to use behavior, was both strong and significant. Also, as per Preacher and Hayes (2008), there was no requirement to test direct effect before and after including the mediator.

**FIGURE 2.** THE STRUCTURAL MODEL (MODIFIED UTAUT MODEL) OF THE SHOWING OUTER MODEL VALUES AS CRONBACH'S ALPHA. ALL THE VALUES ARE ABOVE 0.7.



**FIGURE 3.** THE STRUCTURAL MODEL (MODIFIED UTAUT MODEL) OF THE SHOWING OUTER WEIGHTS. ALL THE WEIGHTS ARE BELOW 0.5



### 3.2.3. Test for Goodness of Fit

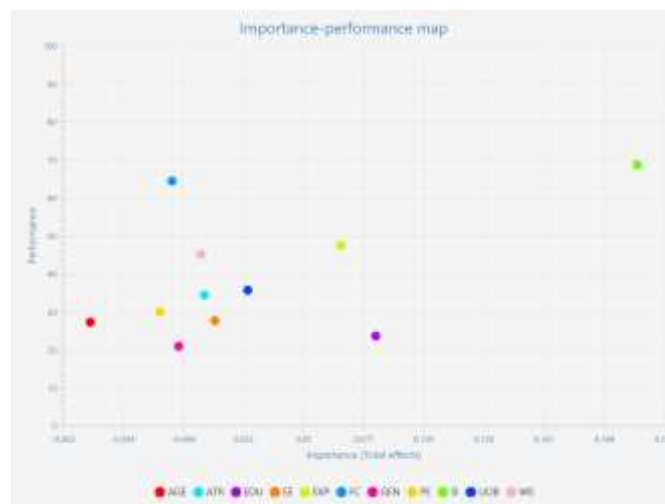
The goodness of fit measure was ascertained as per Henseler and Sarstedt (2013). The standardized root mean square residual (SRMR) was 0.064 which was well below the threshold limit of 0.092. Thus, the model was an overall good fit (Table 4).

**Table 4.** Standardized root mean square residual

Fit Summary	Saturated model	Estimated model
SRMR	0.064	0.092

### Importance-Performance Map Analysis (IPMA)

The construct “effort expectancy” was found not to be the most impactful construct (total effect = 0.109) (Table 55), however its performance was good (Figure 4). This means that the potential for improvement was the highest for this construct. Thus, in actionable terms, the IT companies for obtaining the maximum returns on their user initiatives, could focus on “effort expectancy” the users. The other constructs were close to each other in their performance (Figure 4).



**Figure 4.** IPMA plot

## 3.3. General Public Results

### 3.3.1. Descriptive Statistics

By using Descriptive Statistics as show in table 5, According to the results of analysis, the frequency of male participants in the study was 93, while that of female participants were 54 with the frequency of 63% and 37% respectively.

Participants belonging to the age category of 18 – 25 years were 10, between the age of 26-35 were 48, between the age group of 36 – 45 years old were 56 and just 3 participants reported their age above 55 years of age. The results also explained that the frequency of public sector employees in the study were 100, while those belonging to private sector were 29, 10 were self-employed and 8 were students. 22 study participants had diploma, 83 participants had bachelor's level qualification, 33 had Master's level qualification, 1 had Post-graduation and 8 participants had phd level qualification, in the current survey project.

Table 5: *Frequency and Percentage of the Participants of the Study (N= 147)*

<b>Age</b>				
	<b>Frequency</b>	<b>Percent</b>	<b>Valid Percent</b>	<b>Cumulative Percent</b>
18-25 years	10	6.8	6.8	6.8
26-35	48	32.7	32.7	39.5
36-45 years	56	38.1	38.1	77.6
46-55 years	30	20.4	20.4	98.0
greater than 55	3	2.0	2.0	100.0
Total	147	100.0	100.0	
<b>Education</b>				
diploma	22	15.0	15.0	15.0
bachelor's	83	56.5	56.5	71.4
Master's	33	22.4	22.4	93.9
Post-graduation	1	.7	.7	94.6
PhD	8	5.4	5.4	100.0
Total	147	100.0	100.0	
<b>Gender</b>				
Male	93	63.3	63.3	63.3
female	54	36.7	36.7	100.0
Total	147	100.0	100.0	
<b>Working Sector</b>				
public sector	100	68.0	68.0	68.0
private sector	29	19.7	19.7	87.8
self employed	10	6.8	6.8	94.6

student	8	5.4	5.4	100.0
Total	147	100.0	100.0	

By applied the Scales Reliability and UTAUT Model Validity ( $N=110$ ) and applied Correlation Analysis ( $N= 147$ ) and T-test Analysis of Gender the results showed that:

- All the components of the UTAUT model have Cronbach's alpha value as above 0.7. This means that all the components are valid and reliable.
- The significant positive and negative relationship among different variables of the study. Results showed that attraction is significantly and positively associated with use of behavior. However, use of behavior found to be significantly associated with facilitating conditions, social influence and behavior intention, positively and negatively respectively. In terms of behavior intention, it was shown that behavior intention is positively associated with performance expectancy and effort expectancy, while negatively associated with facilitating conditions and social influence. In addition to this, effort expectancy positively associated with performance expectancy and negatively associated with facilitating conditions.
- There was no significant relationship among Attraction, Behavior Intention, Effort Expectancy, Facilitating Conditions, Performance Expectancy, Social Influence and Use of Behavior and participant's gender.

By applied the ANOVA Analysis for Age, Working Sector, and Education The analysis revealed that:

- There was no significant relationship among Attraction, Behavior Intention, Effort Expectancy, Facilitating Conditions, Performance Expectancy, Social Influence and Use of Behavior and participant's age in the current survey project.
- The participants belonging to public sector reported more social influence by presenting the p value significant at .05. However, there was no significant analysis observed on anova in term of working sectors of the participants, dependent and independent variables.
- The participants with bachelor's level of education show more significant association with use of behavior, attraction and facilitating conditions by presenting the p value significant at .03, .04 and .003 respectively.



### 3.4. Public Response - UTAUT Model Validation

#### 3.4.1. Evaluation of Measurement Model

All the eleven constructs in the model were measured reflectively (Table 6). The composite reliability (CR) was calculated to measure the internal consistency of the constructs. The Cronbach's alpha is used to test the reliability of the data and all the calculated values of Cronbach's alpha against all 11 constructs of the model are above 0.7 which reflects the validity of model. The CR was greater than 0.7 for all the constructs. The outer loadings were significant and found to be higher than 0.7 for all constructs. Average variance extracted (AVE) which is a measure of convergent validity was found to be greater than 0.5 and significant at 95% level. The discriminant validity was established using the criteria of Heterotrait Monotrait (HTMT) ratio (Table 26). This criterion is the strictest amongst the other two criteria for discriminant validity viz. cross loading criteria as compared to the Fornell and Larker criteria. The discriminant validity was established since all the values were below 0.85. All the factor loading in table 1 are above 0.7 and all factor weights are below 0.5 which confirm the model fit and validity of UTAUT Model adding Attraction as an independent variable.

Table 6. Reliability and validity

Construct	Items	Factor Loadings	Factor Weights	Cronbach's alpha	Composite reliability	Average variance extracted (AVE)
Attraction				0.888	0.947	0.899
	ATR1	0.950	0.534			
	ATR2	0.947	0.520			
Behavior Intention				0.927	0.950	0.863
	BI1	0.930	0.505			
	BI2	0.912	0.245			
	BI3	0.945	0.325			
Effort Expectancy				0.955	0.963	0.791
	EE1	0.966	0.164			
	EE2	0.709	0.101			
	EE3	0.961	0.152			
	EE4	0.821	0.214			
	EE5	0.860	0.180			
	EE6	0.932	0.157			
	EE7	0.946	0.156			

Facilitating Conditions				0.882	0.927	0.808
	FC1	0.877	0.314			
	FC2	0.928	0.428			
	FC3	0.890	0.368			
Performance Expectancy				0.956	0.966	0.876
	PE1	0.974	0.356			
	PE2	0.887	0.183			
	PE3	0.957	0.326			
	PE4	0.924	0.193			
Social Influence				0.815	0.886	0.723
	SI1	0.776	0.284			
	SI2	0.888	0.377			
	SI3	0.882	0.505			
Use Behavior				0.903	0.954	0.911
	UOB1	0.951	0.502			
	UOB2	0.958	0.545			
Age		1.0	1.0	1.0	1.0	1.0
Working Sector		1.0	1.0	1.0	1.0	1.0
Education		1.0	1.0	1.0	1.0	1.0
Gender		1.0	1.0	1.0	1.0	1.0

### 3.4.2. Evaluation of Structural Model

The path coefficients (Figure 5 and Figure 6) are ascertained after running the PLS algorithm. The algorithm is designed to reject a set of path specific null hypothesis of no effect. The “f square” value is given in Table 27. Also, the path coefficient from behavioral intention, to use behavior, was both strong and significant. Also, as per Preacher and Hayes (2008), there was no requirement to test direct effect before and after including the mediator.

FIGURE 5. THE STRUCTURAL MODEL (MODIFIED UTAUT MODEL) OF THE SHOWING OUTER MODEL VALUES AS CRONBACH'S ALPHA. ALL THE VALUES ARE ABOVE 0.7.

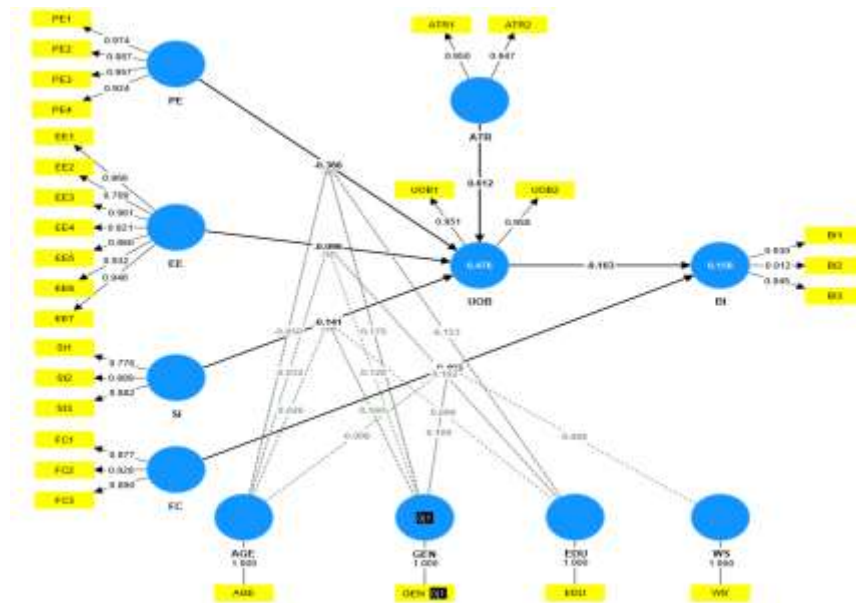
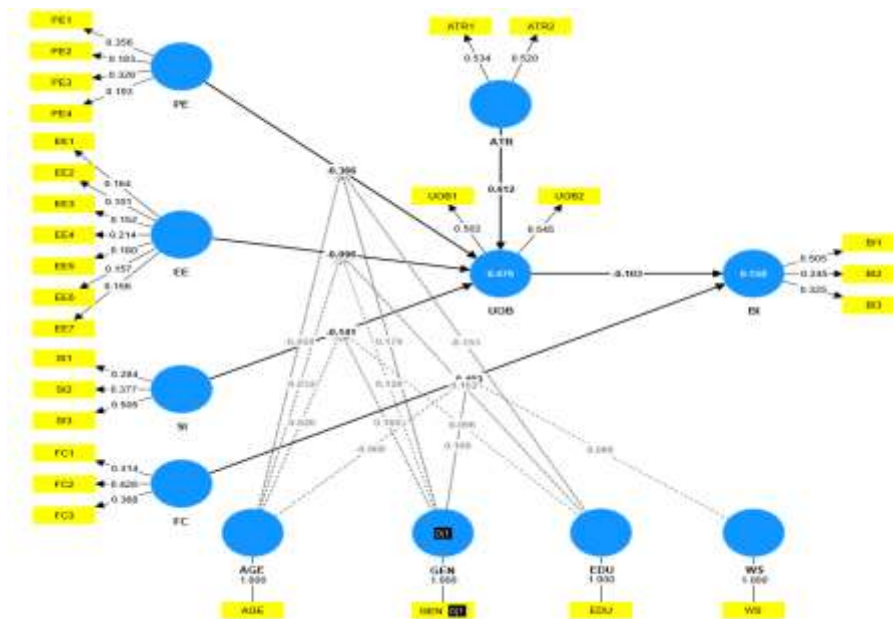


FIGURE 6. THE STRUCTURAL MODEL (MODIFIED UTAUT MODEL) OF THE SHOWING OUTER WEIGHTS. ALL THE WEIGHTS ARE BELOW 0.5



### 3.4.3. Test for Goodness of Fit

The goodness of fit measure was ascertained as per Henseler and Sarstedt (2013). The standardized root mean square residual (SRMR) was 0.061 which was well below the threshold limit of 0.092. Thus, the model was an overall good fit (Table 7).

Table 7. Standardized root mean square residual

Fit Summary	Saturated model	Estimated model
SRMR	0.061	0.092

#### 3.4.4. Importance-Performance Map Analysis (IPMA)

The construct “Use Behavior” was found not to be the most impactful construct (total effect = -0.103), however its performance was good (Figure 3). This means that the potential for improvement was the highest for this construct. Thus, in actionable terms, the IT companies for obtaining the maximum returns on their user initiatives, could focus on “Use Behavior” of the users. The other constructs were close to each other in their performance (Figure 7).

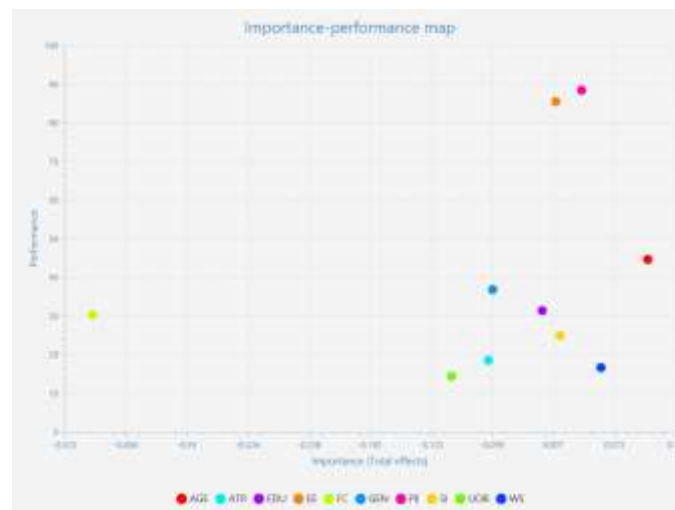


Figure 7. IPMA plot

## 4. Discussion:

A smart city specifies specific standards that must be met in order to ensure that its implementation is effective at all levels of the city's structural hierarchy. The degree to which residents of a smart city are prepared to make use of the various technological advancements available to them is one of the most important considerations to take into account, given that the establishment of a smart city hinges on the utilization of technology in the performance of all of the city's functions. Therefore, it is extremely crucial for the implementation of the idea of smart cities to determine whether or not the people living in a smart city are prepared to utilize the technologies for the day-to-day operations of the city. Further the development and adoption of cybersecurity frameworks makes the use of IT easy and user friendly.

Researchers are looking at technologies from both a technical and a social perspective as they investigate them. According to (Hollands, 2020), a large number of studies believe that the primary component in constructing smart cities and achieving success is the heavy use of information and communication technology. Nevertheless, people and administration are just as important to the concept of a smart city as the technology themselves (Baraniewicz-Kotasińska, 2022). As a result, in order to transform these technologies from merely technical solutions into truly intelligent solutions that can be used to alter the urban environment, cities should be designed with a focus on people and facilitate the inclusion of people in active life within an environment that is enabled by smart technology (Shelton & Lodato, 2019). It is of utmost significance in the modern day, when the idea of a smart city is being put into practice in the urban environment, bringing about changes in people's lives, companies, and other administrative procedures, among other things. (Abbas et al., 2019). The concept of "smart" is applied to government, communities, social learning, environmental sustainability, knowledge, and creativity (Ernst, 2019; Nam & Pardo, 2011).

The purpose of this research is to investigate the elements that influence people's intentions to utilize and adopt cybersecurity frameworks. In our research, we used a method known as partial least squares structural equation modelling (PLS-SEM), which is extensively utilized as a technique for estimating the route models that include latent variables and their respective associations. Specifically, we employed the UTAUT model. The UTAUT theory (Williams et al., 2015) is used by a large number of researchers in their investigations regarding the utilization of e-services, such as e-government (AlAwadhi & Morris, 2008; Li, 2021). Additionally, the UTAUT theory is broadly utilized to investigate the adoption of a variety of information systems.

This model can be interpreted in a number of different ways, each of which includes anywhere from four to seven or more determinants, such as performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FC), Behavior Intension (BI) and User Behavior (UOB). The last two determinants are included to account for consumer behavior.

Within the parameters of the model that was researched, our investigation did not uncover any gender disparities. It is possible that this finding was the consequence of a unique circumstance and that it will not be replicated when performing research on additional samples. At the same time, such a finding may represent a distinguishing characteristic of the people living in Saudi.

Recent years have seen a substantial increase in the number of persons who are of retirement age in industrialized nations, as shown by demographic trends. Because of this fact, it is necessary to pay close attention to the preservation of the quality of life of senior people, in particular, in order to avoid the age-based segmentation of society while using e-services to resolve day-to-day problems. The age gap continues to have a substantial influence on the usage of e-services (Inkinen et al., 2018) and may contribute to digital inequality, despite the fact that older people are becoming more literate in digital technologies.

Additionally, we take into account the model's primary building blocks. The term "Facilitating Conditions" refers to the availability of certain technological equipment, specialized expertise, and the opportunity to acquire assistance when making use of the apps. According to the study that was given, the construct of Facilitating Conditions did not have an impact that was directly related to Behavioral Intention; rather, it has an influence on BI that is indirectly related to PE, SI, and EE.

It has been shown by (Ashari et al., 2018) that persons who own gadgets have a more favorable attitude toward technological advancements. The knowledge and skill competencies of individuals are also a part of the Facilitating Conditions component. While the authors assume that computer usage frequency and prior computer skills have a positive influence on attitudes toward using the technologies have found that frequent computer usage and prior computer skills have a positive impact on attitudes towards using the technologies. According to (Jan, 2018), a person's level of digital literacy as well as the amount of time spent using computers and other electronic devices have a major impact on their perspective about the implementation of ICT.

If we consider these factors as direct predictors of people's attitudes towards technologies, the results of this study differ; however, if we consider that competences and skills in the computer field make interaction with applications easier and make communication efficient without any special effort, this interpretation is supported by the obtained results, since FC indirectly affects the intention to use the applications via PE (expected productivity and efficiency).

This interpretation is supported by the fact that competences and skills in the computer field make interaction with applications easier and make communication efficient without any special effort (easy interaction without special learning).

All of the hypotheses were supported by results significantly and the UTAUT model was validated.

## 5. Conclusion:

The study investigates how individuals in smart cities feel about adopting cybersecurity frameworks in their day-to-day activities. As a result, the idea of a smart city as well as its inhabitants as its primary component were taken into consideration. Following an examination of the many models currently in use for the characterization of the attitudes of a population toward technological advancements, the authors came to the conclusion that the Unified Theory of Acceptance and Use of Technology would be most useful (UTAUT). All of the four hypotheses were validated. The performance expectancy, the effort expectancy, the social influences, and the Behavior intention towards the adoption of such cybersecurity frameworks all have a beneficial impact on the likelihood that residents would actually utilize the frameworks in their day-to-day living. Through the processes of PE, SI, and EE, the Facilitating Conditions construct has an indirect impact on BI. The Attractions (ATTR) construct has an indirect influence on BI, which in turn affects UOB

The findings of this research, the authors believe, will enable the authorities of Saudi Arabia to facilitate all of the processes of putting the smart city concept into action by increasing the population's involvement in the use of applications along with cybersecurity framework in all aspects of day-to-day life. This is what the authors consider to be the most important takeaway from the study. The study is innovative from a scientific standpoint since it does not explore a particular technology using the UTAUT model; rather, it investigates the overall attitude of a community toward the technologies and applications. Due to the existence of this fact, the use of the model may be increased to investigate a greater number of situations.

Nevertheless, the practical applications of this study are where the majority of its value lies. It is something that may be done by the local government in order to improve the population's engagement in all of the activities that take place inside a smart city.

## 6. Analysis Data Availability

The All Analysis Data are Available to access by contact the corresponding author via e-mail address: [mamhalwani@kau.edu.sa](mailto:mamhalwani@kau.edu.sa)



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## **Consumers' Perception of Corporate Social Responsibility in Iraq's Kurdistan Region**

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## Abstract

Managers and researchers are paying more and more attention to corporate social responsibility (CSR), especially in the area of consumer perception and response to CSR. The purpose of this study is to determine how Iraqi consumers in the Kurdistan Region perceive corporate social responsibility, as well as the importance of philanthropic, economic, environmental, ethical, and legal aspects of corporate social responsibility. The study will also compare the findings to those of numerous studies on social responsibility conducted in various countries with the current study. A questionnaire was designed to collect data from 75 participants, including (56%) women and (44%) men ranging in age from (Less than 20) to (More than 30). An appropriate random sample of undergraduate students, staff, and lecturers from Duhok Polytechnic University's Technical College of Administration was taken as a research community. Then comparing the finding of the study with other studies from different countries. The research presented in this paper improves our comprehension of corporate social responsibility from the consumer's perspective in the Kurdistan Region of Iraq. The finding of this study demonstrates that the importance of ethical responsibility was prioritized by the study sample, with economic responsibility coming in second and legal responsibility coming third.

**Keywords:** Corporate Social Responsibility, philanthropic, economic, environmental, ethical, legal.

## 1. Introduction

Today's current topic is how businesses can better carry out their social responsibility in the growth of the new era since stronger standards for CSR performance across numerous industries have been introduced with the passage of time. Public awareness of corporate social responsibility has risen during the last three decades. This is supported by several academic studies and surveys that looked at the issue to understand how social responsibility affects business marketing performance and how it helps to improve relationships between businesses and consumers. According to related research, market consumers are concerned about corporate social responsibility performance (Mohr et. Al. 2001).

It is no longer viable for businesses to maximize economic profits while ignoring social responsibilities as market consumers become more conscious of environmental preservation,

safety, ethics, and the legal system. Relevant domestic and international studies have shown that a moderately high level of CSR can positively impact consumers' buying intentions, as mentioned in (Yu et al. 2021). In addition to corporate executives' efforts to find a formula to balance their responsibilities to owners and shareholders with their responsibilities to other parties. The study's objective is to ascertain the perceptions of corporate social responsibility among Iraqi consumers in the Kurdistan Region. The study also intends to compare the findings with those of numerous studies in the area of social responsibility conducted in various countries.

The purpose of this paper is to ascertain the perception of corporate social responsibility among Iraqi consumers in the Kurdistan Region, as well as the significance of the philanthropic, economic, environmental, ethical, and legal aspects of corporate social responsibility. It also seeks to ascertain consumers' willingness to respond to socially responsible businesses through purchasing decisions and to provide effective support to them. The study also intends to compare the findings with those of numerous studies in the domain of social responsibility conducted in different countries.

The two primary issues that this study seeks to address are: 1.How important is each aspect of social responsibility to Iraqi consumers in the Kurdistan Region in comparison to consumers in other countries? 2.Are Iraqi Kurdish consumers willing to use their purchase intentions to support companies that practice social responsibility? To conduct empirical research to assess the effect of CSR on customers' perspectives, it is important to first review the pertinent literature, explain the pertinent theoretical concepts, and then create a conceptual model that incorporates five dimensions of corporate social responsibility perception. Finally, a survey should be conducted to gather samples from students, staff, and lecturers at the technical college of administration at Duhok Polytechnic University.

## **Research hypotheses**

### **Main hypotheses**

There is a relationship between Consumers' Perceptions of Corporate Social Responsibilities.

### **Sub-hypotheses**

- 1- There is a relationship between Consumers' Perceptions of Philanthropic responsibility
- 2- There is a relationship between Consumers' Perceptions of Economic responsibility

- 3- There is a relationship between Consumers' Perceptions of Environment Responsibility
- 4- There is a relationship between Consumers' Perceptions of Ethical Responsibility
- 5- There is a relationship between Consumers' Perceptions of Legal responsibility

## 2. Literature Review

### 2.1. Corporate Social Responsibility

#### The 1950s: The Beginning of the Modern Era of Social Responsibility

In 1953, Bowen provided the first definition of corporate social responsibility: the need to develop commercial strategies or initiatives to advance civic goals and ideals (Bowen & Johnson, 1953). Social responsibility (SR) rather than CSR was the term used to describe CSR in early literature. This may have been the case because the era of the contemporary corporation's dominance and control in the commercial sector had not yet occurred or been established. The landmark book *Social Responsibilities of the Businessman*, written by Howard R. Bowen and published in 1953, is regarded as the start of the contemporary age of literature on this topic. There were either no businesswomen during this time period, as the book's title implies, or they were not recognized in formal works (Carroll, 1999, 296). Therefore, the term "social responsibility" points to a person's duty to take into account how his choices and actions will affect the entire social system. Businesspeople perform responsibly when they consider the requirements and desires of individuals who might be touched by their decisions. They look beyond the constricted economic and technological interests of their company by doing this (Davis & Blomstrom, 1966, 12).

In 1967, Keith Davis reintroduced the idea of CSR in an effort to overcome the puzzle of social responsibility. He expanded on his earlier notion in a paper on what businessmen owed society. He argued that a concern for how one's activities may affect others' interests in an ethical manner is the foundation of social responsibility (Davis, 1967, 46). He demonstrates how social responsibility extends beyond the finite scope of interpersonal interactions: "Social responsibility goes a long way beyond by emphasizing institutional actions and their impact on the entire social system." As a result, social responsibility broadens a person's perspective on the entire social system" (Davis, 1967, 46).

Johnson (1971) went on to say, the business operates within a socio-cultural system that specifies specific methods of reacting to specific cases through norms and business roles,

and it outlines the recorded procedures of doing commercial matters in detail. In business, social responsibility refers to the pursuit of socioeconomic objectives out of the development of social norms in predetermined commercial roles (Johnson, 1971, 51).

In 1980, Thomas M. Jones entered the CSR discuss with an intriguing point of view. He started by outlining CSR: Beyond what is mandated by legislation and collective bargaining agreements, corporate social responsibility (CSR) is the idea that businesses have obligations to the various stakeholder groups in society. In two ways, this definition is essential. First, the obligation must be freely chosen; a union contract or the law are examples of coercive forces that may influence conduct. Second, the obligation is broad, including obligations to customers, employees, suppliers, and nearby communities in addition to the traditional duty to shareholders (Jones, 1980, pp. 59-60)

If CSR is to be accepted by the conscientious businessperson, Carroll (1991, 40) said, "CSR should be presented in such a way that the complete range of business obligations is embraced." This article presents the claim that total CSR fall under four categories: charitable, legal, ethical, and economic. Moreover, these four CSR components or categories could be represented by a pyramidal graphic. While each of these responsibilities has evolved in some capacity for some time, the importance of ethical and philanthropic obligations has just recently emerged.

Carroll (1999) demonstrates that the expectation behind CSR is that businesses will be able to satisfy customers within a specific time frame.

CSR is classified into six dimensions by Li Haiqin and Zhang Zigang (2010): economy, environment, employees, consumers, law, and charity.

Burga et al. (2017) assert that CSR includes a company's ethical and moral commitments to society as well as other responsibilities that promote societal progress.

Li Haiqin and Zhang Zigang (2010) constructed the six dimensions by Yang Haiting (2015 cited in J.K. and Xin, 2021, 3) from the consumer's point of view to determine the effect of the above six dimensions on customers' buying intention.

The method investigates the impact of CSR achievement on consumer purchase intentions. He mentioned that, in the academic world, CSR has not been given a uniform definition or content.



## **2.2. Categories of Corporate Social Responsibility**

This article categorizes CSR into five areas of responsibility: philanthropic, economic, environmental, ethical, and legal.

### **2.2.1. Philanthropic Responsibility**

In contrast to the other nondiscretionary entities, is voluntary and discretionary (Carroll, 1983). The term "philanthropy" defines corporate actions made to satisfy society's demand that businesses behave responsibly. Including actively advancing human welfare or goodwill through deeds or initiatives. Philanthropy includes business donations of money or executive time to the community, the arts, or education (Carroll, 1991, 42).

### **2.2.2. Economic Responsibility:**

Economic responsibility implies that businesses are anticipated to output perfect services that society requires profitably. Profitability is required for taking on other responsibilities, but is solely focused on profit with disregard for other responsibilities will not be tolerated by society (Carroll, 1991), (Edmondson & Carroll 1999).

### **2.2.3. Environment Responsibility**

Environment responsibility is a component of social responsibility in organizations, according to this definition, the European Commission defined social responsibility as an organization's promise to support society and the environment in 2002 (Yang et al., 2020, 2). Before 2005, many researchers used the term "social responsibility" to describe an organization's environmental problems (Graff Zivin and Small, 2005; Fig, 2005; Tschopp, 2005 cited in Lynes, & Andrachuk, 2008, 378). Recent research has gradually carved out environmental responsibility from social responsibility. Environment responsibility refers to an organization's commitment to improving its environmental performance (Cai et al., 2015 cited in Yang et al., 2020, 2).

### **2.2.4. Ethical Responsibility**

A company's ethical responsibilities are the standards, norms, or expectations that demonstrate a concern for what stakeholders, including customers, employees, shareholders, and the community, deem to be fair, just, or in line with or protective of their moral rights (Carroll, 1991, 41). According to Agiaban et al. (2017, 44-45), ethical responsibilities refer to social norms and customs that businesses must follow but cannot be compelled by law.



### **2.2.5. Legal Responsibility:**

The laws and regulations published by the federal, state, and municipal governments serve as the standards by which businesses must operate. Society has not only accepted companies that operate for revenue. Companies are supposed to carry out their economic objectives within the bounds of the law as part of the "social compact" between industry and society. Legal obligations represent the idea of "codified ethics" since they reflect fundamental ethical standards that have been established by our legislators. Though it is true that they exist alongside economic obligations as essential principles of the free business system, they are shown as the following layer on a pyramid to demonstrate their historical evolution (Carroll, 1991, 41).

### **2.3. Consumer Perception of Social Responsibility**

The terms "socially responsible consumption" and "consumer perception of CSR" should be distinguished right away. Customer experience in the former is "thought to have a favorable or less adverse effect on the physical environment and/or the use of shopping power to communicate social issues" (Francois-Lecompte and Roberts, 2006, 52). Consumers' capacity to "discern between corporate economic duties on the one hand and corporate legal, ethical, and philanthropic responsibilities on the other" is discussed in the latter (Maignan, 2001, p. 65). To put it another way, the first address the social responsibility of a consumer's deeds and/or inactions, whilst the second addresses the value of socially conscious companies to customers. A consumer may support a business by making ethical purchases on its behalf if they feel that the company's obligations outside of the realm of commerce are significant. The consumer's perception of CSR is the main focus of this article as it is of Ramasamy and Yeung's research in 2008.

Little research has been done on the lengths consumers will go to in order to reward socially responsible businesses and punish irresponsible ones. Industry surveys have provided preliminary evidence. According to a Walker Research study, a socially responsible company is more likely to attract the business of 88% of US consumers (Smith, 1996 cited in Maignan, 2001, 58). Similarly, according to a survey conducted by the Council on Foundations, 16% of US consumers seek out do-gooders when shopping, while 40% consider corporate responsibility to be a deciding factor (Council on Foundations, 1996 cited in Maignan, 2001, 58). These studies, however, only look at social responsibility generally and neglect to look at how customers perceive corporate social

responsibility, which is discouraging for firms that care about the environment (Maignan, 2001, 58).

### 3. Methodology

#### 3.1. Measure

Carroll's scales were used in a survey that was conducted (Carroll, 1979). In this study, Carroll's method is expanded to include environmental responsibility as a new responsibility. The scales have been used to measure consumer perceptions of CSR in the Kurdistan region of Iraq. From 1 (strongly disagree) to 5 (strongly agree), the scale is used. We created a three-part questionnaire using the same scales. The first section collects data on the respondents' (Sex, Age, Certificate, Specialization, and Job). In the second section, we assessed consumers' perceptions of CSR using a total of 20 attributes made up of five social responsibility groups (i.e., philanthropic, economic, environmental, ethical, and legal). In the third section, we assessed consumer support for responsible businesses. The following statements had to be evaluated by the respondents in the third section: 1) I could very well spend more for products from a socially aware company, 2) I think about a company's ethical reputation when purchasing, 3) I avoid purchasing goods from businesses that have engaged in unethical actions, 4) I would pay more for goods from a firm that proves concerned for the well-being of our society, 5) If the quality and price of two products are equal, I would choose the company with a good reputation for being socially conscious, and 6) I am ready to go a long distance in order to purchase a good from a business that takes part in social responsibility initiatives.

#### 3.2. Data collection

As an exploratory study, we used a convenient sample of undergraduate students, staff, and lecturers from Duhok Polytechnic University's Technical College of Administration. There are 75 usable surveys, with 56% female and 44% male participants.

#### 3.3 Research variables

**Table 1:** Research variables (Independent variables and Dependent variable).

Independent variables	Dependent variable
X: Social Responsibility	Y: Consumers' Perception
Secondary variables	

$X_1$ : Philanthropic responsibility	
$X_2$ : Economic Responsibility	
$X_3$ : Environment Responsibility	
$X_4$ : Ethical Responsibility	
$X_5$ : Legal Responsibility	

### 3.4. Analysis and Findings

Using the Statistical Package for Social Sciences (SPSS) tool, the data were examined and the study's hypotheses were evaluated. The following procedures were used:

Demographic data are described using descriptive statistics (Sex, Age, Certificate, Specialization, and Job). The mean and standard deviation of the independent and dependent variables are then calculated, as are the correlations between the input and output variables, and finally calculate the regression analysis.

#### 3.4.1 Descriptive statistics

A sample of students, staff, and lecturers from the Technical College of Administration at Duhok Polytechnic University was chosen. The sample was chosen in this manner to ensure the degree of homogeneity in terms of culture, social status, and lifestyle. The demographic characteristics of the sample are shown in Table No.2.

**Table 2:** Percentage of (Sex, Age, Certificate, Specialization, and Job).

Data	Category	No.	Percentage
Sex	Male	33	44%
	Female	42	56%
Age	Less than 20	7	9.3%
	Between 20 to 30	40	53.3%
	More than 30	28	37.3%
Certificate	High school	31	41.3
	Diploma	18	24%
	B.Sc	12	16%
	MSc	11	14.7%

	Other	3	4%
<b>Specialization</b>	Accounting	45	60%
	Business Administration	11	14%
	Banking and Finance	5	6.7%
	Economic	4	5.3%
	Other	10	13.3%
<b>Job</b>	Student	43	57.3%
	Employee	20	26.7%
	Lecturer	12	16%

Tables 2 show the Demographic data percentages (Six, Age, Certificate, Specialization, and Job), According to the table, 56% of research participants are female, while 44% are male. Furthermore, the majority of research participants are aged 20 to 30, with 53.3%, compared to 9.3% and 37.3% for those aged less than 20 and more than 30. In terms of certificates, a significant proportion of study participants have a high school certificate 41.3%. The percentages of Diploma, BScs., MSc., and other certificates involved in the study were 24%, 16%, 14.7%, and 4%, respectively.

Table (2) illustrates that Accounting is the most popular Specialization among research participants (45%), followed by Business Administration, Banking and Finance, Economics, and other Specialization (11%, 5%, 4%, and 10%, respectively). The largest percentage of study participants are students; they are DPU students in stages third and fourth, then employees, and finally lecturers, with 57.3%, 26.7%, and 16%, respectively.

### 3.4.2 Mean and Standard Deviation of the Independent and Dependent Variables

**Table 3:** Mean and Standard Deviation of the Independent Variables.

CSR		Mean	Std. Dev.	Total Mean	Total Std. Dev.
<b>X<sub>1</sub></b>	1	3.97	0.838		
	2	4.25	0.737	4.0867	4.7841
	3	4.13	0.600		
	4	3.00	0.744		
	5	4.15	0.800		

$X_2$	6	4.19	0.692	4.1367	0.53948
	7	4.12	0.869		
	8	4.09	0.873		
$X_3$	9	4.23	0.894	4.0633	0.58137
	10	4.17	0.906		
	11	3.97	0.805		
	12	3.88	0.885		
$X_4$	13	4.19	0.849	4.1933	0.60484
	14	4.20	0.885		
	15	4.03	1.078		
	16	4.36	0.799		
$X_5$	17	3.99	0.951	4.1267	0.52048
	18	4.11	0.781		
	19	4.19	0.817		
	20	4.23	0.746		

Table 3 reported the mean of variables as a measure of research central tendency and Standard Deviation as a measure of data dispersion.

According to Table 3, the average scales' means range from 3.00 to 4.25, and the items related to ethical responsibility and economic responsibility had the highest means, at 4.1933 and 4.1367, respectively. The item related to environmental responsibility had the lowest mean, which was 4.0633 with a 0.58 standard deviation. All of the scales had means higher than 3.00, according to Table 3; this suggests that respondents gave them highly favorable responses.

**Table 4:** Measures of the dependent variable' (Consumer Perception) mean and standard deviation.

Consumer Perception Y		
	Mean	Std. Deviation
1	3.96	1.058
2	4.13	1.044
3	3.91	1.141

<b>4</b>	4.14	0.881
<b>5</b>	4.21	0.874
<b>6</b>	3.99	1.033
<b>Total</b>	4.0573	0.64117

Table 4 reported the mean of variables as a measure of research central tendency and Standard Deviation as a measure of data dispersion.

According to Table 4, the average scales' means range from 3.91 to 4.21, and the  $Y_5$  has the highest mean, at 4.21 with a 0.874, standard deviation, and  $Y_3$  has the lowest mean, which was 3.91 with a 1.141, standard deviation. All of the scales had means higher than 3.50; this suggests that respondents gave them highly favorable responses.

### 3.4.3 Correlations between the Dependent Variables and Independent Variables

**Table 5:** Correlations between the Dependent Variables and Independent Variables.

Variables	y	Corporate Social responsibility				
		$X_1$	$X_1$	$X_1$	$X_1$	$X_1$
$X_1$	0.055	1	0.346**	0.405**	0.277*	0.189
$X_1$	0.377**	0.346**	1	0.532**	0.273*	0.314**
$X_1$	0.331**	0.405**	0.532**	1	0.188	0.269*
$X_1$	0.022	0.277*	0.273*	0.188	1	0.214
$X_1$	0.240*	0.189	0.314**	0.269*	0.214	1

\*\* . Correlation is significant at the 0.01 level (2-tailed).

\* . Correlation is significant at the 0.05 level (2-tailed).

Table 5 demonstrates that the correlation coefficient between the independent variables (economic responsibility, environmental responsibility, ethical responsibility, and legal duty) and the dependent variable (consumers' perception) is significant at the 0.01 and 0.05 levels. There is a strong positive relationship between consumers' perception and both economic responsibility and environmental responsibility, with respective correlation coefficients of 0.377\*\* and 0.331\*\*. At a significant level of 0.05, there is also a significant correlation between consumers' perceptions and legal responsibility of 0.240\*.

### 3.4.4 Regression Analysis.

**Table 6:** Regression Analysis

	$y$	F-test	$R^2$	T-test	Model
$X_1$	0.055	0.223	0.003	0.472	
$X_1$	0.377**	12.107**	0.142	3.479**	$Y = 2.203 + X_2(0.448)$
$X_1$	0.331**	8.995**	0.110	2.999**	$Y = 2.573 + X_3(0.365)$
$X_1$	0.022	0.034	0.0004	0.184	
$X_1$	0.240*	4.454*	0.058	2.110*	$Y = 2.838 + X_5(0.295)$

\*\*. Correlation is significant at the 0.01 level (2-tailed).

\*. Correlation is significant at the 0.05 level (2-tailed).

### 3.5. Developing Research Hypothesis:

#### First Hypothesis

*There is a relationship between Consumers' Perceptions of Philanthropic responsibility.*

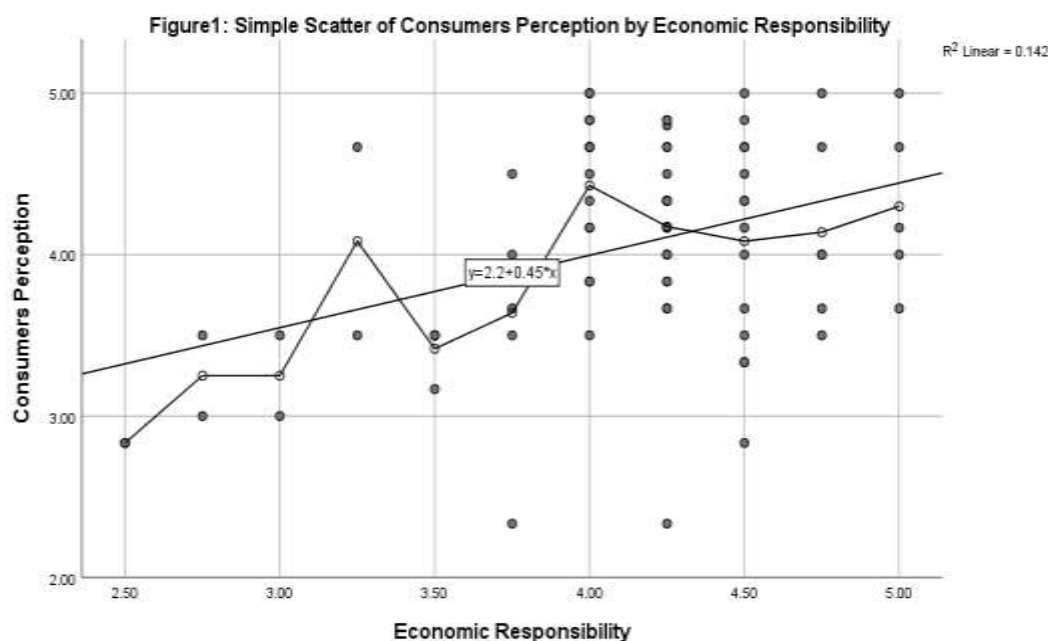
Table 6 highlights the lack of a correlation between consumer perception and philanthropic responsibility at a significant level of 0.01 and 0.05, with a coefficient of correlation of 0.055. As a result, the first hypothesis cannot be accepted.

#### Second Hypothesis

*There is a relationship between Consumers' Perceptions of Economic responsibility.*

The second hypothesis is accepted because there is a correlation between consumers' perception of economic responsibility and it at a significant level of 0.01 and the coefficient of correlation is 0.377 as shown in table (6). Consumer perceptions and economic responsibility are positively correlated, meaning that as consumer perceptions rise, so does economic responsibility. The value of the F-test is 12.107 at a significance level of 0.01, indicating that there is an association between consumers' perceptions and economic responsibility. Additionally, because the value of the  $R^2$  is 0.142, the economic responsibility changes by 14.2% and is still 85.8% influenced by other factors, in addition to random error resulting from the selection of the sample space and the unit of measurement. Since the T-test value has not yet reached zero, it refers to the impact of economic responsibility on consumers' perceptions.

It implies that Consumer Perception is Affected by Economic Responsibility. Where  $Y = 2.203 + X_2(0.448)$  is the regression formula in Table (6) and Figure (1). We can estimate consumers' perceptions of economic responsibility using the regression model.



### Third hypotheses

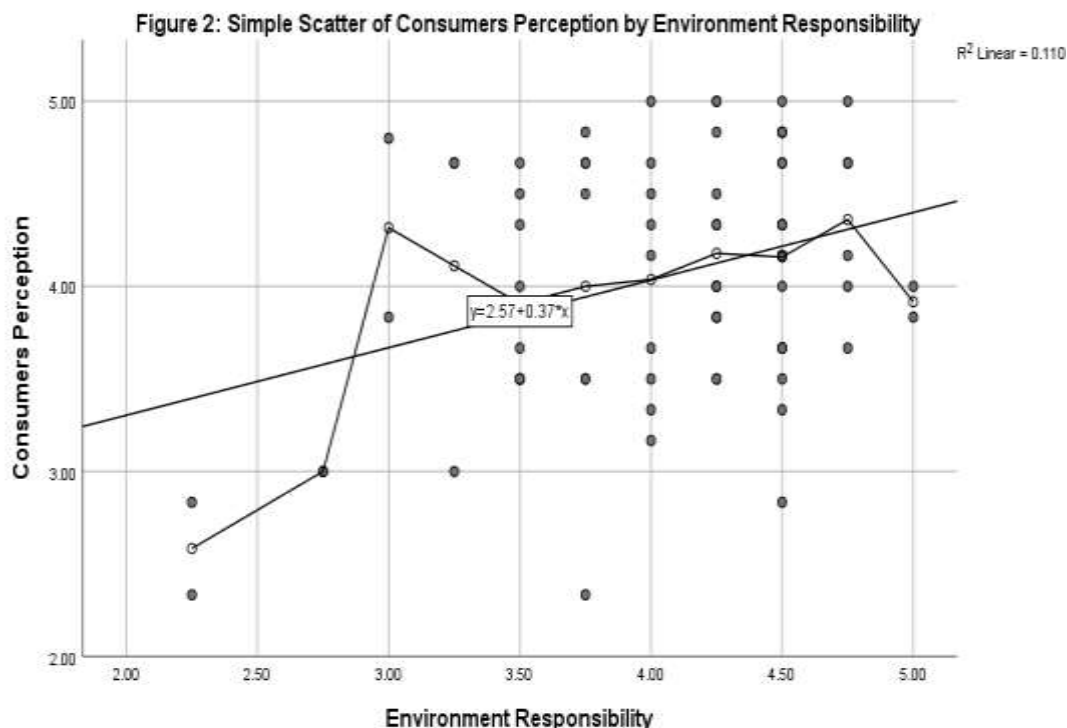
***Consumers' Perceptions of Environmental Responsibility and each other are related.***

The third hypothesis is accepted since Table 6 shows that there is a correlation between consumer perception and environmental responsibility at a significant level of 0.01 and a coefficient of correlation of 0.331.

Consumer perceptions and environmental responsibility are positively correlated, implying that as consumer perceptions increase, so does environmental responsibility. The value of the F-test is 8.995 at a level of significance of 0.01, suggesting that there is an association between consumers' perceptions and environmental responsibility. Furthermore, because the value of the  $R^2$  is 0.110, the environmental responsibility changes by 11%, with the remaining 89% being influenced by other factors. So because the T-test value has still not dropped to zero, it refers to the influence of environmental responsibility on consumers' perception. It means that Environment Responsibility affects the Consumer's Perceptions.



Where the Regression formula in Table (6) and figure (2) is  $Y = 2.573 + X_3(0.365)$ . By the Regression model we can estimate Consumers Perception from the Environment Responsibility



#### Fourth hypotheses

##### *Consumer perceptions of ethical responsibility are related to*

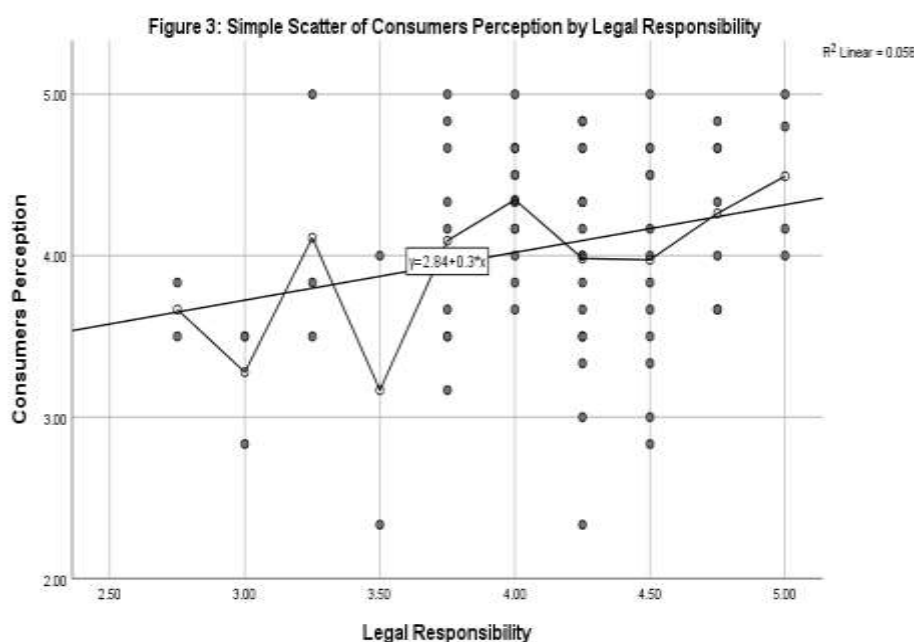
Table 6 demonstrates that there is no relationship between Consumer Perception and Ethical Responsibility at a significant level of 0.01 and 0.05, with a coefficient of correlation of 0.022, indicating that the Fourth Hypothesis cannot be accepted.

#### Fifth hypotheses

##### *There is a relationship between Consumers' Perceptions of Legal responsibility*

The fifth hypothesis is supported by Table 6's finding that there is an association between consumer perception and legal responsibility at a significant level of 0.05 and a coefficient of correlation of 0.240. There is a correlation between them. If consumer perceptions improve, legal responsibility improves as well. The F-test value is 4.454 at a significant level of 0.05, indicating that there is a relationship between Consumers Perception and Legal Responsibility. Moreover, the Legal Responsibility changes by 5.8% and remains 94.2% affected by other factors,

in addition to random error due to sample space and unit measurement. Because the T-test value has not reached zero, it refers to the effect of legal responsibility on consumer perceptions. There is a correlation between them. If consumer perceptions improve, legal responsibility improves as well. The F-test value is 4.454 at a significance level of 0.05, indicating a relationship between Consumer Perception and Legal Responsibility. Even though  $R^2$  is 0.058, the legal responsibility changes by 5.8% while the remaining 94.2% is affected by other factors. Since the T-test value has not reached zero, it informs of how the impact of responsibility under law affects consumer impressions. It means that economic responsibility has an impact on consumer perception. In Table (6), the regression formula is  $Y = 2.838 + X \cdot 5 (0.295)$ . We can estimate Consumers' Perceptions of Legal Responsibility using the Regression Model.



### Comparison of this study's findings with other country's studies

Consumer perceptions of social responsibility differ across countries, according to studies conducted in the United States, France, Germany, and America (Maignan, 2001), Indonesia (Arli and Lasmono, 2010), and China (Ramasamy & Yeung, 2008).

The study demonstrated in table 3, that respondents had high levels of perception of social responsibility; philanthropic, economic, environmental, ethical, and legal with mean of 4.08, 4.13, 4.06, 4.19, and 4.12 respectively, demonstrating that they were aware of the five different types of

social responsibility and their relative importance. Indicating that the study sample initially concentrated on the significance of the ethical, economic, and legal aspects. Priority was given to its commitment to ethical principles in order to keep its employees' behavior within ethical frameworks; however, respondents focused on the economic aspect, giving it priority over its ethical performance. Although Carroll's hierarchy of social responsibility ranks economic responsibility first. However, the outcomes of this research suggest that ethical responsibility is the most crucial variable for consumers in Iraq's Kurdistan Region.

The findings of this study are similar to those of the (Maignan, 2001, 57) study on consumer perceptions of social responsibility in Germany and France, where consumers were more interested in the Ethical responsibility of companies than in Economic responsibility, whereas consumers in America placed the greatest emphasis on Economic responsibility.

Another research reveals that Indonesian consumers are still unaware of and hesitant to support CSR (Arli and Lasmono, 2010, 46). People in Indonesia and other poor nations struggle daily to meet their basic necessities, thus it stands to reason that they would choose the most economical products, regardless of how much or how little a corporation invests in CSR activities (2009, 46). The consumer in Indonesia prioritizes economic and philanthropic responsibility over legal and ethical obligation, according to this information.

Research by (Ramasamy and Yeung, 2008, 119) also pointed out that consumers in China and Hong Kong prefer Economic responsibility, whereas philanthropic responsibilities seem to be the least important. There is no doubt that the reasons for preferring economic responsibility differ according to the economic, cultural, social, and political circumstances of each of the countries mentioned above.

#### **4. Conclusion**

This article divided corporate social responsibility into five dimensions; philanthropic, economic, environmental, ethical, and legal aspects, and analyzes their influence on consumer perception. The study also intended to compare its findings with those of numerous studies on social responsibility conducted in various countries. The following are the main research conclusions:

First, Consumer perception is affected by three out of five dimensions of corporate social responsibility namely; economic, environmental, and legal responsibility. As shown in Table 6, a connection existed between consumers' perception of economic and environmental responsibility at a significant level of 0.01 and the coefficient of correlation was 0.377 and 0.331, respectively. There was also a correlation between consumers' perception of legal responsibility at a significant level of 0.05, and the coefficient of correlation is 0.240. This indicates that Consumer perceptions and economic, environmental, and legal responsibility are positively correlated. On the other hand, there is no relationship between Consumer Perception and Philanthropic and Ethical Responsibility at a significant level of 0.01 and 0.05, with a coefficient of correlation of 0.055 and 0.022 respectively.

Second, according to the study, the respondents seemed to have a high level of consciousness of the various aspects of responsibility, demonstrating their understanding of the proportional significance of the five various aspects of social responsibility. The importance of ethical responsibility was prioritized by the study sample, with economic responsibility coming in second and legal responsibility coming third. Where its adherence to ethical standards was made a priority; however, the respondents also paid attention to the economic aspect, giving it priority over its legal performance. The findings of this study showed that consumers in Iraq's Kurdistan Region place the greatest importance on ethical responsibility. Compared to other studies in the same field, but with different nationalities; American consumers place a high value on corporations' economic responsibility; however, for French and German consumers, the most crucial factors in business practices are legal and ethical compliance (Maignan, (2001, 57), Indonesian consumer takes priority on Economic and Philanthropic responsibility, followed by Legal and Ethical responsibilities (Arli and Lasmono, 2010, 46), for Chinese consumers economic responsibilities being the most important and philanthropic responsibilities being the least important (2008, 119).

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## Investigation of the Physical and Chemical Properties of Underground Water in Kabul City

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### Abstract

The objective of this research is to assess the quality of underground water in Kabul city in terms of health and compliance with WHO and other relevant standards. To evaluate underground water quality in Kabul city, 25 water samples are collected from various locations. Advanced instruments such as the HQ440d Multi-Meter, Turbidity Meter, Conductivity Meter, and Wag-WE10500, along with reagents like Alkali Solution and Calcium and Magnesium indicator Solution, are used to measure different chemical and physical parameters of the water. Various tests are conducted in the field and laboratory. Chemical parameters including bicarbonate, sodium, magnesium, calcium, iron, fluorine, potassium, chlorine, chloride, arsenic, and nitrate are evaluated. Some parameters, such as fluoride, iron, arsenic, sodium, potassium, and chlorine, are within permissible limits for underground water in Kabul. However, findings confirm previous concerns about deteriorating water quality, including increased water hardness and nitrite levels. Parameters such as chloride, nitrite, total hardness, sulfite, and magnesium exceed permissible limits in most areas, including Kabul. Additionally, physical parameters like turbidity, conductivity, TDS, electrical conductivity, alkalinity, acidity, color, taste, smell, and temperature are assessed. All chemical and physical parameters are compared against WHO, S.EPA, ANSA, E.U, IL standards, and the results are presented in a chart for clarity. Comparisons with established standards are analyzed and discussed.

**Keywords:** water chemistry parameters, water physical parameters, water quality reduction, effects of low-quality water, public awareness



## 1. Introduction

Drinking water is a very important substance in human life, although 3/4 of the earth's surface is covered by water, but still, drinking water is received in small quantities in the world. The reason is that water is one of the very good solvents and when water flows on the surface of the earth or underground, it always has some amounts of salts, suspended substances and dissolved gases with it, and this causes the water to flow in different areas. Take on different characteristics. The presence of some salts in water is necessary for human health, and their excessive amounts will endanger human health. Therefore, the existence of healthy drinking water is a guarantee of the health of society and the first step in knowing water is to study the parameters of drinking water (1, 2, 3, and 4) (York: John Wiley & Sons; 1991).

From the beginning of their life on earth, humans lose access to safe drinking water over time due to various factors, and with each passing day, they face a greater shortage of drinking water. Developed countries and societies annually spend huge capital to protect drinking water resources. In developing countries, there is a problem of creating modern and advanced infrastructure, including drinking water systems. Because the creation of such systems requires huge expenses and budgets, which are not available to developing and poor countries like Afghanistan.

Our dear country of Afghanistan and the people who live in it have suffered more than the last three decades due to many wars and in various fields. Reports published in 2011 show that the lives of approximately 85,000 children are threatened by the lack of drinking water (5) (WHO, 2011).

According to UNICEF's claims, there is also a problem of water quality being affected by climate pollution in Afghanistan (5) (WHO, 2011).

The population density in Kabul city is much higher than other cities and regions of the country and it is said that around 5 million people live in this city. The source of drinking water for the citizens of Kabul is the use of underground water. Lately, Kabul area, and especially Kabul city has faced the problem of a significant reduction of surface water due to the lack of annual rainfall. Kabul Sea, which has water only for three months of the year and is quite polluted, forms the main source of the underground water supply of Kabul city. According to research by the Dakar Institute, only 20%-27% of Kabul citizens have access to the central water distribution system, the rest of the citizens get their water from semi-deep or shallow wells using water pumps or hand pumps. (6) (Saffi, M. H., 2011).

Currently, the major concerns in the Kabul basin are the significant reduction of natural underground water reserves and even drying due to excessive use, low nutrition, and high evaporation. The reason for the reduction of underground water reserves and the lowering of the underground water level is considered to be due to the low level of nutrition. This is considered a serious risk for reducing the natural reserve in the aquifer. In addition to the lack of quantity of drinking water, its quality is also one of the major and important issues. According to the research of the Dakar Institute, the quality of underground water in the Kabul basin has decreased due to the increase in the number of salts, water hardness, bacteria, boron, and nitrite concentration. An increase in the above parameters can be considered a serious risk to the health of Kabul citizens and agricultural activities. Residents of Kabul frequently get diseases caused by water pollution, and children are more at risk (6) (Saffi, M. H., 2011) .

Research conducted by the United States Geological Survey (USGS) shows that bacterial contamination has been seen in groundwater and surface water, the level of which exceeds the international standards for drinking water (7) (Mack, T. J., Akbari, 2010).

Campbell (2015) claims that 70.9% of the urban and 39.4% of the rural population in Afghanistan have access to clean drinking water, which means that about 46% of the total population has access to clean drinking water. (25)(Campbell J. A dry and ravaged land, 2015(

Houben et al. (27) (2009b), insufficient sanitation may be related to high child mortality rates. Thus, it is necessary to study the sources of groundwater pollution to prevent other problems that may be caused by groundwater (Houben et al, 2009.(

Uhl (2006) (28). He claims that even most of the urban areas rely on underground water for drinking, while in the country more than 95% of underground water is still used for irrigation (Rana Associates, USA, 2003.(

In addition to the aforementioned problems and threats, the population of Kabul is increasing, which causes more extraction of underground water. This practice is impossible and not allowed due to different factors such as the lack of thickness and watering of water-rich layers. The continuation of the current situation will have negative effects on the quality and quantity of underground water in the Kabul basin and will cause serious problems for social and economic development and environmental security. On the other hand, the continuation of this situation makes it impossible to return the watered floors to a better condition and causes the citizens of Kabul to face a serious problem of drinking water shortage and more water pollution in the future.

According to the evidence and results of research and studies in the field, the issue of assessing the quality of underground water in the Kabul Basin is one of the most important and important issues, and finding the appropriate methods to solve the current problems in the field and predicting and recommending preventive measures require research. It is durable. This study aims to assess the quality of underground water in the Kabul basin and answer questions regarding the compliance of chemical and physical parameters with permissible limits. By finding appropriate methods and recommending preventive measures, this research aims to contribute to resolving the pressing water-related challenges in the region.

## 2. Material and methods

The method of collecting samples from designated areas involved the following steps and equipment:

Water Level Indicator: Used to measure the depth of the water table at each sampling location.

GPS: Utilized to accurately determine and record the geographic coordinates of each sampling site.

Notebook: Used for noting down relevant information such as the sampling location, date, time, and any specific observations.

Standard Form: A prepared form provided by the General Administration of Water Quality Control and Water Supply Materials, Department of Water Supply, Ministry of Rural Development, which includes details required for sample collection.

Laboratory Bottles: Two bottles were used for each sampling location to collect water samples for subsequent analysis in the laboratory.

Lighter or Burnell: Used to sterilize the sampling site by burning off any organic residue or contaminants on the surface.

Sterilizing Materials: Dettol or similar sterilizing agents were employed to ensure the cleanliness and sterility of the sampling site.

These equipment, materials, and devices were carefully utilized to collect samples and preserve the integrity of the water samples during the sampling process. Proper sterilization techniques were employed to prevent contamination, and detailed records were maintained to ensure accurate data collection. To control groundwater pollution and assess its quality in Kabul city, the following methodology was employed:

**Selection of Wells:** Twenty-five wells were identified in various locations across Kabul city for the study. Sampling stations were chosen at sufficient distances from each other, except in densely populated areas where a higher number of samples were collected due to a higher potential for contamination.

**Sampling Procedure:** Water samples were collected from the identified wells using standard methods. Special plastic containers were used to preserve the water samples during transportation to the laboratory.

**Temperature Measurement:** The temperature of the water at each sampling location was recorded as part of the study.

**Testing Categories:** The water samples were subjected to two categories of tests: device tests and titrimetric tests.

**Titrimetric Tests:** Titrimetric tests included the measurement of temporary and permanent hardness, calcium and magnesium levels, alkalinity, and chloride. These tests were conducted following the methods specified in the standard method reference. For example, total hardness, calcium, and magnesium were measured through titration with EDTA, alkalinity was determined using the tetrazolium method with hydrochloric acid or sulfuric acid 0.02, and chlorine was measured through iodometry and silver nitrate titration. Sulfate and bicarbonate levels were obtained through titration with hydrochloric acid.

**Instrumental Tests:** Instrumental tests were performed to measure Total Dissolved Solids (TDS) and Electrical Conductivity (EC) using an EC meter (model CD 20, Aquatic mark, made in Germany) with an accuracy of 0.01. Turbidity was measured using a turbidity meter (model P 2100, Hach mark, made in America) with an accuracy of 0.01. pH levels were measured using a pH meter (model 654, Meterohm mark, made in Switzerland).

**Anions and Cations:** Anions such as fluorine, iron, sodium, nitrite, and nitrate were measured using a spectrophotometer (model 7000) with a precision of 0.1 units, manufactured in England.

The above testing procedures were conducted to evaluate the chemical and physical parameters of the groundwater samples in Kabul City. These parameters provide valuable insights into the water quality and assist in monitoring and managing groundwater pollution.

### 3. Discussion

The most important chemical parameters include the following:

### 3.1 Fluorides (F)

Fluorides are naturally present in water. Increasing the amount of fluoride in drinking water is beneficial for the health of teeth. Children should benefit from such waters.

The excess amount of fluoride in water causes diseases such as fluorosis (line on the teeth) or painful bone diseases in children and adults, and the measure of fluoride in drinking water is to prevent caries and also to prevent the streaking of teeth (Appelo, C, A, J. Postma).

The amount of daily intake of fluoride depends on the geographical area. If the diet includes fish and tea, contact through food is especially high. Exposure to fluoride through drinking water also depends on the temperature of the region, and the higher the temperature, the more fluoride in water should be at least 1.5 mg/liter (Nabizade Nodhi, Others 1375).

The results of the fluoride level of the wells range from a maximum of 1.8 mg/liter in well number 8 to a minimum of 0 mg/liter in well number 7. According to the above-mentioned standards, without the sample of well number 8, all the water samples from (Table No. 3) do not cause any problems in terms of different uses.

Nitrite: The amount of oxidized nitrogen is equal to the total nitrogen of nitrite and nitrite including water. The presence of nitrite and a high amount of ammonia in surface water indicates water pollution with waste materials. In iron-containing waters, nitrites in groundwater are referred to as nitrites. Nitrite is the last product of ammonia oxidation and ammonia in the organization of organic materials, this oxidation process is carried out in soil and water by nitrification bacteria and this process is only possible in the presence of oxygen. The use of nitrogen-containing chemical fertilizers has caused an increase in nitrites in surface and underground waters. Water with a high amount of nitrite is harmful to infants. According to the practice of the European Union, the amount of nitrite in drinking water has been accepted as equal (Mark J. Hammer, 1986). (Program and budget organization 1375).

Therefore, in terms of nitrite (table no. 3), the water of wells no (1, 5, 6, 8, 14, 20, 21, 22, 23, 25) Creates an opinion.

There are health problems caused by this parameter, and it is recommended that necessary monitoring be done so that necessary control measures can be applied in case of a growing trend of nitrite in underground water sources.

Chlorine: high concentrations of chlorine cause taste in drinking water. The taste threshold limit for anion chloride depends on the type of Kat ion combined with it. The threshold for sodium, calcium, and potassium chloride is in the range of 200 to 300 milligrams per liter. No health-based guideline amounts have been suggested for it (Mark J. Hammer, 1986). (Program and budget organization 1375).

The results of the chlorine level in the wells range from a maximum of 251 mg/liter in well number 22 to a minimum of 0.1 mg/liter in well number 17 (table no. 3).

Therefore, the results show that the chloride of the well water (table no. 3) is less than the permissible limit (average value is 106.312 milligrams per liter) and does not cause any problems in terms of different uses.

But the chlorine present in the water of well No. 22 is more than the maximum allowed amount. It likely is one of the reasons for creating an unpleasant taste in drinking water.

Sulfate: The presence of sulfate in drinking water can create a noticeable taste. The unfavorable taste of water varies with the nature of the corresponding Kat ion. Usually, this taste is considered that in amounts below 250 mg/liter, the unpleasantness of the taste is minimized ((Program and budget organization 1375). (Canter L& Others, 1987).

Sulfate in drinking water causes hardness (non-carbonate hardness) and changes the taste of water. Areas, where residents have to use sulfite water, get used to its high concentration. If sulfite is referred to, it will be produced with the smell of rotten eggs, this gas is also produced in deep wells, and its smell is quickly removed due to the effect of aeration.

Sulfate in the water samples of the wells (Table No. 3) of the studied area varies from 0.08 to 360 mg/liter in terms of sulfate ion. A large amount of sulfate in water creates limitations in various uses. Wells's numbers (24, 22, 20, and 18) have to sulfate much more than the water standard (250 mg/liter).

Sodium: The taste threshold for sodium is 200 mg/liter, and since no definite conclusion can be made about the health effects of sodium, no health-based guideline amount has been obtained for it (Program and budget organization 1375). Sodium is an abundant element in water, and due to its high solubility, it is more present in natural waters, and its amount increases in salty waters.

During the softening of hard water utilizing lime-sodium, the amount of sodium in the water is increased with the changes. According to the guidelines of the European Union, the appropriate concentration of sodium in water is 20 mg/L, and the maximum concentration of sodium in water is 200 mg/L. The level of sodium in water should be kept low so as not to cause diseases.

The results showed (Table No. 2) that the amount of sodium in the water source of the wells is within the permissible limit, and in the well water samples of the study area, it varies from 12 to 115 mg/litter in terms of sodium ions.

Total hardness: The hardness of water is related to the specific salts that are present in them, these salts consist of different Kat ions, such as: which is available in solution form with – anions : Water with a hardness of more than 200 milligrams per litter can cause mass deposition in the distribution system and high consumption of soap, and on the other hand, water with a hardness of fewer than 100 milligrams per litter will be very corrosive for pipes (Mark J.Hammer, 1986).

Table 1 shows the characteristics of water hardness (Stumm, W, 1990).

**Table 1. Divisions and hardness of water**

difficulty level	CaCO <sub>3</sub> (mg/l)
soft	0-50
semi-soft	50- 100
little soft	100 – 150
semi-hard	150 – 200
hard	More than 200
very difficult	More than 300D

Water with a hardness of more than 300 mg is considered very hard water and considering that the hardness in the water samples of the wells (Table No. 2) of the studied area varies from 80 to 830 mg/liter. The wells number (10, 11, 12, 13, 18, 20, 22) have a hardness much higher than this value, therefore according to table number 1 of the divisions and degree of water hardness, you are placed in the category of very hard water.



### 3.2 Turbidity rate

Water quality can be interpreted as a lack of water clarity, but water quality should not be mistaken. Water can be dark in color, but not cloudy. It is caused by the presence of extremely low insoluble substances in water, whose amount varies from a very small amount to a large amount that causes the water to become completely cloudy. There are no problems for separating large suspended materials that can precipitate, because placing water in the right place will cause the same materials to precipitate, but small particles can be separated from water by filtering, if the particles are very small, they can be removed by the process of adding aluminum sulfite, etc. Measuring the concentration can be useful in determining the amount of colloidal particles that are not precipitated and cannot be filtered (Krapitov, 1981).

The minimum acceptable standard for drinking water is 5 units and the maximum is 25 units.

The amount of industrial water should be as low as possible, this issue is particularly important for boiler water; because it loads sediments in boilers and can produce foam and be carried by steam. In the food industry, the amount of water needed should be low, because its increase affects the products and spoils them. The amount of water in the cooling systems and central heating systems is a great barrier to heat, which as a result causes overheating and blockage of the taps and also causes erosion of the systems.

The measuring instrument is called a turbidity meter.

The test showed that the turbidity of the water samples taken from the wells in the city of Kabul due to the study by the standard of the maximum desired in some water samples from table number 3 (wells number 4, 15, 16, 17, 19, 24) is higher than the minimum standard.

### 3.3 Electrical Conductivity.

It is a criterion for measuring the electric current of a solution. This electric current capability of solutions depends on the existence of ions in aqueous solutions. The measurement of electrical conductivity shows the substances dissolved in water and its measurement unit is micro Siemens per centimeter [ $\mu\text{S}/\text{cm}$ ].

The results of the electrical conductivity of well water range from the maximum [ $\mu\text{S}/\text{cm}$ ] of 24450 in well number 18 to the minimum [ $\mu\text{S}/\text{cm}$ ] of 227 in well number 7.

The results of the analysis in the electrical conductivity parameter section show that without the water of sample number 7 of the well, all the water samples of the wells (table number 3) are higher according to the WHO standard ([ $\mu\text{S}/\text{cm}$ ] 250).



Total dissolved solids TDS: TDS is a very effective parameter in creating the taste of drinking water, water that has TDS less than 500 mg/liter is considered very good water from the point of view of drinking standard. TDS between 500 and 1000 is desirable and widely 1000 to 15000 is allowed for drinking, but water with TDS of more than 1500 is not acceptable for drinking (Mark Jammer, 1986). (Program and budget organization 1375).

EC indicates the ability to pass electric current in the water, which has the same properties as TDS (Ashton, J., Wampler, P., Kneeshaw, T, 2020).

Using Table No. 3, the results of the water range of TDS changes in the wells are from a maximum of 1100 mg/liter in well No. 18 to a minimum of 131 mg/liter in well No. 7. According to the aforementioned standards, the water of all the wells is acceptable for drinking and use in industries, and only well number 18, which has TDS more than 1000 mg/liter, is not suitable for drinking, which is classified as salty water. (WHO, Geneva. 1993) and causes consumer complaints.

### 3.4 Bicarbonate

Carbon dioxide and bicarbonate in water are the basic components of carbonates and as a result of the hydrolysis of bicarbonate, the water environment becomes alkaline (Ashton, J., Wampler, p., Kneeshaw, T., 2020).

It can be seen from Table number 3 of the water laboratory results that the bicarbonate parameter in the water samples of the studied wells varies from 60 to 410 mg/liter. Bicarbonate in all the well water samples taken for the study is more than the standard (10 mg/liter), which is the best value of the results, the amount of bicarbonate in the well water is from the maximum of 410 mg/liter per well number of 25 to the minimum. It is 0.1 mg/L in well number 17.

### 3.5 Calcium and magnesium

Because calcium and magnesium are the main factors of water hardness. A large amount of elements in water causes an increase in the hardness of water and as a result, limits the different uses of water and as a result limits the different uses of water. The maximum amount of calcium and magnesium was observed in the water of wells No. 18 and 20 (Table No. 2) and these wells have higher hardness than the studied wells in the region. In terms of hardness, the waters of the region are considered very hard waters and create restrictions for various uses.

#### 4. Conclusion

From the point of view of the chemical and physical parameters of the underground water of Kabul city, it is problematic from the health point of view, and in general, the underground water in the lower part of Kabul city is considered to be very hard water.

In terms of most of the chemical parameters, including EC, TDS, SO<sub>4</sub>, NO<sub>3</sub>, and HCO<sub>3</sub>, the water of wells No. 1, 2, 3, and 14 are polluted beyond normal and permissible limits.

The main source of underground water supply in the Kabul area is the infiltration of atmospheric water (snow and rain) through the rocks of the aeration zone to the surface of the underground water, and the infiltration of seawater that flows as a result of rain or after the melting of snow in the mountains.

The lack of annual rainfall in this area has caused the level of underground water to decrease, which, as a result, increases the radius of influence and contamination of underground water due to the absorption of surface polluted water.

The results obtained from this research confirm the previous claims and results regarding the deterioration of the quality of underground water in the Kabul region, such as the increase in water hardness, the increase in the amount of nitrite, etc. as a whole. But it provides more accurate results and results for the absolute majority of water quality parameters.

Based on the obtained results, we can say that the important physical parameters of groundwater quality such as TDS, electrical conductivity, and pH are not good in all parts of the Kabul area, and most of the opinion is the minimum limit of the determined standard.

Some of the chemical parameters of underground water quality in the Kabul area such as fluoride, total amount of iron, arsenic, sodium, potassium, and chlorine are within the permissible limit in all samples.

The amount of chloride in all basins (four water layers) except the sub-basin of Kabul Merkazi is within the permissible limit. Also, the amount of nitrite is within the permissible limit only in the Pulcharkhi sub-area, and for all three other areas it is more than the permissible limit according to the minimum criteria. Of course, the highest amount of nitrite has been received in the Dar al-Aman area.

The amount of sulfite is within the permissible limit only in the Darlaman sub-area, and it is more than the permissible limit in the remaining three areas. In terms of the amount of sulfite in the

underground water of the central Kabul sub-basin, it is in the worst situation with this quantity being more than 75% including 17 samples and the maximum quantity of 360 mg/l.

The general hardness of underground water in all areas for a certain percentage of samples is higher than the permissible limit. But the percentage of violations is very different from the maximum and minimum standards. The highest value of hardness was obtained in the waters of central Kabul samples (830 mg/l CaCO<sub>3</sub>). Overall, it can be said that the overall hardness of Polcharakhi and Central Kabul waters is higher than the other two areas.

The amount of magnesium in the underground water of all sub-basins is more than the permissible limit. The maximum amount of magnesium has been found in the water of Logar and central Kabul sub-basins (75 mg/l).

Based on the obtained results, we can say that some of the important chemical parameters of underground water quality, such as the amount of chloride, nitrite, total hardness, sulfite, and magnesium in the Kabul area are not within the permissible limits for the majority of areas including this area .

**Table 2- Concentration of chemical Kat ions and physical parameters in underground water of Kabul city**

Location	well number	The concentration and balance of ions in water ( <i>mgr / liter</i> )						
		1	2	3	4	5	6	7
		Na [mg/l]	Mg [mg/l]	Ca [mg/l]	K [mg/l]	T/H [mg/l]	Ca/H [mg/l]	As [mg/l]
Khushal Khan Mina	1	23	25	110	0.4	380	250	0
Deh Araban village	2	12	26.7	56	0.1	250	140	0
Afshar-water supply project	3	-	-	-	-	-	-	-

company - Afshar project	<b>4</b>	-	-	-	-	-	-	-
Dasht Barchi (Onchi)	<b>5</b>	<b>30</b>	<b>12</b>	<b>96</b>	<b>6.6</b>	<b>290</b>	<b>240</b>	<b>0</b>
Wazir Castle	<b>6</b>	<b>23</b>	<b>29</b>	<b>144</b>	<b>0.5</b>	<b>480</b>	<b>360</b>	<b>0</b>
straps	<b>7</b>	<b>10</b>	<b>7.2</b>	<b>24</b>	<b>0.2</b>	<b>80</b>	<b>60</b>	<b>0</b>
Paghman- Abdul Ali village	<b>8</b>	<b>68</b>	<b>26</b>	<b>60</b>	<b>3.7</b>	<b>230</b>	<b>150</b>	<b>0</b>
Gulai Mehtab Qualia	<b>9</b>	<b>57</b>	<b>13</b>	<b>26</b>	<b>0.5</b>	<b>300</b>	<b>240</b>	<b>0</b>
National Museum of Afghanistan	<b>10</b>	<b>55</b>	<b>29</b>	<b>33</b>	<b>0.4</b>	<b>520</b>	<b>270</b>	<b>0</b>
Deh Dana Neswan High School	<b>11</b>	<b>67</b>	<b>62</b>	<b>35</b>	<b>0.8</b>	<b>571</b>	<b>170</b>	<b>0</b>
Guzarga (the gaiby castle)	<b>12</b>	<b>60</b>	<b>63</b>	<b>32</b>	<b>0.6</b>	<b>560</b>	<b>180</b>	<b>0</b>
Forty Pillars (Ansarullah)	<b>13</b>	<b>63</b>	<b>59</b>	<b>33</b>	<b>0.6</b>	<b>570</b>	<b>260</b>	<b>0</b>
Chial Stone - Factory	<b>14</b>	<b>65</b>	<b>27</b>	<b>28</b>	<b>0.4</b>	<b>440</b>	<b>210</b>	<b>0</b>
Alauddin project	<b>15</b>	<b>51</b>	-	-	-	-	-	-
areas of Deh Mezang	<b>16</b>	<b>66</b>	-	-	-	-	-	-

Seyyed Jamaluddin University	17	-	-	-	-	-	-	-
Tuberculosis Hospital	18	58	49	250	4.9	830	200	0
Ibn Sina's Hospital	19	-	-	-	-	-	-	-
Muhammad Khan's Pole	20	38	75	195	2.7	800	400	0
Fethullah Castle	21	165	46	45	3.4	285	112	0
Polcharkhi Bank of Afghanistan	22	56	41	200	0.7	670	200	0
Lab Darya (bathing well)	23	35	23	150	0.9	470	340	0
Bagrami- Darya Logar	24	-	-	-	-	-	-	-
Bagrami-Shivaky	25	115	45	44	4.8	480	110	0
average		55	36.55	86.72	1.79	455.88	216.22	0
standards	The optimal maximum of the standard	200	30	200	10	150	-	0.01
	Maximum allowed	200	300	200	10	500	-	0.05

**Table 3- Concentration of chemical anions and physical parameters in underground water of Kabul city**

Location	well	The concentration and balance of ions in water. ( <i>mgr / liter</i> )					Physical parameters of water			
		1	2	3	4	5	1	2	3	4
		Cl [mg/l] ]	Hco <sub>3</sub> [mg/l]	So <sub>4</sub> [mg/l]	No <sub>3</sub> [mg/l]	F [mg/l]	Turbidity [NTU]	E.C [μS/cm]	TDS [mg/l]	pH
Khushal Khan Mina	1	96	110	98	15	0.1	0	842	480	8
Deh Araban village	2	110	65	45	0	0.3	0	442	293	8.1
Afshar- water supply project	3	-	-	37	2.7	0.18	0.29	490	619	7.5
company - Afshar project	4	-	-	0.08	5.3	0	0.32	480	619	7.5
Dasht Barchi (Onchi)	5	107	80	74	20	0.1	0	710	475	7.6
Wazir Castle	6	125	130	118	10	0.2	0	990	484	7.2

straps	<b>7</b>	<i>26.7</i>	<i>60</i>	<i>23</i>	<b>0</b>	<b>0.1</b>	<b>0</b>	<b>227</b>	<b>131</b>	<b>8.2</b>
Paghman- Abdul Ali village	<b>8</b>	<i>21</i>	<i>325</i>	<i>34</i>	<b>26.04</b>	<b>1.8</b>	<b>1.1</b>	<b>900</b>	<b>619</b>	<b>7.6</b>
Gulai Mehtab Qualia	<b>9</b>	<b>111</b>	<i>82</i>	<i>85</i>	<b>10</b>	<b>0.1</b>	<b>0</b>	<b>720</b>	<b>477</b>	<b>7.3</b>
National Museum of Afghanista n	<b>10</b>	<b>170</b>	<i>164</i>	<i>156</i>	<b>0</b>	<b>0.3</b>	<b>0</b>	<b>1068</b>	<b>651</b>	<b>7</b>
Deh Dana Neswan High School	<b>11</b>	<b>190</b>	<i>165</i>	<i>172</i>	<b>0</b>	<b>0.2</b>	<b>0</b>	<b>1239</b>	<b>672</b>	<b>7.7</b>
Guzarga (the gaiby castle)	<b>12</b>	<b>181</b>	<i>150</i>	<i>186</i>	<b>0</b>	<b>0.20</b>	<b>0</b>	<b>1104</b>	<b>659</b>	<b>7.65</b>
Forty Pillars (Ansarulla h)	<b>13</b>	<b>185</b>	<i>160</i>	<i>170</i>	<b>0</b>	<b>0.5</b>	<b>0</b>	<b>1224</b>	<b>670</b>	<b>7.4</b>
Chial Stone - Factory	<b>14</b>	<b>135</b>	<i>100</i>	<i>94</i>	<b>30</b>	<b>0.4</b>	<b>0</b>	<b>927</b>	<b>470</b>	<b>7.48</b>
Alauddin project	<b>15</b>	<b>-</b>	<b>-</b>	<b>40</b>	<b>5.7</b>	<b>0.08</b>	<b>0.51</b>	<b>637</b>	<b>619</b>	<b>7.7</b>

areas of Deh Mezang	<b>16</b>	-	-	<b>98</b>	<b>3.5</b>	<b>0.11</b>	<b>0.49</b>	<b>1093</b>	<b>430</b>	<b>8.1</b>
Seyyed Jamaluddin University	<b>17</b>	<b>0.1</b>	<b>0.01</b>	<b>42</b>	<b>3.1</b>	<b>0.20</b>	<b>0.41</b>	<b>878</b>	<b>619</b>	<b>8.1</b>
Tuberculos is Hospital	<b>18</b>	<i>262</i>	<i>310</i>	<i>360</i>	<b>0</b>	<b>0.2</b>	<b>0</b>	<b>2450</b>	<b>1100</b>	<b>7.6</b>
Ibn Sina's Hospital	<b>19</b>	-	-	<b>46</b>	<b>1.9</b>	<b>0.5</b>	<b>0.37</b>	<b>710</b>	<b>619</b>	<b>7.4</b>
Muhamma d Khan's Pole	<b>20</b>	<i>240</i>	<i>120</i>	<i>271</i>	<b>10</b>	<b>0.2</b>	<b>0</b>	<b>1856</b>	<b>930</b>	<b>7.2</b>
Fethullah Castle	<b>21</b>	<i>200</i>	<i>350</i>	<i>37</i>	<b>18.65</b>	<b>0.89</b>	<b>1.5</b>	<b>909</b>	<b>625</b>	<b>7.68</b>
Polcharkhi Bank of Afghanista n	<b>22</b>	<i>251</i>	<i>170</i>	<i>280</i>	<b>25</b>	<b>0.3</b>	<b>0</b>	<b>1300</b>	<b>883</b>	<b>7.75</b>
Lab Darya (bathing well)	<b>23</b>	<i>149</i>	<i>130</i>	<i>155</i>	<b>25</b>	<b>0.3</b>	<b>0</b>	<b>1000</b>	<b>595</b>	<b>7.69</b>
Bagrami- Darya Logar	<b>24</b>	-	-	<i>260</i>	<b>1.7</b>	<b>0.35</b>	<b>0.37</b>	<b>1211</b>	<b>619</b>	<b>7</b>
Bagrami- Shivaky	<b>25</b>	<i>98</i>	<i>410</i>	<i>118</i>	<b>20.44</b>	<b>0.91</b>	<b>1.1</b>	<b>900</b>	<b>619</b>	<b>7.6</b>



average		106.3 12	123.24	119. 96	7.36	0.34	0.25	972.2 8	599.08	7.60 2
standards	The optimal maximum of the standard	IL 45	IL 1.7	IL 45	U.S.E PA 10	WHO 1.5	U.S.EP A 0.3-5	WHO <250	U.S.E PA <500	WHO 6.5-8.5
	Maximum allowed	ANS A 250	U.S.E PA 10	ANS A 250	WHO 11	U.S.E PA 2	IL 0-25		WHO <1000	ANS A 6.5-8.5

### Data Availability

Requests for access to these data should be made to the corresponding author via e-mail address:

[Asadullahshakir228@gmail.com](mailto:Asadullahshakir228@gmail.com)

### Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper .

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