

# **A Solution for Future Designs using Techniques from Vernacular Architecture of Southern Iran, Evaz**

حل للتصميم المستقبلي باستخدام تقنيات من العمارة المحلية في جنوب ايران ، عوض

by

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## **Abstract**

Historical buildings and structures are a valuable evidence to represent the method of living on the ancient times. In addition, it will prove that how the development elevated in higher positions. The life style of human became easier by the time and development of technologies. The impact of these developments have increased the quality and comfort in human's life. By the time the structure's passive strategies and the way of utilization of it, will not be appropriated anymore because of the mutation in climate change, change in life style, developments, new technologies and natural resources.

Therefore, after a period of time the renovation and invention are two main categories to sustain the environment safe and beneficial. The project of this dissertation is about vernacular architecture in southern of Iran, Evaz. The study has covered the passive strategies and a solution which has been created at ancient times to satisfy human's need such as drinking water. According to this area's weather condition, this region is facing lack of water resources since long time back. That's the reason the architectures designed a structure which could save water for long time without evaporation and getting infected. The reason of selecting this topic is the vital need of human which is water. Lack of rain and water in this region has created long term problem for local people. This dissertation with the assistance of different investigation methods such as literature review, questionnaire survey and numerical method investigated to find a solution for the problem and future use of the structures like water cistern which is made for the investing water for long time and was successful method during all these years. Through developed technology and passive strategy, a solution has been introduced to this society with covering of all requirements and solving problems of water problem in this region.

The solution has been analysed from different aspects and author has described how this solution can help human's essential requirements and how this method can have affirmative effect on economic situation of this city. In the other hand all the solutions have been given by the respect to the environment and historical structure of Evaz city. In addition to indelible the value of previous expertise and continue their method with updated technology system and in innovative technique. The result of economic aspect demonstrates with selecting accurate solution for not only vital and environmental need but also economical requirements of the city can be motivated and jobs can be created by integrating technology and updated system to the sources in the heritage buildings.

In conclusion part integrating PV panel to the heritage structure has given a great feedback of durability of the structure same time of meeting local people's requirements.

## المخلص

تعتبر المباني والمنشآت التاريخية رموز قيمة لتمثيل طريقة المعيشة في العصور القديمة، بالإضافة إلى إثبات تطورها مع مرور الزمن، ولكن في زمننا الحالي أصبح أسلوب حياة الإنسان أسهل مع تطور التكنولوجيا، مما زاد من جودة الحياة وراحة الإنسان، من الجدير بالذكر أن منشآت التصميم الحرارية لم تعد مجدية في الوقت الحالي بسبب تغير المناخ، وتغير نمط حياة الإنسان، و توفر التقنيات الجديدة لخدمته والموارد الطبيعية الكافية لاستمرار الحياة

ولذلك يعتبر الابتكار والتجديد في زمننا الحالي فئتان رئيسيتان للحفاظ على بيئة آمنة وداعمة لحياة الإنسان. سوف يتناول البحث النمط المعماري الدارج في جنوب إيران (عوض) بدءاً باستراتيجيات التصميم الحراري المستخدمة منذ قدم لتلبية احتياجات الانسان المعيشية كشرب الماء.

بسبب تأزم حالة الطقس في عوض تواجه المنطقة نقص في الموارد المائية منذ عقود مما دفع المعمارين لابتكار تصاميم تعمل على حفظ الماء لفترة طويلة دون تبخرها.

إن السبب وراء اختيار هذا الموضوع هو الحاجة الحيوية للإنسان للماء، فقد تسببت قلة الأمطار والمياه في هذه المنطقة بخلق مشكلة على المدى الطويل للسكان المحليين.

ستقوم الأطروحة بالإعتماد على نظريات مختلفة و تجارب سابقة، بالإضافة إلى الاعتماد على الاستبيانات و الإحصاءات للتوصل إلى حل لهذه المشكلة واستخدامها في المستقبل لهماكل تخزين المياه وحفظها لفترة طويلة وذلك عن طريق استخدام التكنولوجيا المتقدمة واستراتيجية التصميم الحراري لإيجاد حل جذري لمشكلة حفظ المياه في هذه المنطقة.

لقد تم تحليل المقترحات من جوانب مختلفة، حيث قامت الأطروحة بشرح ديناميكية الحل لتأمين المتطلبات الأساسية للإنسان وكيف أن هذا الأسلوب يمكن أن يكون له تأثير إيجابي على الوضع الاقتصادي لمدينة عوض.

أما من ناحية أخرى، فقد قامت الأطروحة بإعطاء حلول مع المحافظة على البيئة المحلية و البنية التاريخية للمدينة و الاستفادة من الحلول السابقة مع تطبيق التكنولوجيا و التقنيات المبتكرة.

إن الحلول المطروحة لها تأثير إيجابي على الجانب الاقتصادي و ليس فقط الجانب البيئي مما يشجع على خلق فرص عمل عن طريق دمج التكنولوجيا ونظام محدث للمباني الأثرية.

وفي المحصلة كان لاستخدام ألواح الطاقة الشمسية في الأبنية الأثرية نتائج إيجابية كديمومية الآلية و تلبية متطلبات السكان المحليين.

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## **Introduction**

### **Overview**

By the time, technologies increase and human are having most updated techniques for better living, natural resources are being reduce and harmed because of different environmental situations. One of the most important reasons of the negative impact on natural resources is global warming and climate change. Today the entire world is facing global warming's impact and outcome .it will be continues for tomorrow as well. The impact includes reduction of glaciers, high temperature, change in rainfall, plant, implication on human, sea level rising and droughts increasing.

(Climatehotmap, 2016). A quantity of further warming is inescapable. According to the climate hot map (2016), the five main regimentation of the global warming impact are:

- Temperature
- Society
- Ecosystems
- Oceans
- Freshwater

This paper's investigation is focused on natural resource of water (rain) and the selected country for the study is Iran. Today the country Iran is facing a serious problem of water crisis as well. The whole country affected because of the water limitation. The media and social networks are working on this issue to make people aware of the serious problem, which will affect their life in near future (Madani, 2016). The famous rivers of and lake of Iran such as Urmia lake and Zayandeh River is shrunk and mostly dry (mapsoftheworld, 2014).

NASA predicted that Iran would have drought ahead for 30 years. On this basis, the current dry areas will be drier, deserts will be increase and the tropic areas will become rainier .This change in some areas will be more intense and effective. Iran is a country that pointed out in the report twice named as one of the countries where the climate is deadly in this regression forehead (Arab, 2013). (Figure, 1)

According to Dry climatic of south of Iran, Larestan region (Evaz), the situations had the impact on professionals to create various phenomenon in the region. Except the North of Iran and north coast of Iran, the rest parts always had lack of rainfall. Therefore, remarkable effort happened in the great plains of Iran from vernacular architecture aspect (Kazemi, 2012).Water is the one of the most important elements for human’s life. Lack of water can raise many problems in comfort and living style as well. In a small city in Iran,Evaz which is located at the south of this country, is having the same issue of lack of water resources in the region. People are facing the problem since long time back especially Because of its particular type of weather and condition which is hot and dry. (Figure 2)

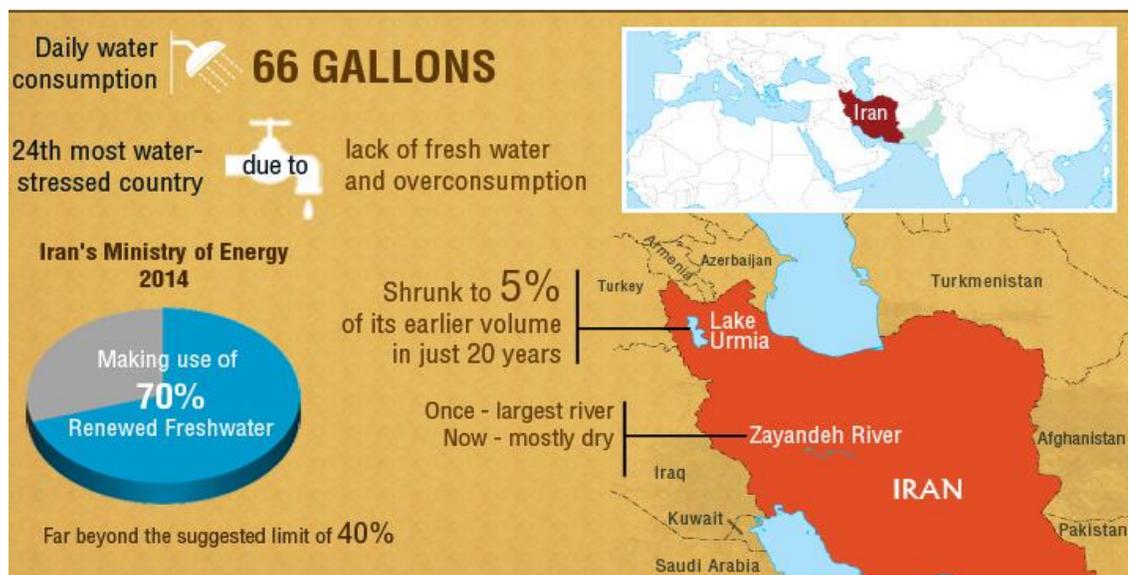


Figure 1: water crisis around the world, Iran, mapsoftheworld, 2014

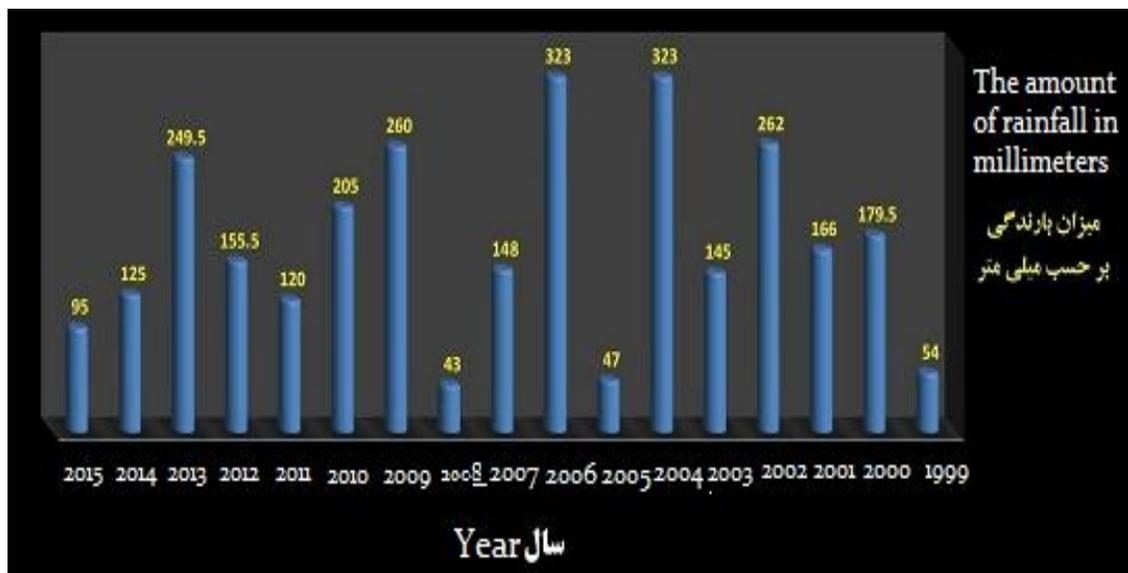


Figure: 2 Rainfall in Evaz, Iran, A.Z.Shafae, 2015

The author was interested to look from sustainable part of view to this city and find out how people are surviving and what they have done in the aspect of the passive strategies to solve the problems, which comes from the weather and water conditions in Evaz. In addition, what they have planned for solving this problem for the future as well.

The water which is provided by the city is not enough for the residents therefore they are buying extra waters for their drinking and daily requirements. As long as lack of rainfall and continues of the same issues was there, many years back some solutions were provided by the architecture and engineers of the town for harvesting rain water and use of the maximum amount of rain water for citizen's daily requirement. In addition, some passive strategies has applied on the houses and residential places, which are significant for those period and now days as well. Although these strategies were beneficial for the city, as long as the impact of the climate change is getting worse, some of these solutions might not be useful anymore. Therefore, author has decided to create and improve the solutions, which for the sake of resident's life cycle. In this distinct situation Evaz city cannot expect to get support from the other places such as before in near future. Therefore, it is the

time to think and find a credible solution for Evaz to solve the problem and sustain the available resources such as water in this city.

Plenty ages back while there remained no modernized organizations for human requirements, passive approaches played a big role in public's life at the time. The research has concentrated on a small city in Iran where vernacular design had strong impact on sustaining certain requirements in human's life. Particular strategies have been applied to work out people's ecological architectural and environmental subject matters and it has been continued until today. Humans were creating changes in ecosystem of the environment to harmonize geographical situation since ancient times. (Mirahmadi and Altan, 2015). The particular condition of the weather and water in Evaz is the reason of lack of rainfall in this city that effected on Recruitment to solve the problem. Author will review the history of the architectural in Evaz and will define the problems and solutions gradually. Then will present sustainable solutions to assist residents of this region in their problems and hard days. In addition, save their future by the best innovative ways.

After the investigation on today's environmental situation (focusing of Evaz city), the author has been motivated by knowing about the smart methods that has been created by ancient people to harvest the rain water. In the other hand Vernacular architecture of Evaz designed by logical sustainable reasons. Therefore, the author was inspired to create some solutions, which could assist them to have and sustain their own style and culture by combining it with latest modern solutions for future as well.

The reason for selecting the city of Evaz is to sustain comfort level of living for residents with the challenging climate and city principles.

This is encouraging and challenging topic to find and improve the solutions for the water problem in Evaz, in general, it's important to define sustainability matters for the future. The city, Evaz has actual imperfect environmental and natural resources. These difficulties have produced alternative sociability problem. Many of citizens

traveled to diverse towns and now days they are living out of the country. This investigation classifies the vernacular architecture and its strategies in this city in order to produce thoughts for modification and to make connection between traditional and contemporary essentials. Additionally, the study purpose is, to raise some resolutions applying a mixture from traditional and modern designs in direction to recommend superior and more valuable methods to save energy, and at the same time, supportable design proficiency (Mirahmadi and Altan,2015).

## **1.1 Geographical Background**

For analyzing any site, the geographical background is important. The reason is, author is required to define the climate situation and the position of the city according to the country and its features, which can help in finding solutions for the issues of the city. (Figure 3, 3-1)

The city that is located in the Fars region is called Evaz, the distance between these cities to the next, which is Gerash, is about 20 km, the famous Shiraz city is far from here about the 370 km, and it's located on the southeast.

Water is restricted in this area and the reason is the lowest rainfall that this city obtains. In traditional architecture, vernacular construction prepared solution for multitude years. Consequently, water cistern is the main point to concentrate and discuss about it in this study with more detail and specifications (Mirahmadi and Altan, 2015).



Figure 3: Evaz map, Google map (June 2016)

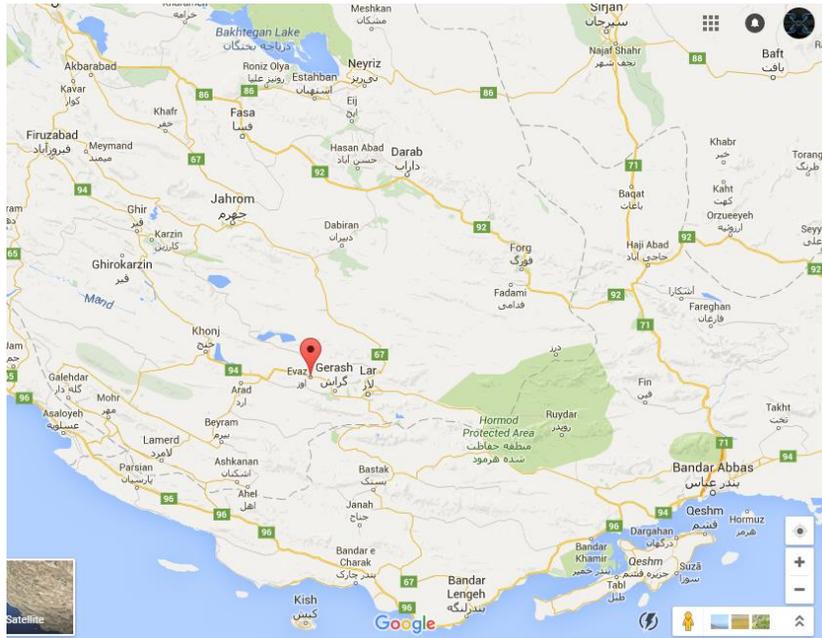


Figure 3.1: Evaz map, Google map (June 2016)

## **1.2- Aim of the research**

Every research is created based on the purpose and aim of an issue. All the studies and process of investigation should have a part which obviously discusses about the aim of the research to be aware of which direction and path is this investigation going through. A sustainable designer or architecture after studying sustainable design in built environment should be able to define problems in the environment and find an appropriate solution for the problem. Water as a vital need of human is on the risky situation today therefore finding solution to sustain and save the water in the other word to enhance rainwater and the water cistern (storage) is the main purpose of this research.

Especially in the areas which has lack of the rainfall and people are struggling with it. This study has investigated on the small city of Iran, Evaz. The reason of selecting this city was the especial condition of the climate in this city and lack of rainfall that was the reason for ancient people to create water cistern with special features. Those water cisterns, which are very essential for people since there was no electricity and extra energy power and resources in human's life, today are inconvenience.

The main aim of the research is to Enhance the rainwater collection and the storage, While ancient people believed that although the water cisterns has great impact in saving human's life, it's a holy structure and symbol of the city as well . Therefore, from historical background it will assist to sustain the storages as well and make its life continues for future generations of the city which are always valuable for Evazi people.

### 1.3- Objective

After specifying the aim of the research, in this chapter will define what author is obtaining to achieve the aim. The main Objectives of this research are:

- To operate renewable resource such as solar energy for natural disasters and to save natural resources such as, water as well.
- To modify and update the water cistern because, the consumption of the ancient water cistern is decreasing time by time.
- .To enhances capability and method of using water cisterns.
- To enhance the capture of the rainwater.
- To evaluate and estimate the method of capturing rainwater
- To purify rainwater,by use of renewable energy for the health of the Evaz citizens.

The objectives will assist to increase the Sustainable awareness after performing solar panels in the city and people will get more use to it .will distinguish further about the value of the renewable energy and natural resources. Affording updated technology such as solar panel in the small city of Ewaz that may have a great impact on the economic and style of people as well.

Water cisterns and its feature has strong passive design strategies which can be use today as well but because of environmental reasons and global warming some changes came about on the method of using it.

Some of water cistern is useless today although it can be useful and helpful for humans' most important requirement for life, such as drinking water. In the next chapter which I sliterature review, will review the similar projects who worked on rainwater capture and harvesting plus purification of the water to make them portable water. There is more description about the passive strategies as well, which is covered in literature review.

#### **1.4- History of water cistern in ancient times**

To understand the situation and evolution of the water cistern more clearly it's important to study the history of it from the day of invention until today. This introduction of history of Evaz will give a brief to the water cistern and will prepare the readers to understand better about the aim and objectives of the research in addition it will show the reason of demand of the water cistern. The next chapter will define about the aim and objectives and the points are mentioned as well.

The storage of water cistern previously was water puddles only by the time with developments of the civilization the methods of saving water has been change. In the ancient civilization of Iran, Egypt and Mesopotamia (the land between two rivers) water cistern had head cover with impenetrable walls. In addition, Greece and Rome had the same method to restore water.

These storages were noun as cisterns, water cisterns, Cistern, warehouse, Pond, artificial Source, Intake, Pond and Lamb. Although the way to reach water were not same in all the countries but all of them had some method to save the water. Water cisterns are holy structures, which has been made very professional way with combination of creativity in structure, climatic and art of it. (Memarian, 2007)

In the past, the circulation of elements, source and consumer were in coordination together although today with changes which happens to human life this circulation and coordination system has been lost the balance. With the piping network people thought there is no more need of saving water and some of the water cisterns became abundant

and useless. By the time and requirement of people proves that still there is need of the another source more than the city piping network which can help people in the case of any problem in the networks and need of water specially in dry and hot climate such as Evaz region. The water cisterns in south specially Larestan region is very famous and noun today as well in addition at the year 2008 when the piping in the network got problem and there was no water to use for one-month people were conducting water from the water cisterns although if there was no water cistern in the area people couldn't satisfied themselves. This condition happened in Khonj city which is close to the Ewaz.

From many years back the problem of drinking water was one of the most important issues in this region. Therefore, using rain water and saving it for future use was one of the common ways for the people of this region. In the other hand for many years the water which was providing by piping network was not sweet and drinkable it was good only for daily necessary needs not drinking, that are the reason people's drinking requirement were so dependent on water cistern.

In the edges of the desert water cisterns were the center of villages and towns and in most of the neighborhoods they were the units of attractions. The technical points and architectural in the water cistern has special credit because the builders of these units has made them discerning and by accuracy at many important points such as the amount of the pressure on water, surface of the water with the floor under the water, plastering issues sides the building, ventilation, water treatment and pollution prevention. (F.Salmanpur, 2013)

The art of choosing decoration of the exterior of the water cisterns specially the entrance and in some cases selection of the interesting poems on the top of the entrance is the proof that these structures had very strong relation with the features and spirit of the occupants near them.

The important reasons of building water cistern in these regions are the evaporation of water directly by sun's heat and airflow and Deterioration of water in open area and warming up the water due to sun exposures.

The style of the water cisterns in Iran is different according to the climate and architectural style. There are some private water cisterns which are noun in houses in cities or in the villages usually it was constructed under the yard surface these kinds of water cisterns were rectangular or square shape with plain surface. If the cistern was in the yard collecting water was from the window close to the ceiling or in the ceiling with bucket. And if the storage were under the residential Space access to water was possible by water pipe. These storages or water cisterns had ventilation or wind tower to change the air and have the refreshment. The space of these water cisterns are enough for three to four years of using of water. (F.Salmanpur, 2013)

The other type of water cistern is public water cisterns; these water cisterns are huge and noticeable water cistern which the builders are ruling people, wealthy and righteous people. City water cistern: this kind of water cisterns were built in centre of the areas and close to the religious places, training, welfare and commercial places. The survivors show that these kinds of the water cisterns had more capacity and were satisfying the need of bigger population in the area for some months. The vital need of these structures was the reason to select special materials and best quality once. Wide stairs, tall wind towers, porch and head of the door is decorated in artistic way.

The most famous water cisterns in Tehran are: Seyed Esmayil, Saheb Eivan, Baba Nozar Yoozbasg, Seyed Vali, Emamzade Yahya, Reza gholi Khan, Chehel tan and Gharibian alley. In Semnan Anbar gholi and Sorkhe, in ghazvin Haj Kazem water cisterns and Sardar Bozorgm in Mashhad Hoz loghman water cisterns m Hoz mirza Nazerm Bala kooche, CHEhel Paye and in Kashan Seyed Hussain Dokhan and Gozare Ab o Khan were the famous example units in Iran province. (F.Salmanpur, 2013)

After studying the history of the water cisterns, it's the time to discover the reasons beyond the water cistern. Reasons are starts from aim and objectives therefore next chapter will define the aim and objective of this research.

## **1.5-The City of Evaz**

Evaz sites at 54 degrees southeast 53 minutes' east longitude, north latitude and longitude from Greenwich meridian, 27 degrees 34 minutes. It receives minimum rainfall, which is the reason why water is restricted in this area [6]. In summers, the climate is hot and dry, sometimes temperatures reaching around 46°C during the day. Although the winters are typically cold and likewise dry, moderate climate is available in Evaz during autumn and spring.

From the climatic conditions, the area's climate is hot and dry, with average rainfall of 220-180 mm per year, which is more influenced by the Mediterranean air masses in autumn and winter. Maximum temperature 48-46 degrees for the months of July and August, and a minimum temperature of zero degrees, is related to the months of December and January. There is limited agricultural area in this city, the famous tree and landscape includes citrus trees, palm trees and planting vegetables. The average relative humidity of this area is maximum 58% and minimum 29%. The number of frost days; 51 days has been reported (Fig.4). The most important reason behind this is the lack of water resources, extreme heat, irregular rainfall annually, and cheap lands (Mirahmadi and Altan, 2015). (Figure 4)



Figure 4: Evaz plain in March 2011

The city's population is around 23000 people (H.Seddighi, 2012). On holidays and summer, it increases because a considerable amount of Evazi people has shifted to other cities and countries around Persian Gulf and others. Evazi people who has immigrated to Persian Gulf's countries, usually they consider a part of their income to help their hometown especially for the places such as construction areas, hospitals, schools and universities. At present, a considerable number of those who were living abroad have returned to Evaz and some of them were invested their income over there (Mirahmadi and Altan, 2015).

## **1.6-Architecture in Evaz**

History of Evaz goes back to pre-Islam era. In terms of the important factors of formation of the Architecture in south of Iran and Evaz, different buildings have been constructed, old/vernacular architecture have focused on important factors such as climate and weather for each area. Observing these factors causes the influence of comfort ability and comforting in the space with balance and beauty that is the reason how they became center of the attention. To reduce the heat, architecture was using different methods through passive strategies. Evaz is also included in hot and dry climatic conditions. They designed the buildings in a way of narrow streets and winding, high walls for houses to decrease direct sun light and assist to build a shade. (H.Kamal, 2005)

Forms of monuments were two types introverted or extroverted. Introverted is noun for houses with yards inside the building and extroverted is the building which looks like cage and yard is designed out of it [9]. In order to provide a good atmosphere in warm and cold seasons, the methods which has been used by architecture of this region also included, under the ground in homes, mosques, double shell roofs and selecting suitable

materials, such as mud and brick was the other principles to keep the house cold in a summer warm in the winter (H.Kamal, 2005).

Wind tower is one of the developed factors of Iranian architecture; it has a huge usage in hot, humid and dry areas. Wind tower is used especially on the top of the houses to direct the air flow into the space to create a fresh and cool air. Creating openings on the four sides of the tower assists the wind flow to enter more without difficulty. At this point, there are some simple and some with more beautiful works on it. A wind tower, which is located in Evaz, is shown on the top of the houses and four sided designs at the past where it was used in luxury houses (Figure.5) (Mirahmadi and Altan, 2015).



Figure 5: Wind tower in a historic house in Evaz in November 2010

### **1.7-Factors Affecting Architecture Styles**

After the climatic conditions, political and security issues are the factors of creation of regions. When the country was unrest, Evaz as other cities of Iran became like a castle. The city was enclosed within a fence fortified with towers and ramparts. To ensure the

security of the city, the wall had been put up with several gates and guards with special defenses. Moreover, in order to further strengthen the two fences surrounding ditch and water was launched between the ditches (H.Kamal, 2005)

Economic factors are another reason of formation of structures in architecture of ancient cities. In any society, political peace with the support of craftsmen and artists, i.e. talented people, will lead to economic growth. Creation of Gheisarie Bazar, shopping centers, caravanserais inside and out of the city and develops of pathways has straight impacts on creation of contexture of old city. Impact of religion is obvious in observing tombs and holy shrines, which has been developed duration of time. These tombs are belonging to outstanding spiritual personalities; in the past time of history, it was an attractive place for people to visit and observe religious ceremony. Taste of Board of Governors and Influential personalities is another impact on architecture and structure of old textures in each place (Mirahmadi and Altan, 2015).

Architecture of Evaz have inspired by many factors as mentioned earlier. During the history, some changes occurred that affected the city. Evazi people who are living in the Gulf region and who are interested in righteous support most of the peoples' needs (Mirahmadi and Altan, 2015).

## **1.8-Overview of Traditional Architecture in Houses**

Traditional architecture of hot and dry cities has been divided into two styles of Introvert and Eccentric. Evaz has introvert style. In this style, yard is located in the middle of the house and rooms are located around the courtyard, which is almost square shape (Fig.6).

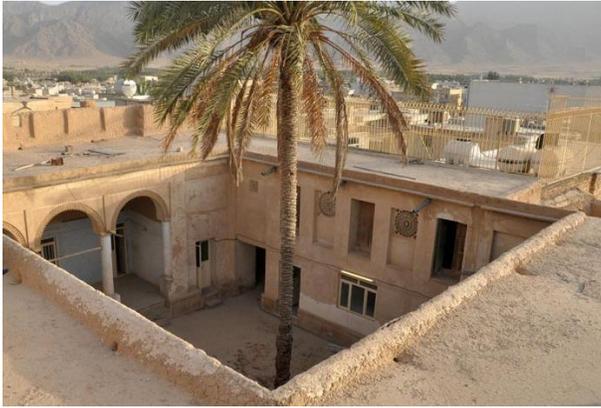


Figure 6: courtyard from the top view, Alipour house, in south of Iran (M.A Nobahar, 2015)

Because of the hot weather conditions and strong radiation of sun, lighting design was in a way to have shades and indirect natural light for interior spaces (EPNU, 2010). Most of the skylights were made from rock and plaster. In addition to add a beauty and shine to the room, glass door were designed with colorful glass pieces to adjust the interior light (Figure 7) (Mirahmadi and Altan, 2015).



Figure 7: Historic house of Sodagar in Evaz

Ceiling of the ancient houses were flat and built with wooden beams. The beams were made from Tamarisk and palm tree, which are popular and grow well in the warm climate. In the middle of the ceiling, there was design of diamond, geometric shapes with paintings and colors, which made the design special, and beautiful (Mirahmadi and Altan, 2015) (Figure.8 and Figure.9).



Figure 8: More than 100 years old two story residential building in Evaz; Esmaili Home



Figure 9: Traditional ceiling design, Evaz, Mirahmadi house, July 2015

One of the purposes in traditional home style was to make the home look animator and pleasant. That's the reason small garden is always a major key of the traditional architecture which was famous in Evaz. Variety of trees which are suitable for hot and dry climate was available in these gardens specially palm tree, Because of its high productivity and matching with the dry climate of the region Palm tree were more in attention of the people. Rock pools were used in some luxury houses, which assist the view to look more attractive. For occupant's daily water need, wells were drilled in houses (Mirahmadi and Altan, 2015) (Figure.10).



Figure 10: Wells in houses for daily water use in Evaz museum

### **1.9-History of Water Cistern (Berka) in Evaz**

Hot and dry climate conditions and lack of adequate rainfall in more than six months in a year and seasonal rivers were the reason to motivate architecture to create new ideas of the cisterns, bands and canals. Cisterns were made to save water in rainy days. Water cisterns are important not only as one of the most important structures of water,

in fact, it was guidance for passengers and caravans in the past for whom were passing the way in the desert and plain (Mirahmadi and Altan, 2015), (Fig.11).



Figure 11: Evaz cisterns, July 2011

Accordingly, the cisterns are a symbol for architecture of rural in Iran. The oldest water resource in Iran belongs to Eilami Dorantash in Chaghazanbil of Khuzestan state (province). This water cistern is build 1250 years before BC. There are many water cisterns located in the south of Iran and islands in Persian Gulf, which prove the value and importance of human to secure a vital element, water (H.Kamal, 2005).

In Islamic duration, water cistern had increased rapidly and today there are many historic places from those periods. Water cistern usually divided in two categories; the water cisterns which are used generally by everyone in the area and region (more public), and the second one more private water cistern for inside the houses. (Mirahmadi and Altan, 2015).

### **1.10-Criteria of Evaz Cistern:**

Evaz cisterns are one of the most famous cisterns in the region. Generally, the original plan of the cistern is available in two designs.

1. Circular plan and domes roof (Fig.12)
2. Rectangle plan



Figure 12: Circular plan and domes roof, July 2011

The design of water resources are the common ones in the south of Iran. The resource of the water in these cisterns comes in the cylinder shape, which has been constructed in the middle of the ground. Ratio of diameter in the source depended on the size of the pond. Domes were used for circular pond designs and it were calculated on acquire mathematic calculations with the best materials that is the reason they lasted for long time and stayed beautiful (Mirahmadi, Altan, 2015).

### **1.11-Construction Methodology of the Cistern:**

People in the past were using traditional ways to build this vital element; there were different ways of construction for these famous cisterns. The device, which they were using, called Pargar (compass); this was used to create the dome shape. Pargar made from a board and from four sides of that board were ropes, which were connected to four sides of the pond. Therefore, the architecture of the pond became from moving around the pond with the ropes until it reached the require size of the dome, and this was the way to create an accurate environment of the pond.

On the top of the pond there is a stone element called ‘Kakol’ when it appears, it means that the work is completed. The dome was installed on the wall, which has been called

‘Ghors’ which means strong and fit. In addition, it gave height to the cistern. The base (Ghors) helps cisterns’ height to be higher and it helps to the movement of airflow, which is affected on the water to be fresh and cold (Mirahmadi, Altan, 2015).

### **1.12-Shape of the Dome:**

To make the shape of the dome, the architecture was picking and sticking the stones row by row and each new row were organizing the stones more forward. That was the way as it goes higher the stones size was becoming smaller. Usually after building four rows, ceiling should get one-meter slope to achieve the shape of the dome. In the huge sizes of cisterns, two Ghors (base) were required to stay the dome on it (Fig.13). After building the dome, outline was covered by mortar, to protect the mortar from the cracks resulted by water and strong heat in this area they were covering it by plaster and clay. (Mirahmadi, Altan, 2015).



Figure 13: Circular plan and domes roof, July 2011

On the top of the pond there is a stone element (Kakol) when it appearances means that the work is completed. The dome was installed on the wall, which has been called (Ghors) which means strong and fit. In addition, it gave height to the cistern. The base (Ghors) helps cisterns height to be higher and it assist the movement of the airflow, which is effected on the water to be fresh and cold. To attract less sun with heat transfer,

they had made the cover of the cistern with plaster. In addition, the white color of the plaster helps passengers to aware of water from the far view (Mirahmadi, Altan, 2015).

### **1.13-Air Conditioning in the Cisterns:**

In Evaz's cisterns, they use the holes around the cistern with the specific distances instead of the wind tower (Figure.14).



Figure 14: Holes around the cistern, July 2011

### **1.14-Materials used in the Cistern:**

Certain materials used in the construction of the pond. They used stone and mortar in the floor (source) of the ponds and in building stone tablets. They made the mortar soft, hardly with shovel. Unlike plaster, mortar can be very resistant and durable in an environment where there is lack of water. The plaster in dry and away from water can be more durable based on the experiences and human resources over time, Homeira Kamal has mentioned in his book (Mirahmadi, Altan, 2015).

Accordingly, mortar used for floors and walls which in directly connected to the water and plaster used for dome and the top which is in dry area and under the sun.

Nowadays, because of the difficulties in making mortar material, architecture is using cement instead of mortar, which does not have the same value of mortar. In addition to the design of the cistern in the past, they were building two shelters with stone platform attached to the cistern for passengers and caravans whom were passing that way, but in nowadays, they do not apply it anymore. The way to the access of water source was stone stairs, which has been made inside the cistern periodically. The amount of the stairs was depending on the size of the cistern. In the front of the cistern in direction of water flow were small, hence pond this part protects water from waste and suspended things (Mirahmadi, Altan, 2015).

This specification was applied in cisterns out of the city as well with a small difference. In cisterns out of the city there were platform in the direction of Qebla (Muslims' pray direction) for passengers who want to pray in the comfortable place. Mostly the cisterns belonged to Safavie Empire (1502-1736), which has been repaired after. Below are some examples of water cisterns in Evaz:

## **1.15-Famous water cisterns**

### **1.15-1 -Mulla Mohamad Water Cistern:**

Mulla Mohamad water cistern was built more than 750 years ago in Afshari period and is one of the most famous water cisterns in Larestan region, and despite the long years of standing, it remains strong. This infrastructure is made in round and dome shape. The great dome stands on two bases (Ghors) where one base is higher than the other as it was much easier for architects to build it that way. The water cisterns have been repaired and reconstructed several times during their life span. When it rained, the water comes from a faraway to the water cistern by a channel or river, which is known as river from the top (Roode bala). Water entered Mulla Muhammad cistern and once it was full, then it moves to the next water cistern. After the Mulla Mohammad water cistern, it enters the Haj Ghanber water cistern, which is also located beside it. Nowadays also, people are used to getting water for their daily use from the Mulla

Mohammad water cistern as before it was done in the past (H.Kamal, 2005) (Figure. 15).



Figure 15: Mulla Mohammad water cistern and the inscription, H. Seddighi, 2012.

### 1.15-2-Water Cisterns in Nakhlestan Bereneh (Groves of Bereneh):

In the set of Bereneh Groves, there are four water cisterns with two different shapes of circular and rectangle plans. The water cisterns had been made in different sizes with materials such as stones, mortar and plaster. The set is divided into two shapes; circular and rectangle. The circular plan water cistern has been named as the twofold Solfa 1 and Solfa 2, and Rafeyei water cistern. The Solfa water cistern is made in circular and dome shapes and the top of the dome, there is a small part, which is similar to identical small column. The water cisterns are a middle size and originally had three entrances for collecting water, although today, two of the entrances are closed and only one is open for use. The materials used in this water cistern are stone, mortar and plaster (H.Kamal, 2005) (Fig. 16).

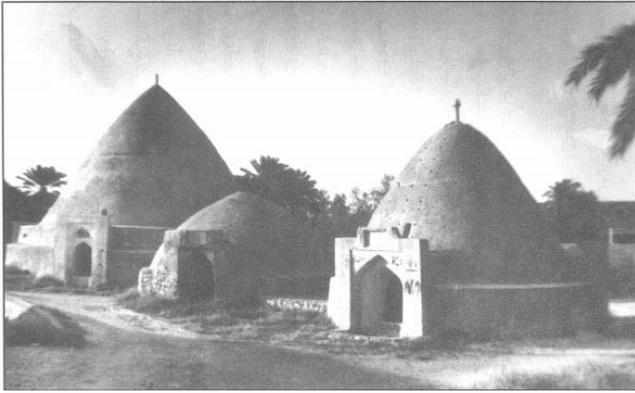


Figure 16: Nakhlestan Bereneh, June 2004

Nowadays, the water of this cistern is not useable but the structure is still strong and has a good condition. On the southern arch of the cistern, on an old stone, there is a print that this water cistern is known as Solfa water cistern and has been made by Haji Mahmood Shamsayan at 891 Hijri Gahamri, and repaired by Mohammad Amin Rafeyi, son of Abdulla at 1391 Hijri Ghamari. Moreover, Solfa cistern is registered in the list of Monuments of Fars. Rafeyi water cistern is another type of circular water cisterns of the Nakhlestan Bereneh, which has a large size and a circular plan with conical shaped dome ceiling, and the small part on the top is called stone Tassel (Kakole Sangi). The exterior of the water cistern is covered by mortar then thatch and plaster to extend the durability (H.Kamal, 2005).

Today, four arch shaped entrances help to reach the waters inside. On the southern arch of the water cistern, there is a print on the stone frame that this water cistern was built by Mohammad Amin Rafeyi (son of Abdulla), and belonged to the year 1391 Hijri Ghamari for public use. Only one rectangular shape of water cistern is available in the set of Nakhlestan Bereneh. This structure has a large size and has two entrances on the eastern and western sides, and there is no print of information on the structure. This water cistern today does not have a good condition and has some cracks, which should be repaired as soon as possible otherwise this beautiful structure may be destroyed. (Fig. 17)



Figure 17: Solfa water cistern and the inscription, June 2012

### **1.15-3-The set of the water cisterns of square of the corner of the water cistern (Meidane Larde Berka)**

Originally had nine water cisterns in the famous square of “Larde berkah” but recently two of them has been totally destroyed. The builders name is unknown unfortunately but from the design and the shape of the water cistern, which is circular and has a dome ceiling with the material of stone used, plaster and mortar, archeologists has been noted the historical value of the water cisterns in this area. In this set of the water cisterns, there are some water cisterns, which are more famous than the others, such as Agha Water cistern (builder is Agha Abdul Lari), Haji Mohammad Zaman (the name of person with this name was the responsible for this water cistern but was built by Mir Mohammad Taghi), Sar’ab, Dokorsi (built by Abdulrahim Aziz Hghshenas), Lagi, Sheikha (built by Sheikh), Dotey Takhi. Those with no names mentioned are without any writing or print on the water cisterns (H.Kamal, 2005) (Fig.18).



Figure 18: set of the water cisterns of square of the corner of the water cistern (Meidane Larde Berka), June 2004



Figure 19: Holes around the cistern (Seeiran, 2011)

#### **1.15-4-The structure of sheikh Sheikh's Water cistern**

Water cistern has a medium size and it has a round shape with dome ceiling and the tassel stone on the top of it. This water cistern is from the type of cistern which has a short dome. The exterior of the dome is covered in order by mortar and after by thatch. In general, the materials of this structure are: mortar, plaster and stone. The water cistern has four entrances with vault and the concept is to be symmetric. From each entrance there is a place for water to be enter and to collect the water from the inside

water cistern. On the east vault entrance there was a stone frame which eight verses of poem is written on it. Unfortunately, by time these poetries are not readable at the moment. At the end of the poem it shows the date of 1335 Hijri Ghamari. The builder of this water cistern was Mohammad Sharif Faghihi. The structure of Sheikh Water cistern is still good and it's close to Musalla mosque which as one of the famous mosques in Evaz(H.Kamal, 2005) (Figure-20).



Figure 20: Sheikh's Water cistern, (M.Rahimi, June 2016)

#### **1.15-5-Reis Mohammad Saeed Sodagar water cistern**

This water cistern is located in Moallem Street and close to the Musalla mosque, same as Sheikh Water cistern. In general, the materials which have been made the water cistern are mortar, plaster and stone. The structure of the water cistern is large and round shape with dome ceiling as well. This cistern has two disks (Ghors), the first disk is higher than the second one. On the top there is a tassel stone appearing. The structure of this water cistern has 6 entrances to the water however now days only 4 of them are in use and the other two has been blocked. Local Architectures has designed the water cistern as per of people's need according to Evaz weather which its weather is mostly

hot and dry so a shade part is designed as well for people to stand there and collect the water from the cistern (H.Kamal, 2005) (Figure.18 ) and (Figure.19).



Figure 21: Reis Mohammad Saeed Sodagar water cistern, (M.Rahimi, June 2016)



Figure 22: Reis Mohammad Saeed Sodagar water cistern, inscription (M.Rahimi, June 2016)

#### **1.15-6 Current Water and Climate Situation in Evaz**

Lack of water and hot climate has created the reason for native people to immigrate. Since long time back Evaz faced with a problem of drinking water. In the past, the city's tap water was salty, it was only for use of washing, and watering the plants, however in January 2008, they have started to use fresh water piping network of the city of Salman Farsi Dam. Although Evaz is still facing with the same problem of water and using the water from cisterns to supply its water demand, it became an issue because the abundance of fresh water that is subject to sufficient rainfall to fill the Salman Farsi Dam. In the past and today, the main source of drinking water and of this city were large stocks of the cisterns inside and outside of the city. According to the latest statistics, about 750 large and small cisterns (water reservoirs) made to supply drinking water in the city through the people of the region. (Mirahmadi, Altan, 2015)

## **2. Literature Review**

### **2.1-Introduction to literature review**

The purpose of literature review chapter is to identify the researches that have similar idea of harvesting and capturing rainwater and combining them with updated systems of renewable energy and vernacular architecture of old structures. Several research has been investigated with a quit different component. These sample researches shows the value of the vernacular architecture, rain harvesting methods and the solutions which sustainable engineers are trying to save the old structures, which is symbol of the history. In this chapter will introduce the samples of the researches, which are related to the topic.

Shedrack R.Neybare has done his research on portable water in Uganda. His research is based on the surface water, ground water and rainwater supply system. There are a few differences between these two papers such as climate and weather condition but the objective and aim of both is reviewing the portable supply system and harvesting rainwater and analyse them for improvement and solutions. (Neybare, 2012)

Process of providing portable water with required amount and good quality is still significant in Africa, Asia and developing countries. One of the main purposes of the Uganda is to improve quality of water according to the health problems such as darkness color, infectivity, and microbial. As long as improvement and developments increases more importance may be located on, the chronic health relevant linked with pollutant such as asepsis by products.(Neybare, 2012). In this part of similarities water cisterns in Evaz is also facing same issues according to the health of the residents although Uganda paper is covering larger space in the country and they have enough rain during the year

In addition, to encourage the method of rainwater harvesting mainly, two matters encompassing city rainwater use were analysed: quality of the rainwater and the performance side of Rain harvesting systems. (J. Despins, 2008)

According to the investigation on different research on the same issue most of the papers has the same RWH storage but the differences are in the sizes, amount of water, and amount of rainfall in that city.

Most of the storages are contains: conduction system, container for rainwater storage, pump and catchment surface. (J. Despins, 2008)

Harvesting water in Uganda is from the surfaces and roofs of the houses, which may have the potential of infectivity from the different sources such as dirt, excremental matters from animals or birds. Sometimes wind carries these pollutants and directs them inside the water.(Neybare, 2012). The main solution for these contaminations is filtration method for rainwater after harvesting process. In Evaz because of the structure of the water cistern less pollutant could enter to the water but last few years because of not using proper methods for collecting the water and some other different reason, which are mentioned in next chapters the changes and solutions are required as well, such as Filtering the rainwater. Different types of filter and storage are available some examples is collected here to show the process clearly. (Figure. 3)



Figure 23: common Rainwater Harvesting and Storage Tanks, Neybare, 2012

The three major points which RWH systems should be based on are local skills, materials and equipment. As long as rainwater might be infected and polluted by hazardous and bacteria chemicals requiring treatment before usage. Slow sand and

solar technology and filtration are the other techniques to decrease the contamination. (Helmeich.B, Horn.H 2009). Another similar project who worked on the harvesting rainwater in Ghana and their aim was to harvest the rainwater, as a solution for sustainable water supply for household use in two rural areas in Ghana. In this journal, the author pointed that the main problem of the rainwater is the contamination. One of the main solutions to solve this problem is the solar energy for purification of the rainwater which cause from roof materials that is made of local materials such as thatch made-up, dried crop residues and straw.(geojournal,2012)

Although in Evaz the water cisterns are covered with dome shape of structure, solar energy can have a great impact on purification of the water and the source. It can be integrated with updated technology such as solar panel as well.

After introduction of rain harvesting, there are similar passive projects, which their innovation is based on assessment of solar energy for improvement of the building in addition to solve the problems, which cause from nature and human life styles.

Supporting the sustainable solutions by the authorities is one of the most important steps to perform the solutions for environmental problems. Frequently the execution of sustainable solutions is costly and the maintenance support is significant in this field. Concentration of the government and authorities on the natural resources and vernacular architecture is very essential since normal people cannot afford them as long as it's not their own private property. That's the reason author has done study to recognize similar projects which has been supported and accepted by government and authorities as well. Although there are limited research resources available to evaluate as similar projects, since each place has its own vernacular architecture design and rules.

Dubai Government is really supporting the sustainable solutions for the heritage buildings. The Possible of incorporating PV in the Heritage Sites Case Study of Dubai Museum is the research topic which is related to this research. Anwer Hadi Faraj (April 2015) has done investigation on the heritage buildings and the impact of using updated

sustainable resources that can reduce the CO2 emissions and air pollution as well. The relation between this research and the water cistern topic are both studies have been concentrated on heritage and valuable structure, which are parts of the vernacular architecture. Researcher Anwar is trying to develop the system that is beneficial to sustain and recover. People's acceptance is one of the main issues according to changes in old structures and the impact on the appearance of it. He has selected PV panel for integrating the heritage building to an updated system. The PV panel system is selected according to the location of the building, area, orientation and if the space is shaded or not shaded. In the other hand capability of the PV panel and its configuration is a noticeable issue for selecting the type of the PV panel Restoration, rebuilding, treatment and conservation are the four major approaches to sustain the tradition buildings Integrating PV panel to the vernacular architecture had the purpose to reduce CO2 emission for the reason he has selected. (Anwar Hadi Faraj, 2015).

Relevant to the vernacular architecture and passive strategies, designing in sustainable way can help to assist saving the energy and more comfort to human's life. Diverse solar passive features have been applied for natural ventilation of vernacular buildings in the India. And the methodology used is survey as well. Vernacular architecture recourses to constructions built consuming locally obtainable materials in a useful style planned to meet the requirements of ordinary citizens in their position and time. The majority of the native design replies to the local weather (Albatici, 2009).

According to the various weather and conditions the requirements of architecture is different to convince necessary needs of the people. That's the reason of the development of passive design process and vernacular architecture through centuries (Singh et al., 2009).

Here is example of some solar passive facial appearance and Vernacular architectures in humid and warm climate condition region: "(A) come up to and open space in front of the building, (B)Chajja and extensive roof, (C) window hang over, (D) adobe house production, (E) arrangement in veranda to hide daylight sun from ingoing to the rooms,

(F) window blind ended up of selectively operable and wood, and (G) air opening in ceiling.” (singh, Mahapatra, Atreya, 11 May 2011) (Figure 24)



Figure 24: architectures and solar passive facial appearance in humid and warm climate condition, (singh, Mahapatra, Atreya, 11 May 2011)

The features of bioclimatic in vernacular structures of dissimilar climatic districts shows each area is required for special thought and passive strategy in warm and humid climate the building area for family is large with open space in the meantime in the cool and humid climate is less than warm and humid therefore in the cold and cloudy in less than warm and humid and cool and humid.

Infiltration is high in warm and humid weathers and cool and humid too but in the cold and cloudy is low. When it comes to the envelope side the tightness is low in both warm and humid weather with cool and humid weather but in the cool and cloudy it has the maximum tightness for the envelope.

In the warm and humid climate, shading is present and well known however, for cloudy and cool with humid is not quantified.

The ratio of warm and humid zones in north east of India is 0.22 and in cool and humid is 0.15 however in cold and cloudy is 0.11.

In the zones which weather is warm and cold with humid courtyard is available only in rural houses not in the urban houses though in the cold and humid is not present.

In addition, the orientation of building plan in warm and humid zone is similar to rural house at east and west direction. South facing and urban houses are not definite same as cold and humid climate conditions. Shape of the building plan in warm and humid weather is U shaped and rectangular however in cool and humid the shape is like rectangular or L-shaped and cold and cloudy has square plan.

These strategies were applied in north east of India to keep the house cool in the summer and hot in the winter although the researcher has mentioned in his paper that these strategies were applicable in summer more than winter, the amount of reduction of the cold air was not enough and suitable. The methodology of this paper is survey from 150 families (singh, Mahapatra, Atreya, 11 May 2011)

Although the passive design played a big role in human's life through century's changes and updates were necessary for some techniques which has been effected and changed by climate change, culture, natural disaster and people's life style. Therefore, smart improvement is requiring for different problems in different techniques of vernacular architecture and passive design strategies. Most of the strategies who has been design through the centuries are still in use and effective for the environment the main purpose for sustainable designer should be updating the systems by respect to the old passive strategy which has assist human's life for many years ago. Respecting means change the strategy or add a new solution very preciously so it does not harm environment or have negative influence on it. In addition, it has to meet occupants need.

## **2.2- Impact of Economical status**

Solar energy is propounding a main source for the futurity, not just for the country of Turkey, moreover for the entire world. Consequently, the expansion and use of solar energy technologies are increasingly becoming vital for sustainable financial growth. (Mujgan etin, Nilufer Egrican, 2011)

According to the job opportunities when there is less facilities in a city immigrating of citizens will be an obvious condition. Although introducing a new technology will add more facilities for easier life in the city it creates more job opportunities as well. Relevant to the researches and studies in this field solar panel is capable to formulate two types of job which are indirect and direct job opportunities. (Mujgan etin, Nilufer Egrican, 2011) (Figure 25)

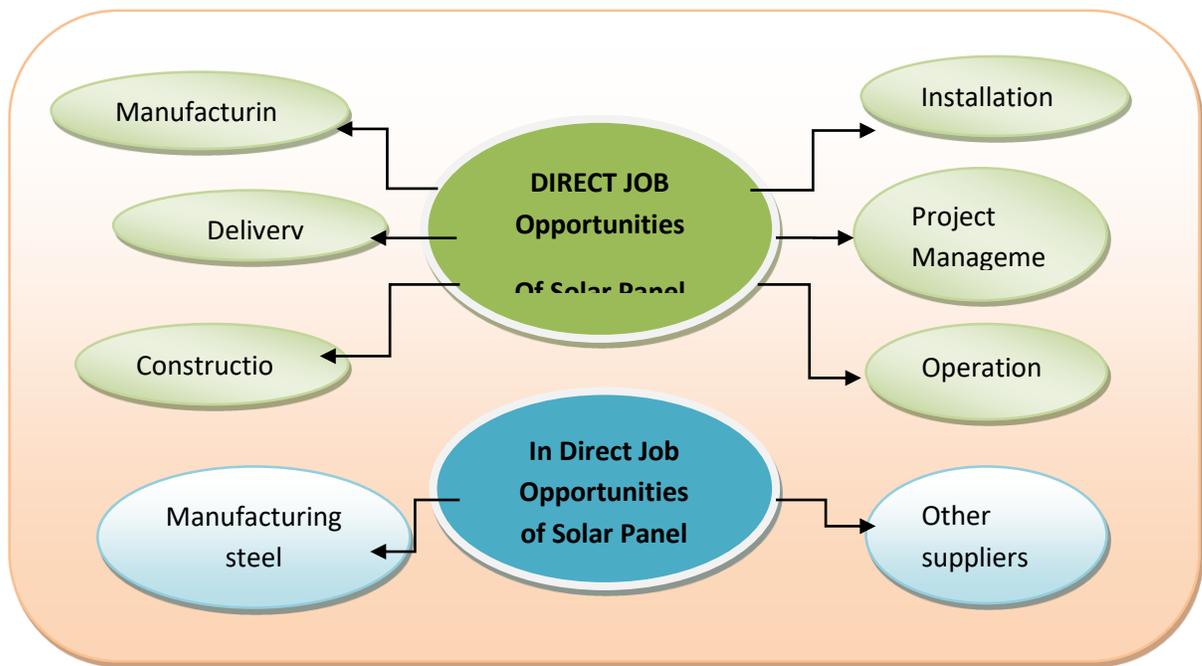


Figure 25: Description of the job opportunity of solar panel, based on summarizing from (M. Cetin, N. Egrican, 2011) paper, graph by author

In the result of the bar which shows how solar panel can create job opportunities, EPIA which is the European photovoltaic industry association the amount of the job which will be create by solar panel installation and servicing of PV system will be much more by the year 2030. Around 10 million job will be created in these fields as per EPIA studies and researches. In addition, during the process of production, 10 jobs have been produced for each MWP (megawatt peak) and throughout the procedure of setting up the number are concerning 33 jobs apiece MWP.

In a result of this case study proves that how the procedures of the solar panel can help the economic situation of a place or city who is required updated system and the latest technologies which solar panel.

Meanwhile investigating on the similar projects in documentary of dissertation and articles of Iranian resources there are several investigations on water cisterns in different cities of Iran.

The residents of Larestan (south of Iran included Evaz) region still believes that water cistern's water is more cooler, tasty and safer than piped water because they believe that piped water is produced from Salman dam which is salty and needs water refinery treatment. (F. Salmanpour, August 2014)

In the year 1981 a book called new energy from old buildings has been published which focuses on the renovation and sustainability of old buildings for saving on historical, cultural and architectural values of the building. According to this book by protecting the buildings, we can protect the latent energy of the building and keep it in the cycle. In continues to this discussion not only buildings such as museum, in fact any building that has a reasonable physical situation is a good case to reuse it. (Banazadeh, 2013, p.49)

### **3. Methodology**

#### **3.1-Introduction**

This section will introduce different methodology systems, which have been used by previous researchers for the similar investigation topics. Then will define the best method which is suitable for this research. Although it depends on the author's recognition but most of the similar projects have selected same methods.

The methodology applied in this research is the qualitative method. Drastic literature review has been carried out to classify as much data as possible from present literature. To gather further information on local level, field studies were undertaken linking interviews with local people and data collection through observation. Studying photographs of current situation in the city of Evaz, involving cultural personalities of Evaz for their consultancy and online surveys with Evazi people are some of the other methods such as surveys and social communications used in the research to further enhance the study and the investigation intended on the vernacular methods of Evaz (Mirahmadi and Altan, 2015).

In addition, calculation and numerical method carried out to support the solution, which is offered by author.

#### **3.2-Review of the previous methodologies**

##### **3.2.1-Online survey and Interviews (questionnaire)**

Online survey is the most suitable investigates technique mainly for the subjects in contact with the community estimation and allows the investigators to find extensive local and exteriority data, cost-effectively. In addition, it can be occur in logical adjustable time. Anwar Hadi has selected survey questionnaire as well to evaluate how

people think about the changes and integrating PV panels into the old museum buildings. Meanwhile this part is similar to the research so author has selected questionnaire survey for evaluating different issues, which is in communication with water cisterns and resident's problems.

(A.H.Faraj, 2015).

The mentioned research that focused on the heritage building is similar to water cistern research because both are integrating a new technology on the old and heritage buildings, therefore it is necessary to aware of opinions of the community and people who lives and belongs to that city and region. There are various kinds of believers and opinion in the case of heritages and historical structures.

Salmanpour has mentioned in her research that according to various kinds of natural disasters, the best method to study these water cisterns is combination of methods such as interviewing people with the high experience and knowledge about water cistern evolution. Since they are aware of what happened before and what are the stages of changes during the past years. (F. Salmanpour, 2013)

The survey methodology for the research of solar passive feature in future architecture of South-north of India to understand the situation better from the resident's point of view, survey has been conducted. The survey distributed between 150 households (50 houses in each bioclimatic zone).in addition its Interrelate with 300 residents in any bioclimatic region. (Singh, Mahapatra and Atreya, 2011)

Also in the states of Arizona, Colorado, New Mexico and Utah were investigation for the RWH (Rain Harvesting Water) and their aim was to explain the importance of the rainwater workout and strategy. This research had the challenge to discover what restrict and facilitate the development of RWH in these states. The author has mentioned for the data collection, has followed a most similar case study approach

including a newspaper analysis, policy analysis and interviews with professionals well informed about rainwater harvesting. (R.E.Greenberg, 2005).

Experience and knowledge about the past are importance matters to define the problem and analyze the situation from the past. Therefore, it is a great assist to develop the systems and reach to the valuable solution.

Survey method does not require highly developed tools to spread the questionnaire or gather the responses. In addition, it also allows for straight relations with the observers. Consequently, the researchers have chances to make clear any uncertainties or explanation may grow through the observers.

The main advantages of the online questionnaire are; great number of people can be involved such as residents and who are out not in the country for any reason. There are massive sorts of survey website presented for different categories. Comparatively it has minor expenses than On-site survey since there are no paper required and does not necessitate to travel and any specific instrument. The feedbacks will be automatically recorded and access to the responses is very easy. . The questions can be any format such as chart, table. The questionnaire can be send by emails and it can be communicated with social media programs as well (A.H.Faraj, 2015).

### **3.2.3-Literature review**

In general studying heritage and historical structures and buildings is not an easy task until can find a valid resource, books, articles and websites.

Because of the changes that happened to the water cistern by time in the history especially in the city of Lar, which is half an hour far from Evaz, faced strong earthquake several times. Therefore, evolution of water cisterns is different in several

periods. In addition, studying historical, logbook and available resources is helpful and a part of literature review. (F. Salmanpour, 2013)

Some study sites are not too close to visit and monitor it, therefore information and studies of the previous research and investigations can be extremely obliging in the categories of the heritages buildings.

There are some similar projects, which the investigator was monitoring it and trying to find the solution from direct communication with the site. L.A.Wooten has submitted paper about how to evaluate water quality parameters in harvested rainwater. First, she has selected literature review to find the fundamental information to start her research after that she did experimental and static analysis to prove her conclusion and give the solution. Although the type of the water cistern and harvesting rainwater is different from Evaz water cistern but data collection method for the selected sites are the same as literature review. The two sites she has selected are in Charleston, SC Metropolitan. Moreover, catchments of the rainwater are from the roof surface in this particular site. (L.A.Wooten, 2015)

Literature review can support to discover the previous processes and criteria for future procedure and invention in solutions.

This method is indeed helpful in this case but it is not sufficient, although it is a first phase to identify the circumstance, site plan, and revolution of the water cistern from the past until today.

Study and investigation of the elements and the passive strategies of the water cisterns will give a strong direction to evaluate and identify how those strategies can be convenient today as well. In addition to discover and find out if these strategies are requiring any change or modifications to stay longer and useful and what are the solutions for them.

Literature review is one of the methods, is utilized extensively through a huge number of papers as a major method to attain the objective of the study. Therefore, this

technique requires a massive quantity of papers to analyze in arrangement and to attain successful outcome. In contrast, between several outcomes from various papers must be achieved sufficiently.

This method can assist in eschewing iteration and obtain the advantage from others errors. Consequently, it is beneficial in constructing the investigate inquiry and think over the goal and objectives of the research. (S.B.Nazzal, 2015)

### **3.2.4-Calculation and Numerical method**

Calculation and mathematical method is required for solar panels constantly, therefore this research is using calculation and mathematical solutions as well. Although in this case of water cisterns, the concentration is more on a part of passive design and innovation in eleven water cisterns. These evaluations and analysis are required to show the solutions and new idea for safety of the sustainable issues of them. Only one method is not sufficient to cover all the raised problems in the water cisterns.

Numerical method is typically applied in combination with other research methods particularly to establish the penetration of the environment feature on the PV cell in Dubai museum's efficiency. (A.H.Faraj, 2015)

The major purpose of the study of the employment impact of solar energy in Turkey is researching the employment outcomes of solar energy manufacturing in Turkey. A number of self-governing news plus study, who evaluate the recruitments strike and economic of solar energy production in the globe, have been reconsider. Extensive choices of techniques have been utilized in individual's studies in instruction to forecast and compute to the employment outcome. Via the ability of objectives for concentrating on solar power (CSP) plants and the photovoltaic (PV) in the solar Roadmap of Turkey, the forecast of the straight and indirect employment effect to Turkey's financial system is probable. (M. Cetin, N. Egrican ,2011)

Employment impacts of solar energy in Turkey in 2020.			
Subjects	PV	CSP	TOTAL
Construction budget (EURO/Wp)	3-1.7	2.8-2	
Installed power (MWp)	4,800	200	
Investment (million EURO)	14,400-8,160	560-400	14,960-8,560
Employement/MWp	37-46	10	
<b>Total employment (person)</b>	<b>177,000-220,800</b>	<b>2,000</b>	<b>179,600-222,000</b>

Table 1: Employment influences of solar energy in Turkey, (M. Cetin, N. Egrican, 2011)

According to these case studies, calculation method is required for analysing PV panels. Although it is not enough to cover all the subjects. Therefore, the other methodologies are requiring for completion of the process.

### **3.3-Selection and justification of the method chosen with, Details of the method**

After studies and investigation in similar projects that has been used solar panel and passive strategies for sustainable solutions, author has discovered main points. The first selected method is literature review for the reason that:

- Literature review is the first and most important part of this research. The reason is before opening the chapter of problems and solutions .it is essential to be aware of the previous situation in passive strategies and environmental background of the structures. In addition, without previous background analysing the problems and giving solution is not an easy and logical task..
- Literature review is the method which will assist to know during the time which kind of changes might happen to the site, such as climate and technology criteria, therefore it will give a better expanse for the investigator to analyse the issues.

- In the other hand literature review gives information about all the similar projects, this is done for the same topic with the same problem so author will not repeat the same procedure. Therefore, new ideas and solution will come up during the study.

The second method selected by the author is questionnaire and survey for the reason that:

- Meanwhile after the investigation about the topic, which is consider as a heritage and valuable source of a city it is important to know resident's feedback about the problems of that structure such as water cistern, therefore questionnaire and survey is important method too.
- For creating sustainable idea for a place or resource of natural energy in a city, it is important to be aware of resident's living situation in communication with the source, in this case direct communication and access to the local people is a good chance to get aware of their situation with the assistance of survey method.
- Communicating with local people with the assistance of the survey method can get the information about the occurrence happened to the water cistern, in addition the effect and impacts which local people are receiving today. In addition, to compare with the effects in long years back.
- The other reason of questionnaire survey is the effective feedback and general idea could get from the local people since they are very familiar to the area's situation.

The third method that is selected for this research is Numerical and mathematical method.

- According to the solar panels and its requirements a short method of calculation is required for this research therefore author has selected numerical method as well to analyse the amount of required solar panel and the process.
- Economic impact is one of the significant aspects for the result in offering any sustainable solution for the environment; therefore, numerical method is required in this stage as well.

In addition to complete, this journey author is using different methods for covering all the necessary parts of the research also solutions in 3D images is provided to describe more clearly about the solution and new ideas.

## 4. Data Analysis

After defining the methods and introduction to similar projects author found that harvesting rainwater is an important issue in all of the world and each city and country has to find its own solutions according to its environmental background. To understand the feedback of Evaz people for updating systems of the ancient structure, the survey method has been distributed between them. 108 people have responded to the Survey. They were citizens who live in Evaz or who belong to this city and their age were between 30 to 60 years old and the gender were both male and females. The survey is created in both languages of Persian and English to be easier and faster for those who lives in Iran, 97 people replied on the Persian survey and the rest 11 answered to the English one (figure-36).

The people who are responded to the survey are those who are active in development of the city such as managers of the Evaz museum, local civil engineers, local architectures, researchers and author of the historical books which belongs to Evaz (The survey is attached at the end of this research after references.)

Normally water demands for residents are different in Evaz, depending on the seasons as per the information which author got from interviewing with Evazi people; in the summer, because of dry and hot weather water demand is more than winter. In moderate season for families with two to four people, water demand is 1000 Litr is enough for 4 month in the year, although in families with larger capacity such as 7 to 8 people the 1000 litre is enough for 2 month only.

This amount of water provides from the water cisterns. Water cistern is the most important element in Evaz city. People are still consuming the water from it. According to the survey, the maximum importance the water cisterns have for people of this region. (Figure 26)

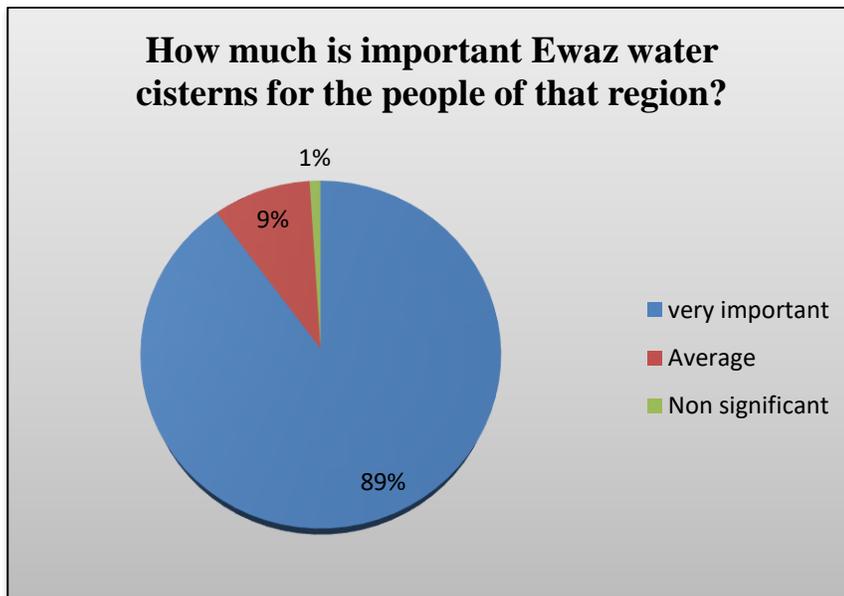


Figure 26: Graph shows people’s opinion about the importance of water cistern, survey by author

The graph bar shows the value of the water cistern. According to the first graph, 89% of the citizens believe that water cistern is very important for people’s life in Ewaz. While just one percent believes, it is no significant for the region. The rest 10 percent indicates that the water cistern is important element for the region.

In summery most of the people (99%) believes that water cistern is important for continues of people’s life.

According to the chart, 14% of the Evaz citizens believe 100% of drinking water in Evaz is provided by water cisterns although 11% believes the use of water cistern from water cistern is less than 50%. In the other hand 39% of Evaz citizens replied to the question that the amount of water consuming from the water cistern is 80%. Finally, 18% believes that 50% of water supplies are from the ancient structure. In the result 11% of Evaz citizens has voted for less than 50% of water consume therefore the others voted for more than 50%.

That is the reason searching and finding solution for sustainability and safety of the water cisterns are certainly important in this stage. The other resource of water is Salman dam, which is not full of the water all the time in the year. In this case, water cisterns play a big role to satisfy the requirement of the residents. Improving and updating the system of the water cistern is essential for the life of the citizens (Figure-25) and (Figure-27).

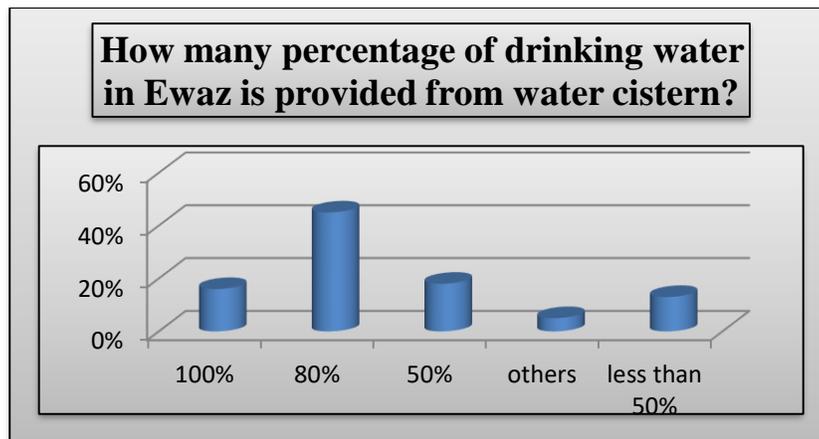


Figure 27: Graph shows how much is the demand from the water cistern for drinking water, survey by author

#### 4.1-Problems of Cisterns:

The first problem, which has been mentioned in the research, was lack of rainfall, which is related to the climate conditions; some other problem has been created in these years and was the reason to stop using some of the cisterns. The quality of water after drought reduces because for long time water is unmoved and some people does not use the water through healthy ways so the place will have a contamination. That is why people stopped using them. On the other hand, the study proposes some sustainable design solutions for these problems, which can solve this issue and people, can continue using the rainwater in a face of fresh and healthy way. As soon as most of the water

requirements are supported by cisterns, it is necessary to solve human health hazards in cisterns (Figure-25 and 26), (Mirahmadi, Altan, 2015)

The main categories, which cause problems for water cistern, are:

- Water pollution

Water as a vital need of human's life is really important to be healthy and fresh to drink. There are different kinds of pollutant and hazard in water which can harm human's body. From the chemical to wastages can make a high effect of water's purity.

- Destruction inside the water cistern
- Pollution from the human

The first part of pollution by human is the wastages such as food, plastics and extra. In the culture of Evazi people, it is necessary to protect the water from the wastages but still there is wastages can find in the water cistern and the reason is when someone left the wastages of his use somewhere close to the water cistern by wind and rain time it gets move and directed to the water cistern.

Another type of pollutions made by human is oil and gas of vehicles normally they build the water cistern close to the main street for people to be easier to have an access to the water cistern. By the time and the pollutant which cause by vehicles, when it's raining it will wash the street and sometime it directs them to the water cistern. So there will be chemical hazard in the water as well.

- Pollution from animals
- Damages by nature

As long as Evazi people are using water cisterns since long time this part of survey has been created to share the information according to the pollutions of the water cistern (Figure 30).



Figure 28: Graph shows the percentage of harm and injure people from the water, survey by author

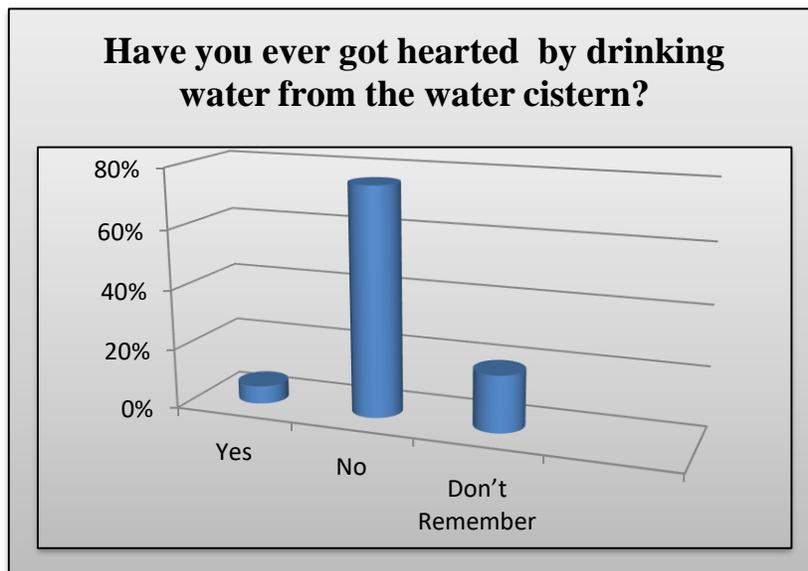


Figure 29: Graph shows the percentage of the harm and injured people from drinking water from the water cistern, survey by author

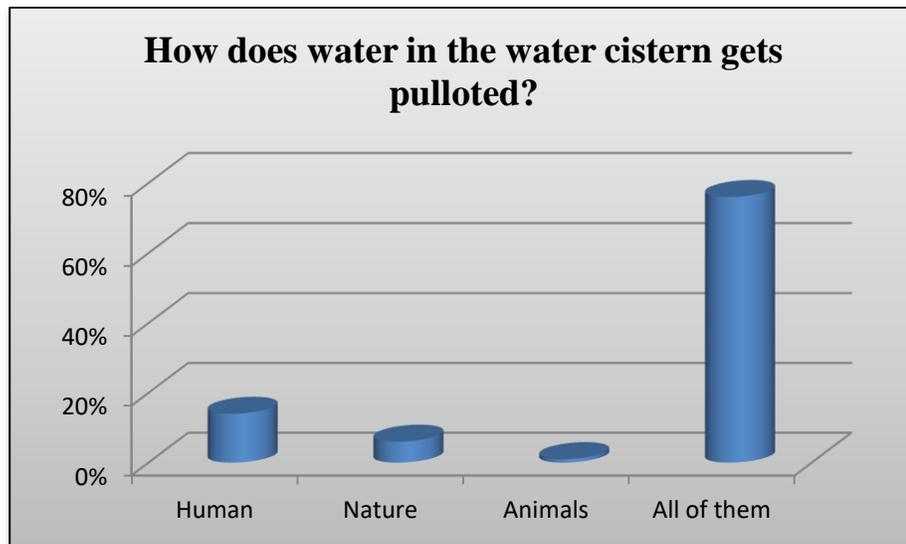


Figure 30: Graph shows the factors which effect on the pollutant of the water cistern, survey by author

#### **4.2-Sustainable Solution:**

Although people from ancient times were adding chemical liquids in the water to kill the bacteria in the water, by the time the pollution inside water was increasing because of the reasons which has been mentioned via survey and literature background , therefore the other solutions are required which could cover most of the problems in the water cisterns. According to the previous passive strategies some new ideas has been introduced by author to protect the water cistern from pollution and contamination and reuse the water cisterns which are not in a good condition to use their water as a portable water source.

The best way to protect the water from microbe and bacteria is water filtration idea. Water filter machine can create movement in the water in addition to kill the bacteria and hazards inside the water. To activate the filter electricity is the major element,

which is required but the lack of power, is another problem, which also requires another solution. As mentioned before, Evaz has a strong solar power, which has not been used until today. Using solar panel to produce electricity for those water cisterns will be a new idea. As per the research on different kind of solar panels, it has been discovered that with installation of a solar panel on one cistern can produce electricity power to nine other cisterns as well. Radiation of sun in the south orientation is more powerful than any other orientation (Mirahmadi, Altan, 2015) (Figure-31).

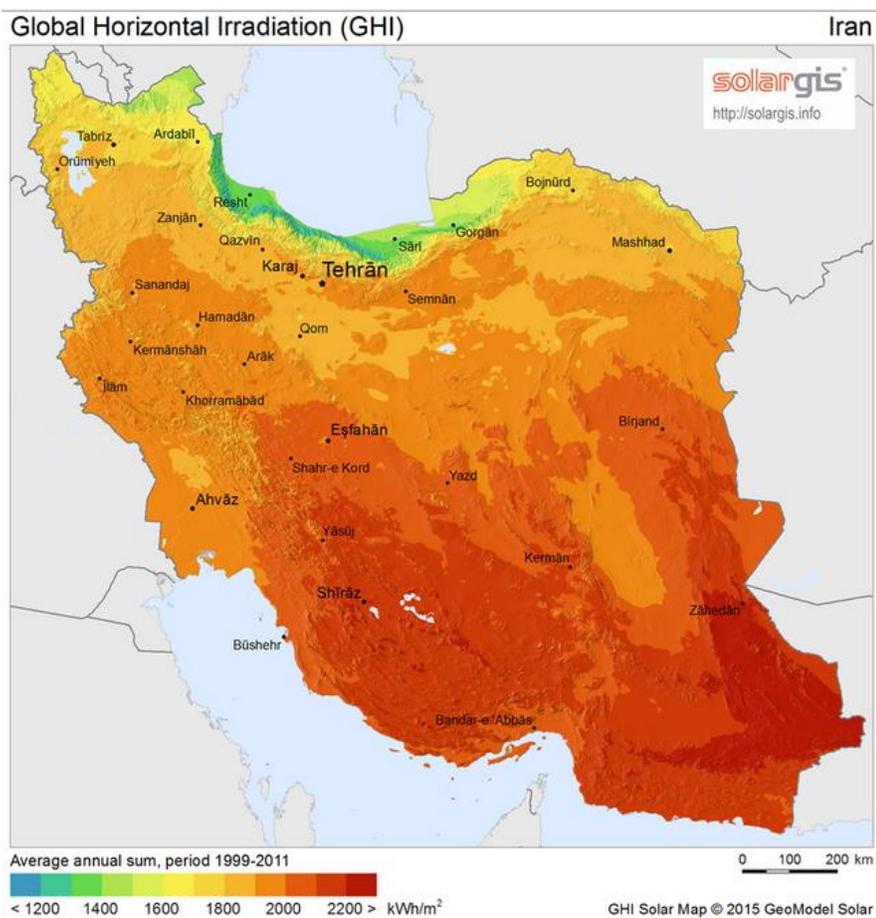


Figure 31: Radiation of sun in Iran (1999-2011), (Solargis, 2015)

		Climate data location	
		Unit	
	Latitude	°N	32
	Longitude	°E	53
	Elevation	m	1498
	Heating design temperature	°C	-2.57
	Cooling design temperature	°C	33.74
	Earth temperature amplitude	°C	25.54
	Frost days at site	day	52

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree days	Cooling degree - days
	°C	%	kWh/m <sup>2</sup> /d	kPa	m/s	°C	°C-d	°C-d
January	3	64.1%	3.40	85.2	4.7	3.6	449	0
February	4.7	56.2%	4.48	85.1	4.8	5.9	362	2
March	8.8	48.8%	5.15	85	4.9	11	281	33
April	15.9	35.0%	5.90	85	4.6	19.3	83	182
May	21.3	25.8%	6.71	84.9	5	25.6	11	342
June	26	19.9%	7.38	84.7	5.9	30.9	0	472
July	28.2	19.4%	7.01	84.6	6.5	33	0	559
August	27	19.8%	6.69	84.8	6.2	31.2	0	523
September	22.5	21.4%	5.90	85	5.3	26	2	371
October	16.6	30.2%	4.73	85.4	4.6	19	61	209
November	10.3	41.9%	3.60	85.4	4.4	11.4	218	56
December	5.1	57.5%	3.09	85.4	4.7	5.6	380	4
<b>Annual</b>	<b>15.8</b>	<b>36.7%</b>	<b>5.34</b>	<b>85</b>	<b>5.1</b>	<b>18.5</b>	<b>1847</b>	<b>2753</b>
Measured at (m)					10.0	0.0		

Table 2: Specification of the climate data in different month of the year (Solargis, 2015)

### 4.3-Site plan

The site which has been selected is the eleven water cisterns site which is in front of the Payam Noor University in Evaz city. This place is not too far for people to come and collect the water. For the first time and to try how will be effect on utilization of water in the site of Payam Noor is selected. (Figure-33)



Figure 32: site plan of the 11-water cistern, Google map

## 4.4 Details of the Process for the solar panel with water filtration device:

### 4.4-1 Water filtration device

At the first point author has done investigation on the required water filtration device and its process to analyze what kind of the pump and capacity is suitable for water cisterns. After discussion with professionals and engineers author came up with a solution, which were provided from the similar projects in literature review as well although author has noted the differences and requirement of the Evaz water cistern with water harvesting system in different countries.

The 1/2 Feed Pump will be handling the suction of the water and will produce the necessary pressure in feeding the RO System with water coming from the cistern. Then,

in the 400 GPD Light Commercial Reverse Osmosis Water Filtration systems, there are five RO stages.

First stage is Sediment Pre-filter, it screens out dirt, sand, rust and other microscopic particles 15 times smaller than a grain of sand.

The second Stage is Carbon Pre-filter, granular Activated carbon to reduce chlorine, color, odor and absorbs volatile.

The Third Stage is Carbon Pre-filter, activated carbon block pre-filter reduces elements that cause water to taste and smell unpleasant, including the taste and odour of chlorine.

Next stage is RO Membrane. Here, TFC RO Membrane with pores of 0.0001 micron squeezes out the dissolved substances, including radium, virus, bacteria, salt lead, heavy metals, arsenic and many others. The last stage is the Post Filter. Post polishing carbon filter removes any possible residual taste from the tank. The recommended replacement time is replacing the sediment Pre-Filter & Carbon Pre-Filter at least 4 to 6 months and the recommended replacement of the RO Membrane and Post Filter is once every 2 to 3 years.

Next, is the 4GMP Ultra Violet filter. Ultraviolet water purification is the most effective method for disinfecting bacteria from the water. Ultraviolet (UV) rays penetrate harmful pathogens in water and destroy illness-causing microorganisms by attacking their genetic core (DNA). In the final stage, 100 gallons Food Grade Storage Tank will be there which can accommodate the water consumption of the resident. (Figure, 33)

- 4GPM UV:24watt,220v/240v AC, 50/60Hz (Per Day Consumption:

(0.576kW h/day)

- RO SYSTEM:1.2A \*4=4.8A,220v/240v AC, 50/60Hz (Per Day Consumption:

(2.76kW h/day)

- PUMP:1/2HP,0.37kW,220v/240v AC, 50/60Hz (Per Day Consumption:  
(8.88kW h/day)

Total Electricity required per day consumption is: 12.216 kws/ Day

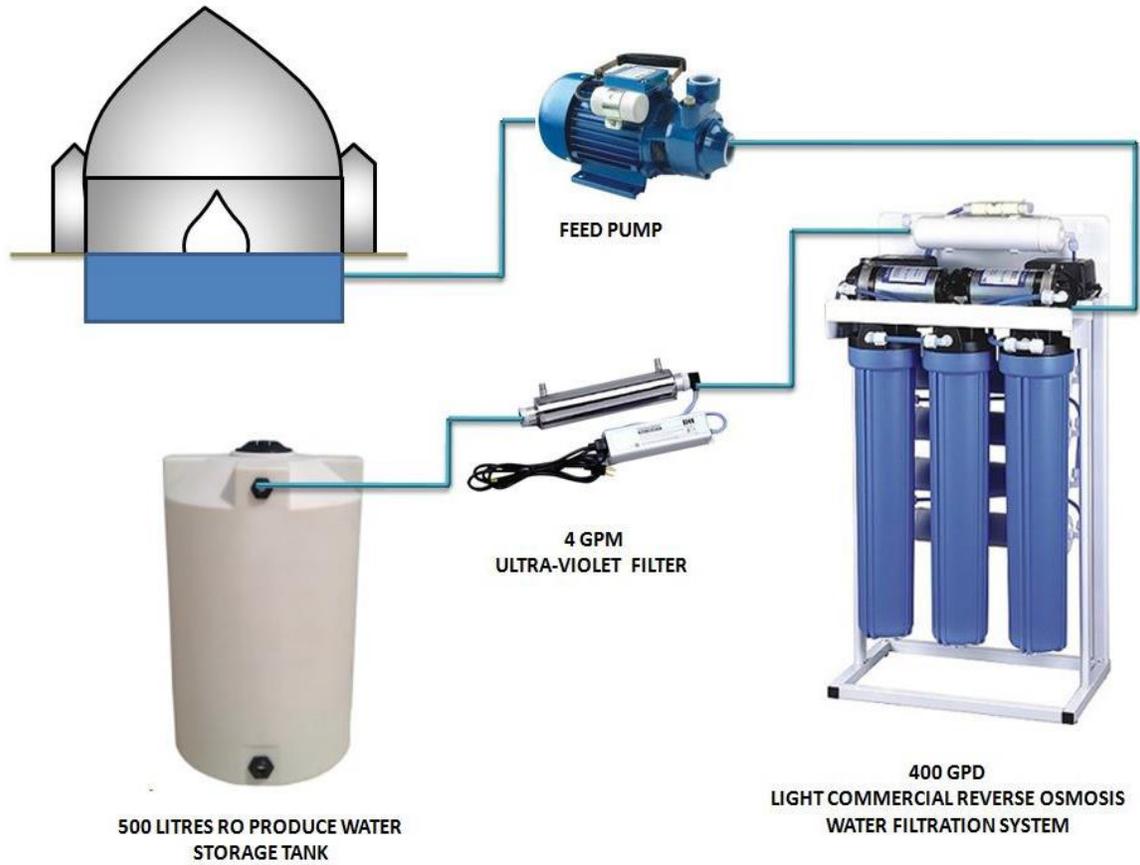


Figure 33: Detail of water filtration process, F.TEscon , Ultra Tec water treatment

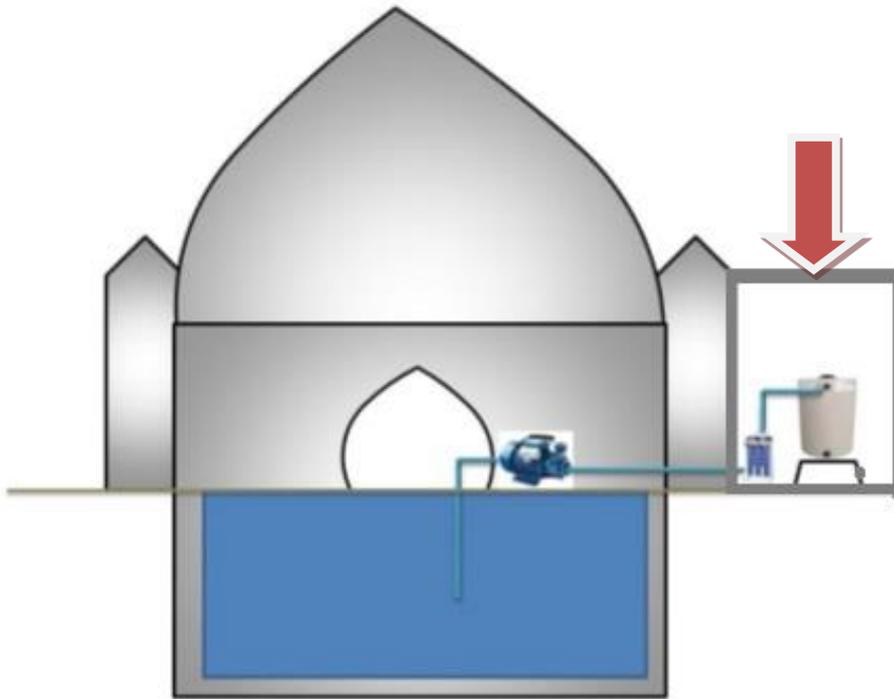


Figure 34: Detail of water filtration process, F.TEscon , Ultra Tec water treatment



Figure 34-1: The space, which will water filtration, and tank devices locate, by author

400 Gallons per day RO Unit can fill the 100 gallons storage tank 4 times.  
4 times / 24 hours will be 6 hours per cycle to fill 100 gallons. 6 hours power consumption will be 3.054 kW. Therefore 2 cycles (200 Gallons) = 6.108 kW (12 hours daily)

200 Gallons / 100 resident = 2 gallons per person daily

The process of 11 water cisterns with one solar panel with electricity capacity of 12.216 /KW provides 400 Gallons water per day. Now if two solar panels apply on the site for 11-water cisterns 800 gallons / 3000 liter water will be the outcome of this solution. In the result per month, we have 90000-liter water. The required water of each individual per month is approximately 50 liters. In this case, this filtration method is suitable for 1800 people. This amount is acceptable for assisting for portable water in Evaz city. In addition, this system can apply for south regions in Iran, included North West of Hormozgan state and southeast of Fars state as well because they use the same water cistern system for their portable water use. Also it will be more suitable for the small city and villages with less than 5000 people population. According to the statics, there are around 500 villages and small city located in this region. Therefore, this system will be updated version of water cistern to save people's life for healthy portable water in this region.

#### **4.4-2 Solar Panel descriptions and details**

To generate the water filtration devices as mentioned will be require for suitable solar panel. Two solar panels with capacity of 12.216/KW for each is essential in this part of the solutions.

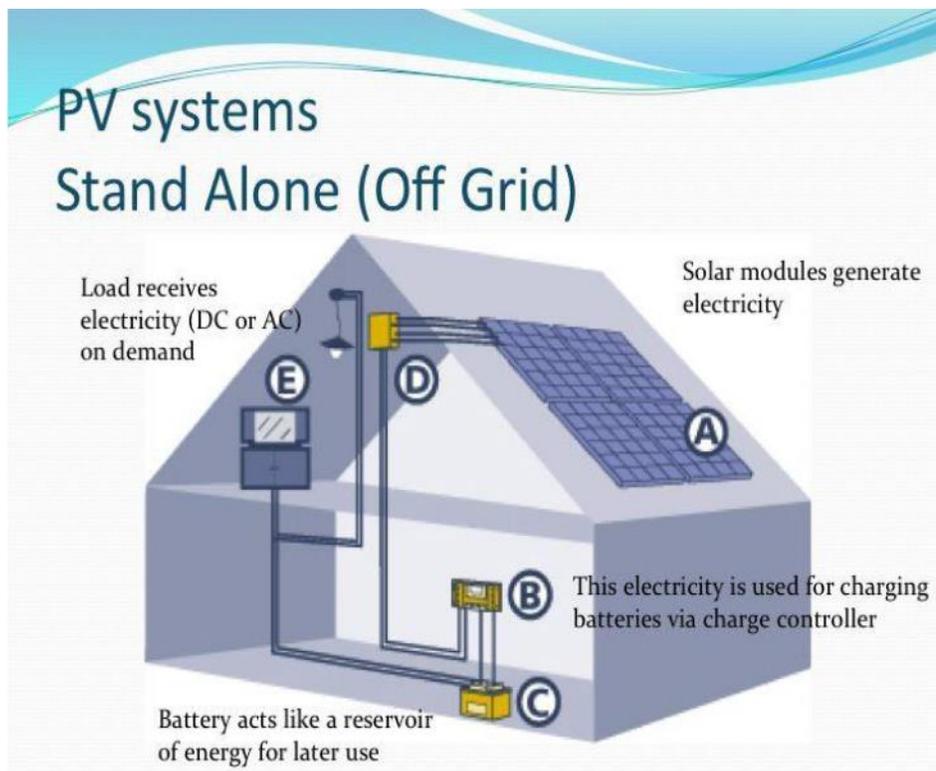


Figure 35: Process of the solar panel, (apex power concepts, 2015)

Panels are used to power the load. Charge controllers are used to control the charging of the batteries, which enhances the life of the batteries. Batteries are used to store charge and power the load when the sun is not shining.

The batteries are designed to operate for 1-day of no-sun back up. An inverter is provided to convert DC power from the battery to AC power so that the loads can be operated. Cables and connectors are provided to wire the system completely. A solar mounting stand is provided to place the panels. Because of the dome shape in water cistern, it has been decided to design the solar panels in with the dome shape. After analyzing both quotations for two different panels, there was a huge price difference. Therefore, the decision was to choose the normal shape of solar panel, the specification of the panel is mentioned in table number 3, (Mirahmadi, Altan, 2015)

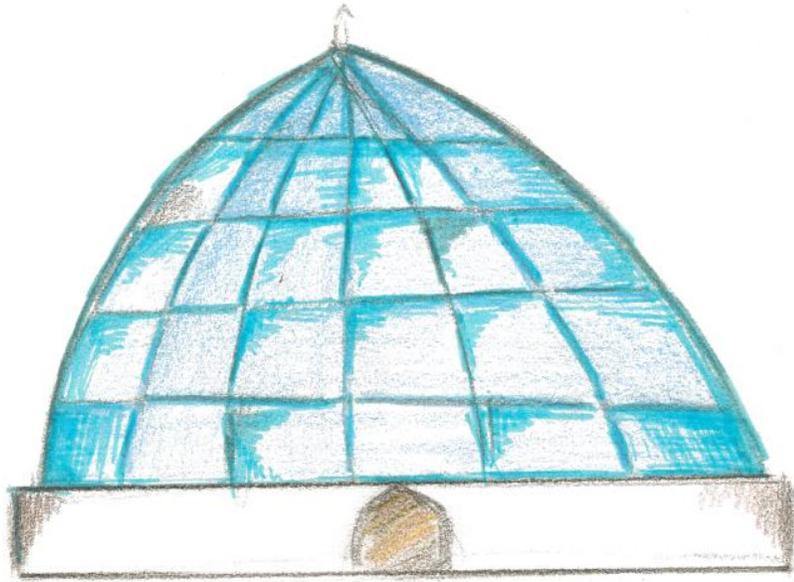


Figure 36: Dome shape solar panel idea/concept

In the dome shape solar panel design, cistern looks more beautiful but the price increased a lot. In the city similar to Evaz, investing for this amount of money needs management that is more precise. With the experience of being in cultural and city development meetings of Evaz city, discovered that Evazi people are interested to invest and develop their small city of less natural resources. Although this idea and concept is looking beautiful and useable, the cost is not reasonable since it will cost around 400,000 Dirhams .

Therefore, the second option will give same process and good amount of power to filtrate the water for peoples' daily water use. (Mirahmadi, Altan, 2015)

In the other hand it's not necessary to install the PV on the cistern to get effected on the outward of it. It can be install close to it such as street light. Therefore, this last option, according to the safety conducts is also better and logical idea it's not easy to reach specially it's located in the plain area, which there are no homes, and there is no traffic in this area as well. (Figure 38)

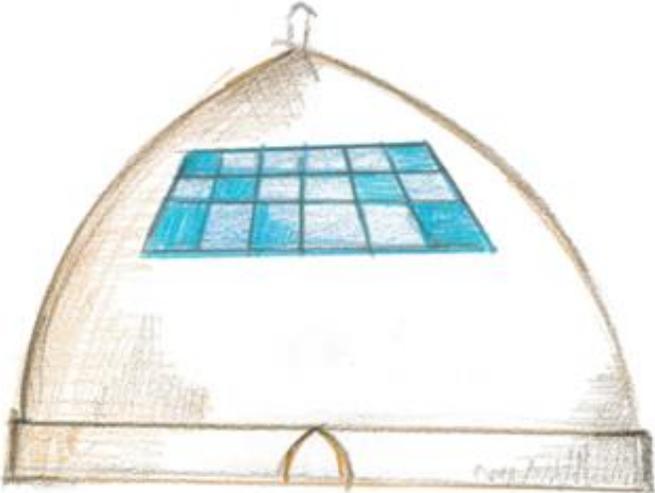


Figure 37: Rectangle shape of the solar panel idea/concept

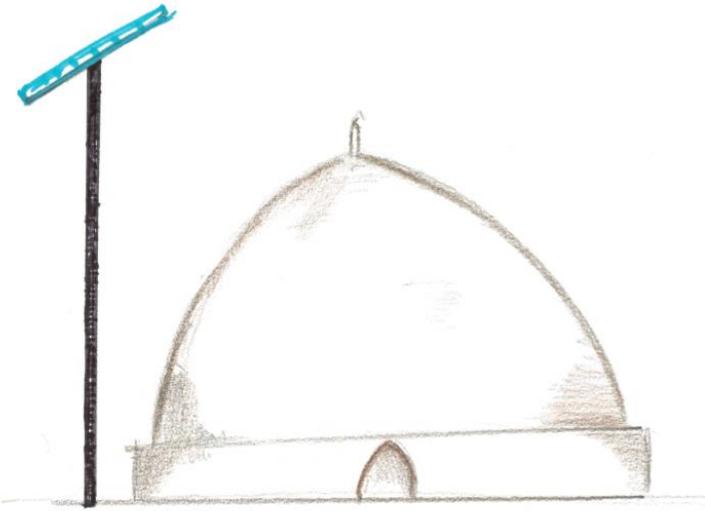


Figure 38: water cistern and the solar panel in the side, Idea/concep

#### 4.4-3-Specification of the solar panel:

Here is the details and specification of the devices, which are connected to the solar panel and comes with it. (Figure: 39)

Quantity	Item	Description	Unit	Origin
13	Solar modules	DUSOL, DS72300, 24VDC, 300W, poly-crystalline cells with aluminum frame.	Nos	Dubai
1	Inverter/charger	Schneider 6048, 48V 6 KVA pure sine wave inverter and charger	Nos	France
1	Charge controller	Schneider Mppt 80 -600, 80A 12/24V charge controller 600V maximum input from pv	Nos	France
24	Battery	Sunlight RES 5 SOPzS 605, 455Ah@C12 ,2V, advanced Low Maintenance Tubular Plate Batteries for Renewable Energy Storage	Nos	Greece
1	Stand	L3, and L10 Aluminum Mounting stand, for mounting 3 panels per stand and 10 panels per stand respectively with adjustable inclination	set	China
1	Dc junction box	Dc junction box with busbar and fuses f	Nos	Assorted
1	cables	Cables and connectors required for the installation of the system		India

Figure 39: specification of the solar panel and the devices, apex solar panel

The dimension of the solar panel is 990x1955 from the outline and 935x1890 from the inside. (Figure: 40)

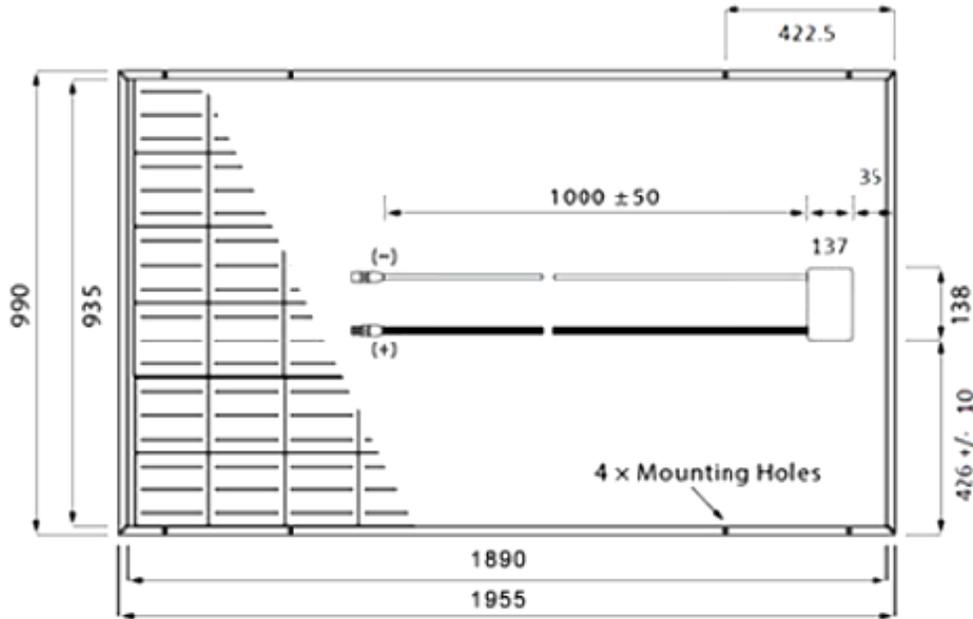


Figure 40: Dimension of the solar panel, apex solar company

The selected solar panel has 72 cells from polycrystalline 3BB cells with the size of 156.5mmx156.5mm. The front glass is made of tempered low iron pattern glass with 4mm thickness. The frame of the solar panel is made from anodized aluminum silver. (Figure: 41)

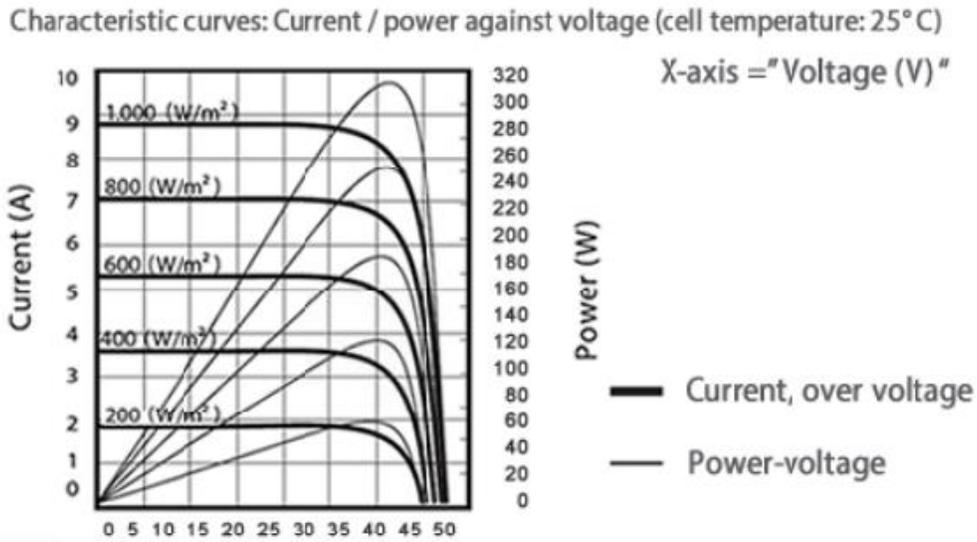


Figure 41: characteristics of the solar panel, apex solar company

#### 4.4-4-Cost benefits analyzes

In the city of Evaz the water resources are shortage and limited. Most of the time people are obligate to buy additional water to meet their requirements. However, they are spending for drinking water and urban water is not recognizing to drink; investing on the water cistern will be essential thing to do for the city. Water cisterns are supporting people for their daily requirements .In this case people agree to invest and get the benefits of the water cisterns which was considerably helpful since 1250 BC. The graph bar shows Evaz citizen's opinion about spending and investing on the water cistern if it's required or not. Beforehand any innovation on ancient structure its necessary to be aware if the nation of the region is going to accept these modifications or not.

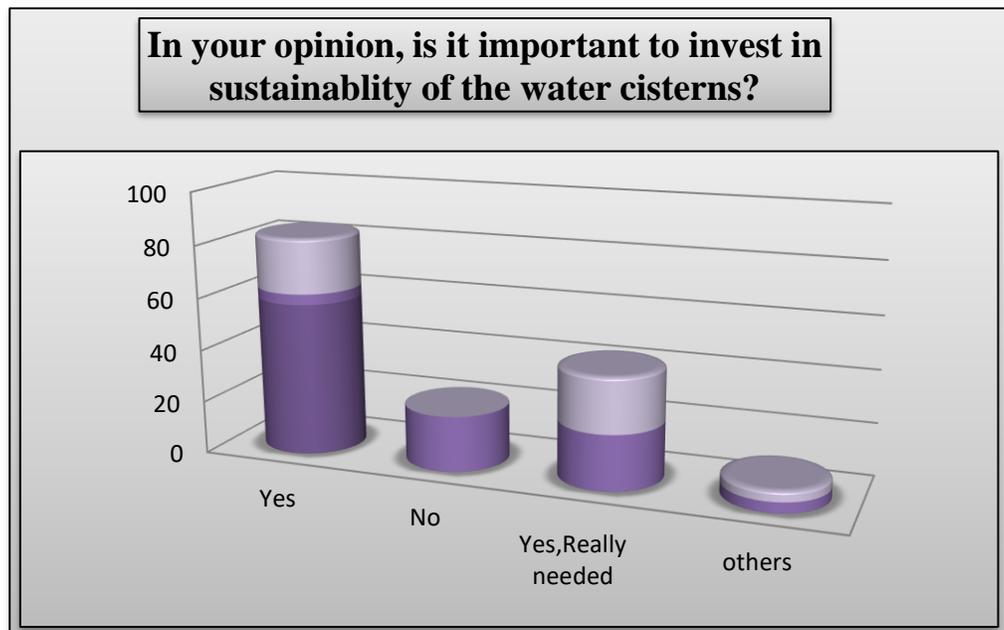


Figure 42: Graph bar shows people's opinion for investing on water cistern, survey by author

As is presented in the bar graph Evazi citizen's opinion regarding investing for sustainability and investment on the water cistern 58% of the people are come to an

understanding with investing on the innovation of water cistern although 4% said it doesn't require. Meanwhile 21% of people said it is really needed. In addition, 4% wrote their opinion about the investing for water cistern, an individual has mentioned since there is no updated system to solve the water issues this can be a respectable idea for usage of it. Another individual has mentioned investing on water cistern is essential for both sustainably and utilization of the water cistern. The last opinion came from a person who believes urban water is not 100% safe, means we have to grow up the water cisterns and update the use and the way which is it now.

In summery most of the people (95%) believes that spending and investing for water cistern is required for today's need. In addition, there should be a solution, which can cover the issues of the water cistern for today and the future. In the other hand when the sustainably of the ancient structure is required there will be some additional expenses to pay for assisting of durability of the building. Now a day building a new water cistern is not inexpensive and not everyone is willing to disbursement for it.

Therefore, it is important to create an innovative system for durability of the structure especially when it's a vital substance of humans need. The ancient structure is valuable in all countries, here in Evaz this structure is not only an old and historical part of the citizen's life but it played a big role of intelligent passive structure to meet the peoples need without processing and requirement of electricity or additional energy resource. In fact, with investing and updating today's water cistern will be a great idea to save it for future and sustaining for many years. Although the age of these water cistern is more than 700 to 800 years with modifications which is made in helping nature and life system of the people, it's necessarily to update it after some years for staying beneficial for peoples need. Here you can see the opinion of the citizen about the durability of the water cistern in the future.

The graph shows the opinion of the people in Evaz according to durability of the water cistern in today's situation. As is seen from the given illustration, 72% of the people believe that durability of the water system is depending on the how people use them.

Although 4% believes that it will not be available any more if we continued using it on this way. Merely 18% said it is going to be stay for long time. The percentage of people who believes the water cistern will not stain in this way for the future is higher than the people who believes this well remain the same for upcoming use.

In summery a few people believe the durability and sustainability in today's condition will be stain for the future. Therefore, with the maximum answers can get the result of that the water cisterns need to be update in a sustainable way. This matter is vital for human's life for Ewaz otherwise in the future with the conditions of global warming and changes in nature and rainfall a big problem will be created according to drinking water and the amount of water for daily uses at residential and commercial places.

Building a new water cistern with a standard normal size today will cost around 100,000 to 150000 Dirham. If we are going to build a new water cistern, it's going to cost a high price as long as modification and reuse of numbers of 11 water cistern with 12.216 /KW load for 12 hours with 1-day autonomy is costing around 68,000 Dirham. In this case investing in water cistern modification is a smart and great deal. This method can save them for the future not as an ancient structure only but as a part of vital life.

According to the reasons and evidences in this part of the survey, which is based on Evaz citizen's opinion regarding their needs for water resource, the water cisterns system should be updated to remain and survive humans need in the future. And the amount which will be spend for it is to assurance human's life in the future and hesitate facing a big issue according to the main vital need of the people (Figure 43).



Figure 43: process of filtering machine inside the water cistern, idea/concept

In addition, there were some other issues in water cistern with solutions from authors view:

One of the main problems of the pollution is when an animal is entering to water cistern to drink water and it's not easy to collect water most of the time it's possible that animal falls in the water and could not save itself. Therefore, it is important to have a metal door, which can be open easily by human over there (Figure 44).

In addition, installing a metal door will not be costly but it can assist the water cistern system to stay more clean and useful for human's need. The other advantage of adding door is, it will not destroy the shape of the water cistern just will avoid entering any animal to the inside of the water cistern. In the other hand the heritage look of water cistern will stay same and useable (Figure 45).

In the second part people are in use to collect the water by sending bucket or pail to the water and pulling it out. This process can be use today as well but for people who are not able to do that or doesn't have the power to hold a heavy bucket there is another solution offered by author which is not costly in fact cheap and easy. By adding the pipes and machines inside the water cistern adding an extra pipe with tab is not a big

deal to make the process of collecting water from the water cistern, easier without any difficulties this part can be connected to the filtration tank as well (Figure-38). In this case any passenger or human who is passing by this city which is hot and dry most of the times, can collect the water for drink easily. In the other hand, importing water by tank for residents will be easier too.

Now the situation will be different, water is clean and the process of collecting water is much easier with just small changes which will not effect on the outlook of the water cistern, also will make human's life easier. In addition, it will add to water cistern life and utilizing from it. Most of the research and studies which has been done on similar projects were costly and required a high power and help of the government to solve the issues. But these solutions any benefactor can solve the problem and assist to sustainability of the water cistern and human's life.

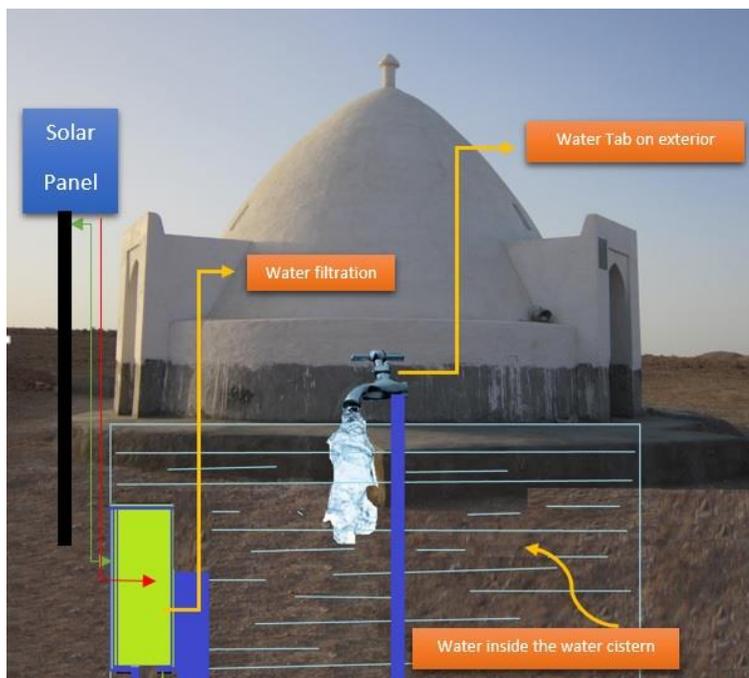


Figure 44: process and the piping inside the water cistern, idea/concept



Figure 45: avoiding entering animals to water cisterns, idea/concept

#### **4. 4-5-Maintenance and safety**

In view of the fact that there is no moving element in solar panel it necessitates extraordinarily miniature maintenance. Just A little period of time in the year, the panels have to be looked over for whichever grime or wreckage that might assemble on them. Therefore, after installation of the panel the maintenance won't be hard to manage. Somehow bringing a new system in the town can help people to add their knowledge and meet their satisfaction. In addition, it can create jobs for people as well, since Evaz's population is not much and not a huge works are available for the applicants. In fact, his kind of solar panel can be used for electricity of the residents living place also as long as Evaz is always facing electricity problem for residents in the whole year specially in the summer which weather gets hot and the consume of the air condition will increase more than expect. Shortage of electricity in the summer afternoons is another problem of Evaz citizen which can be solved with the same solution of solar panel as well so it's a great opportunity to start solving problems by natural energy resources to cover and solve another energy resources problem

Location of the solar panel is going to be close to the water cistern and above it therefore normal people cannot have an access to it easily. According to the safety manner weather in Evaz has normal conditions there won't be a very heavy rain or snow in a result solar panel can stay more and have a longer life.

Nowadays automated cleaners are available which it works with sprinklers. It has to be programmed first then it can automatically clean the panels without any human's help it's moreover a great idea if the weather is dusty and frustrating the solar panels (Solar panel maintenance - the solar company, 2016) (Figure 46).



Figure 46: Automatic system of maintenance for solar panel, Solar panel maintenance - the solar company, 2016)

## 5. Conclusion

This chapter will cover the findings of this research as well as providing conclusions and recommendation for future work and the important issue's solutions.

The issue of the natural disasters and climate change in the world has been strongly effected on the water requirements of the people in Iran. In the first step author has identified the amount of the rain during the year and how much water can be store in Evaz city. After the intoriduction to Evaz and its features author brought similar projects which are focused on rain harvesting methods and filtering the water for daily uses although for Evaz project the focus is on the portable water not just water for daily uses.

After analysing the importance of water cisterns and the value of it for Evaz citizens this result has come up that the issues of the water cistern has to be solve in the earliest time to be able to save water for vital need and daily requirements.

The aim of this study is to find out the problems and solutions for the lack of the water problem in south of Iran by assistance of vernacular architecture and sustainable solutions.

In the literature review section different kind of similar projects has been introduced and the system that the author recommended. Author has mentioned the parts of filtering system can be use but according to the lack of rainfall and climate condition, the system will be different to Evaz project. To complete the information of the readers' author has added the introduction to history of Evaz and the history of the structure. in addition author has mentioned the most famous water cisterns in Evaz as well. In the passive strategy side also she mentioned the passive roles of evaz architecture to get the inspiration for the solution and suggest a solution which is more suitable and acceptable for people of this region.

After analyzing the history and information of literature review the next part was research methodology which author have selected three different methods such as survey, literature review and Numerical and calculations. The reason of the Survey method was to analyze feedback and opinion of Evaz residents, according to the changes and problems of drinking water. Literature review has been selected because the site was not close to the author and to compare and analyze the impacts from the past was not, therefore she has studied the previous papers and gathered information from books which belongs to Evaz and that region. The Numerical and calculation was required because author selected solar panel to generate the electricity to filter the waters in the water cisterns the amounts and calcution was necessary to define how this solution can be effective for their vital need and economical situation. Also the methods of different similar paper were studied and analyzed in the methodology section.

After collecting all the data , solution came up to save the captures of the rain water and use them for portable water. By the solar panel electricity could be generate and 250000 liter of rain water can be save and use by the people with filtration devices which can work 24 hours per day. Author has mentioned this system can be applied not only in Evaz, in fact in most of the small cities and villages around it because they have the same water cisterns with a bit of different look as well.

The details of the devices such solar panel and water filteration machine, all has been mentioned by author. For the economical side also, author has described that building a new water cistern today is more costly than applying this solution on 11-water cistern. The advantage of this technique is that instead of building one new water cistern, 11 water cisterns are getting in use again.

Water cistern as a most important element of this region is evaluated. For the purifying and creating best method and design, author is given sustainable solution by facilitating the solar energy for the purpose of filtration method to refine the water and prepare it for drinking. South of Iran has a strong power of solar energy which can be very

beneficial for obtaining power to use for this process. In addition, new ideas have been advised to support the ancient shape of water cistern. Idea of the metal door is given as well to avoid entering any animal or wastage inside the water cistern. The idea of using solar panel is going to be cost effective at this time, while using one solar panel can have the power to filter 10 water cistern, which is equal to building one new water cistern. In this case, of sustainable solutions, all the matters should be considered carefully and precisely. Especially when the product's cost is high. In the first stage, designer should consider who is going to pay for the product and how it is going to help the city and the people's life style.

Evaz had built universities, schools and hospitals on the support of the people and they are highly looking forward to improve the city. Therefore, applying this solution is not far from what has been suggested and proposed within this paper with the support of this study. Some related research has already shown the benefits can be achieved from applications of solar panels; how effective solar panels can be and extensive amount of electricity that can be generated from the sun, because of Iran's geographical position and the gaining amount in solar radiation. Therefore, the considerable amount in cost and energy can be saved for the future of the Evaz city in Iran (Mirahmadi, Altan, 2015).

### **5.1- Recommendation for future work**

These kinds of cases are not only sustainable solutions it's also cultural and educational as well. Therefore, perception of the citizens is helpful and considerable in this topic. While the water cisterns are located outside and inside the city both, people are communicating or passing those areas daily, they are very familiar with its processes and also aware of the value of it. In addition it's comprehensible for them to know how much they have to care about it to save the water and the vernacular structure for today's and tomorrow's generation as well. Now days most of the authorities are trying to motivate people to save the water and respect the environment more than before.

They are trying to motivate people by social media programs to keep the city clean specially during rainy days, clean up the pathway which water gets in and from that side will enter to the water cistern. The good news is people has accepted the issue and they do not hesitate to do anything to save the environment and human's life which is connected to the water (figure 47& 48).



Figure 47: local people cleaning the pathway of rain, A.Rahimi, 2016



Figure 48: local people cleaning the pathway of rain, A.Rahimi, 2016

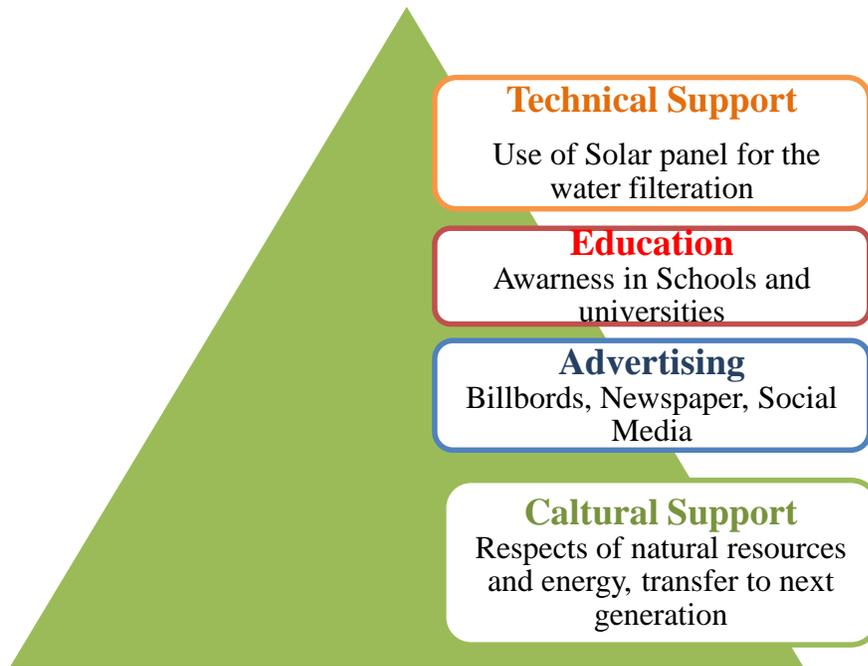


Figure 49: the main four sections for sustainable environment in Evaz city

The recommendations are divided in four categories to save the water and water cisterns. According to the figure no.42 to save water cisterns and water is not an easy task. All of these four sections should work strongly. The weakness in each of these sections may have an impact on the sustainability and durability of the city's water cisterns.

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## Appendix

### Survey Questionnaire

- 1. How much is water cistern important in Evaz?

1.  very important

2.  Important

3.  Not important

4. Other (Please Specify)

- 2. Do you think after 100 years still people will be using water cisterns?

1.  Yes

2.  No

3. Other (Please Specify)

- 3. How is the cleanness of water cistern?

1.  It's always clean

2.  It's never clean

3.  Sometimes it's clean sometimes not

4. Other (Please Specify)

- 4. How the water does get polluted?

1.  By human
2.  By animals
3.  By nature
4.  all of the above
5.  Other (Please Specify)

- 5. Could innovation in water cisterns be effected in using the water cisterns?

1.  Yes it is
2.  No its not
3.  Yes but it's difficult
4.  Other (Please Specify)

- 6. Have you get harm from drinking from the water cistern in Evaz?

1.  Yes , and I'm not drinking it anymore
2.  No, I don't its healthy
3.  Few time , I don't remember
4.  Other (Please Specify)

7. Have you heard before if anyone was harmed from drinking water from the water cisterns in Evaz?

1.  Yes, this is the common thing is this area
2.  No, never heard its safe
3.  Yes, I heard but few times
4.  Other (Please Specify)

8. What do you think about innovation considering water cisterns or adding a part on it, in Evaz?

1.  It will be good idea
2.  I don't think changing in the ancient historical element is good idea
3.  No
4.  Other (Please Specify)

• 9. Continuing of water cistern in this way which is today, how long will remain?

1.  long time
2.  it won't remain

- 3.  it depends on the people how they use them
- 4.  if there is innovation in using it it will remain longer
- 5.  Other (Please Specify)

- 10. How much does it cost to build a water cistern today in the year 2016?

- 1.  No Idea
- 2.  Its costly
- 3.  It's not costly
- 4.  Other (Please Specify)

- 11) Do you think spending for sustainability of the water cisterns will be effective?

- 1.  Yes
- 2.  No
- 3.  Yes, It is Necessary
- 4.  No, it's already destroying doesn't require to spend more
- 5.  Other (Please Specify)

- 12. On which part of the water cistern innovation will be effective?

- 1.  the place which water enters

- 2.  shape
- 3.  water cleanness
- 4.  interior of the water cistern
- 5.  Material of the water cistern
- 6.  all of the above
- 7.  Other (Please Specify)

• **13.** How many percentages of your drinking water is provided from the eater cistern?

- 1.  100%
- 2.  80%
- 3.  50%
- 4.  less than 50%
- 5.  Other (Please Specify)

**14.** Do you have any suggestion for enhanced use of the water cistern in Evaz?

- 1.  No
- 2.  Yes (if yes, please specify in others)
- 3.  Other (Please Specify)