

Under the Patronage of His Excellency **Eng. Abdulrahman bin Abdulmohsen AlFadley**
Minister of Environment, Water & Agriculture

منتدى المياه السعودي
saudi water forum **SWF 2024**

Contributions of Dams to achieving the Sustainable Development Goals For the Water Sector In The Kingdom of Saudi Arabia

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Senior Advisor For MEWA & UNDP



29 April – 01 May 2024



Hilton Riyadh Hotel & Residences
Riyadh, Saudi Arabia

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مساهمات السدود في تحقيق أهداف التنمية المستدامة لقطاع المياه بالمملكة العربية السعودية

د. يسري مطر
مستشار بوكالة المياه وبرنامج الأمم المتحدة الإنمائي



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1-Main Challenges in Water Sector in Arid & Semi-Arid regions

Main Challenges in Water Sectors in Arid and Semi-Arid Regions

- Water scarcity is quite a common phenomenon, not only impacting arid and semi-arid regions, but also affecting the areas receiving heavy rainfalls.
- Arid and semi-arid regions, will face many problems in Water Sector such as:



Rainfall scarcity



Increasing in water demand



Draughts, Desertification



Dropping in groundwater level



Water Pollution



Flash Floods Risks.



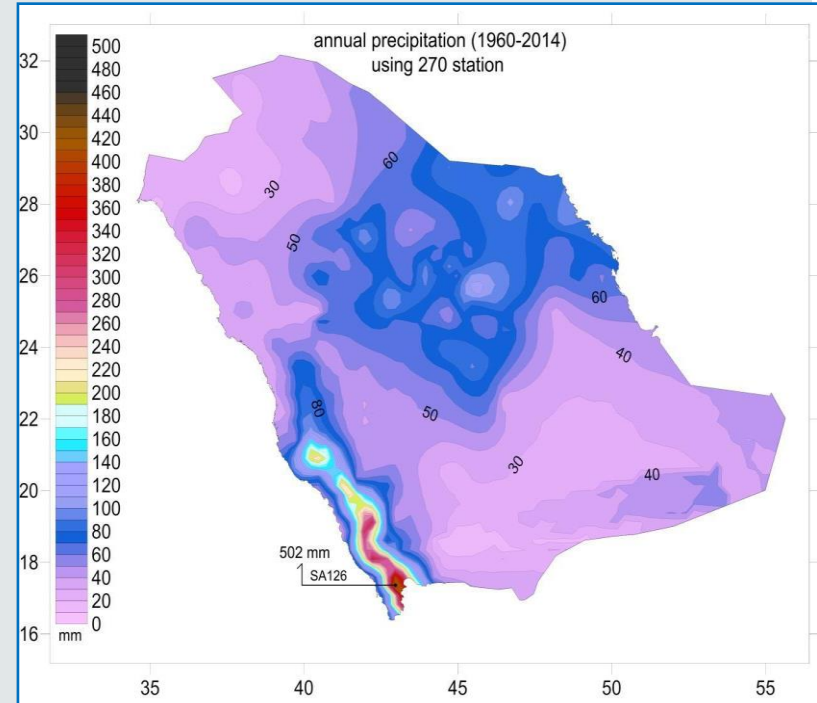
Saltwater Intrusions



Climate change

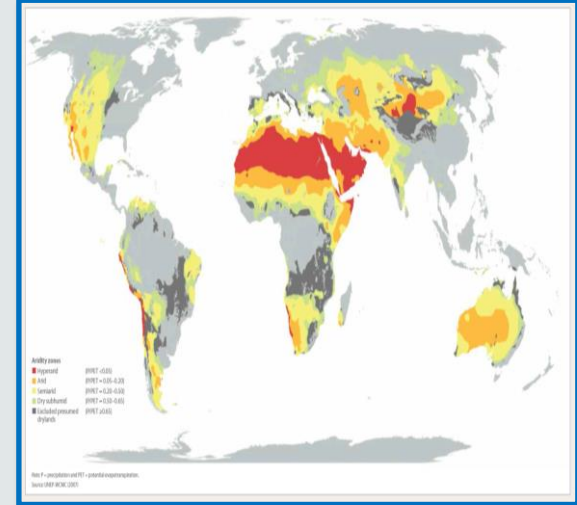
Precipitations & Runoff in Kingdom of Saudi Arabia

- Precipitations in Saudi Arabia varies from as low as 20 mm/year in the Empty Quarter, to 500 mm/year in the mountainous regions in southern Saudi Arabia.
- Annual precipitation depth is estimated as **103 mm**.
- Annual precipitation volume is estimated as **160 BCM** per year across the country.
- Annual Runoff volume is estimated as **8 BCM** per year across the country.
- Approximately 30-40 % of the total Annual Runoff can be harvested in Dam Reservoirs (**2.5-3.5 BCM**).



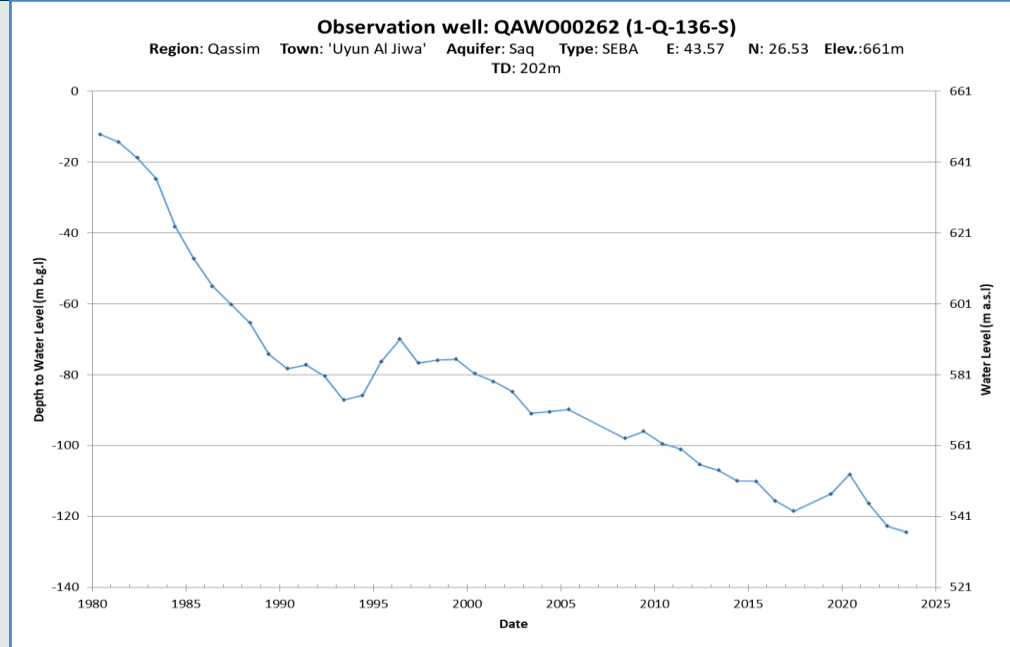
Main Challenges in Water Sector in Saudi Arabia

- ❑ Saudi Arabia has faced main challenges in the water sector due to the rainfall scarcity, high evaporation rates, temporal and sporadic spatial distribution of rainfall, increase withdrawal of groundwater, drop in groundwater level.
- ❑ “Water Poverty Threshold” is less than 1,000 m³/capita/year including drinking water, food, industry, agriculture, and daily use.



Impacts of Climate Change on Groundwater Resources in KSA

- ❑ Groundwater is the major freshwater source especially for arid and semi-arid regions.
- ❑ The relationship between climate change and groundwater recharge is significant.
- ❑ The reliance on groundwater during drought seasons results in overdraft, degradation of groundwater quality.
- ❑ Finally, the Climate changes will affect the Water Resources Management (Water Demand and Water Supply)



increase withdrawal, drop in groundwater level in Saq Aquifer, KSA

2-Sustainability Development Goals



In 2015 United Nations adopted the Sustainable Development Goals (SDGs).

SDGs are a set of 17 goals, and 169 targets that develop such goals.

These goals are part of the 2030 Development Agenda.

These targets should be met before 2030

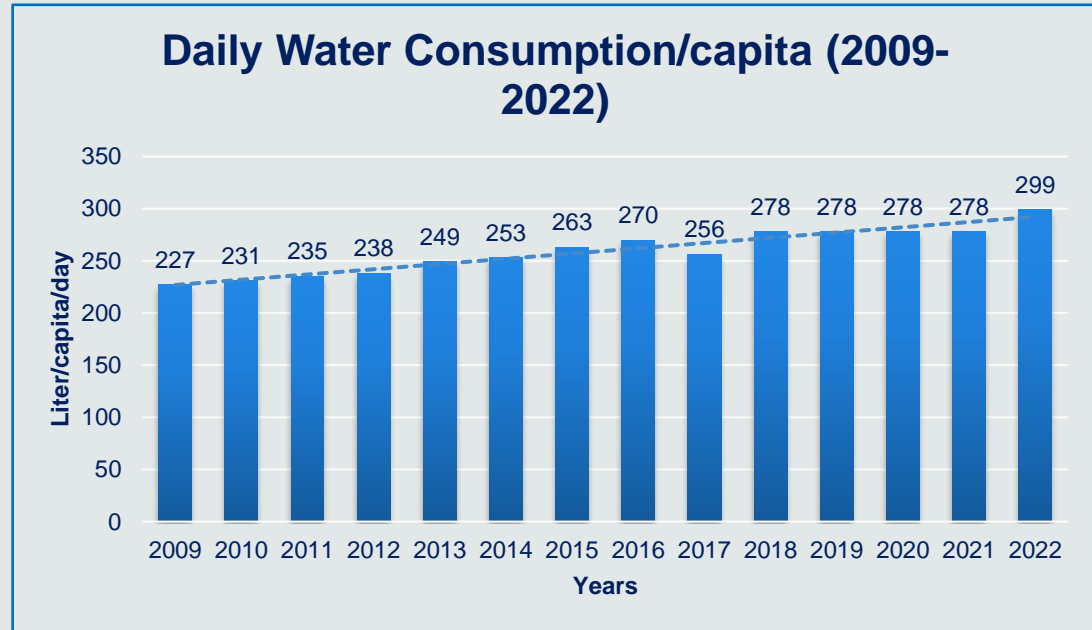


SUSTAINABLE DEVELOPMENT GOALS



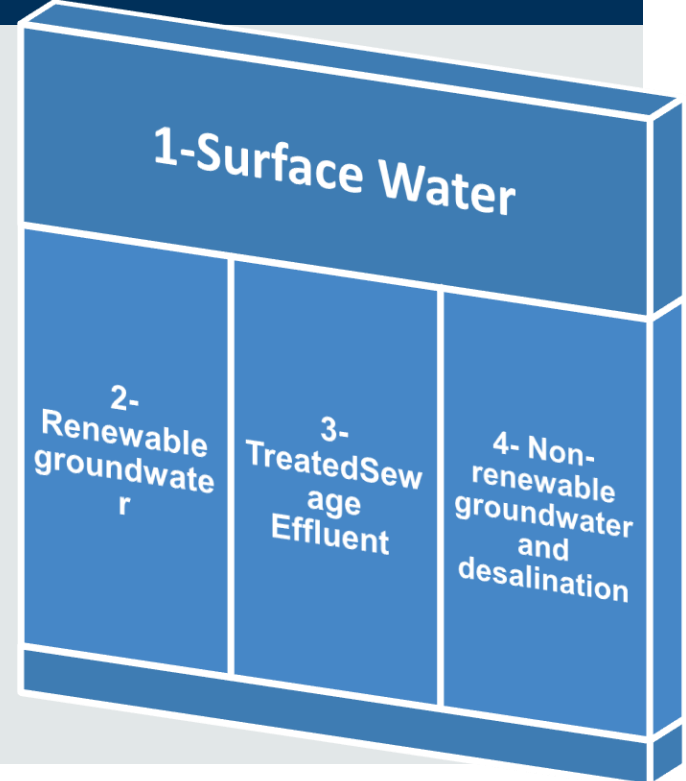
Urban Water Consumption in Saudi Arabia

- The average daily urban water consumption rate (2009-2022) is =248/liter/capita/day
- = The annual per capita 90.5 m³/capita



The National Water Strategy 2030 in Kingdom of Saudi Arabia

- ❑ In 2018 (MEWA) has developed a comprehensive strategy for water, which consists of a vision, strategic goals, and associated programs and initiatives.
- ❑ The strategy's main goal is to achieve 'a sustainable water sector.'
- ❑ **Program 2: Water Resource Management** aims to optimize the use of available water resources.
- ❑ Non-renewable groundwater in Saudi Arabia currently contributes about 80% of the total Water Supply.
- ❑ Renewable groundwater also contributes about 9% of the total Water Supply (2.3 BCM).
- ❑ **Prioritization of water supply** sources should be **based on the least economic** and environmental costs.



3- Dams in The Kingdome of Saudi Arabia

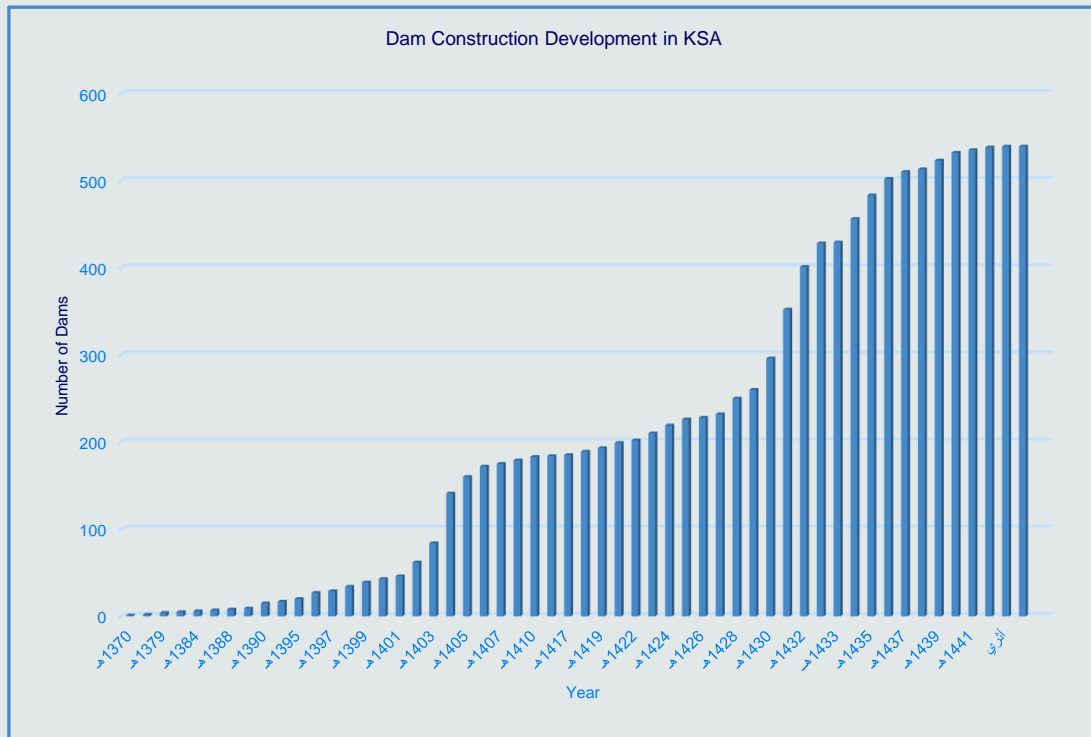
Why The Kingdom of Saudi Arabia needs to Dams??

- Dams are considered a good technique for enhancing the benefits from the rainfall harvesting and surface runoff during rainstorms frequencies, augmenting the groundwater recharge and improve the its quality.
- Storage of water from the rainy season to the dry season, or even from wet years to dry years is highly important in such areas.



Summary of Dams in Kingdom of Saudi Arabia

- The Kingdom of Saudi Arabia has paid a great attention for constructing of dams as early as 1956 and up to date, to maximize the benefit from renewable water, to increase the rates of groundwater recharge in the wadi deposits (Alluvium) and to benefit from them for water supply.
- Now, The total number of dams attains 574 surface and Underground dams having 2.6 BCM total Storage Capacity



Ikrema Dam- Makkah Region



Rock Fill Dam, 250m L, 11 m H, (0.5) M.m³ (1956)

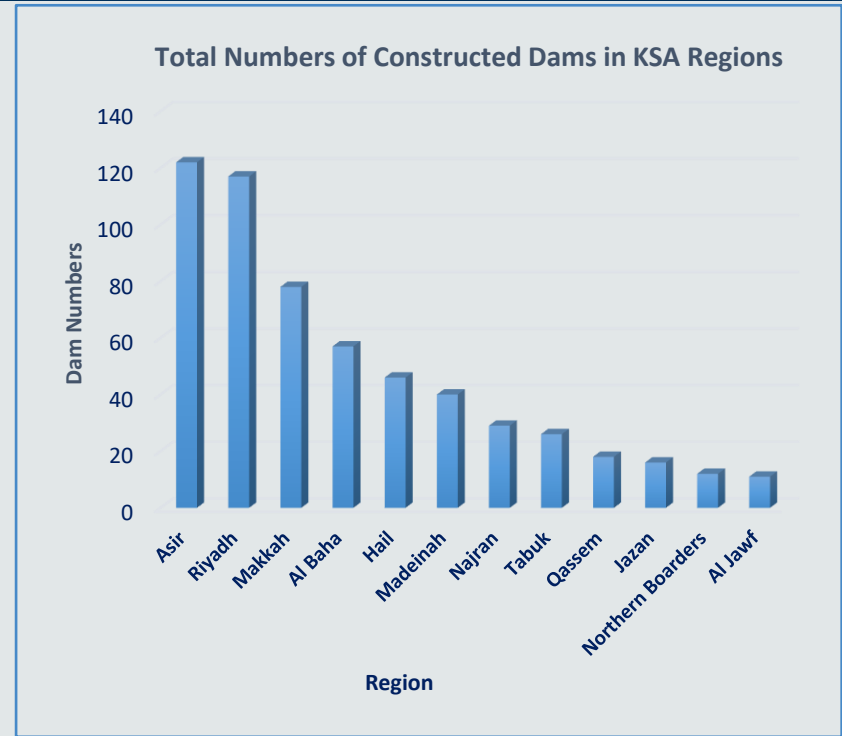
Qanuna Dam Makkah Region



Concrete Gravity Dam, 326m L, 46 m H, (79.2) M.m³ (2018)

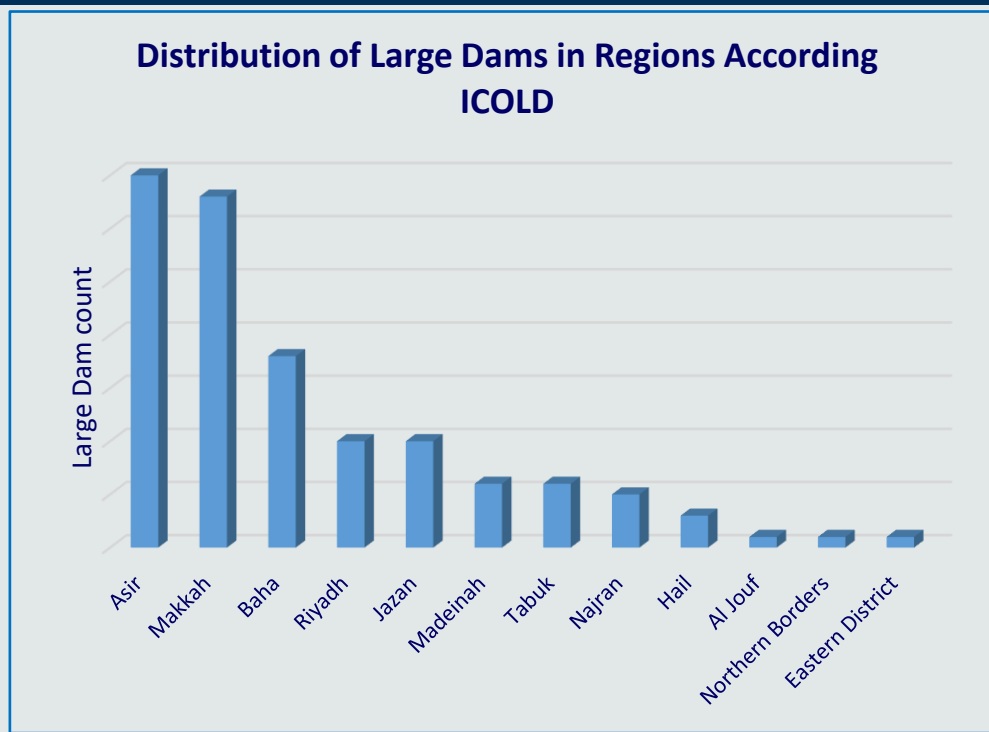
Total Numbers of Dams in KSA

Region	Dam Numbers	Stoarge Capacity M.m3
Asir	122	591.21
Riyadh	117	104.37
Makkah	78	988.67
Al Baha	57	188.76
Hail	46	29.01
Madeinah	40	117.69
Najran	29	107.93
Tabuk	26	29.11
Qassem	18	8.05
Jazan	16	339.34
Northern Borders	12	65.93
Al Jawf	11	15.80
Eastern Borders	2	11.22
Total	574	2597.09



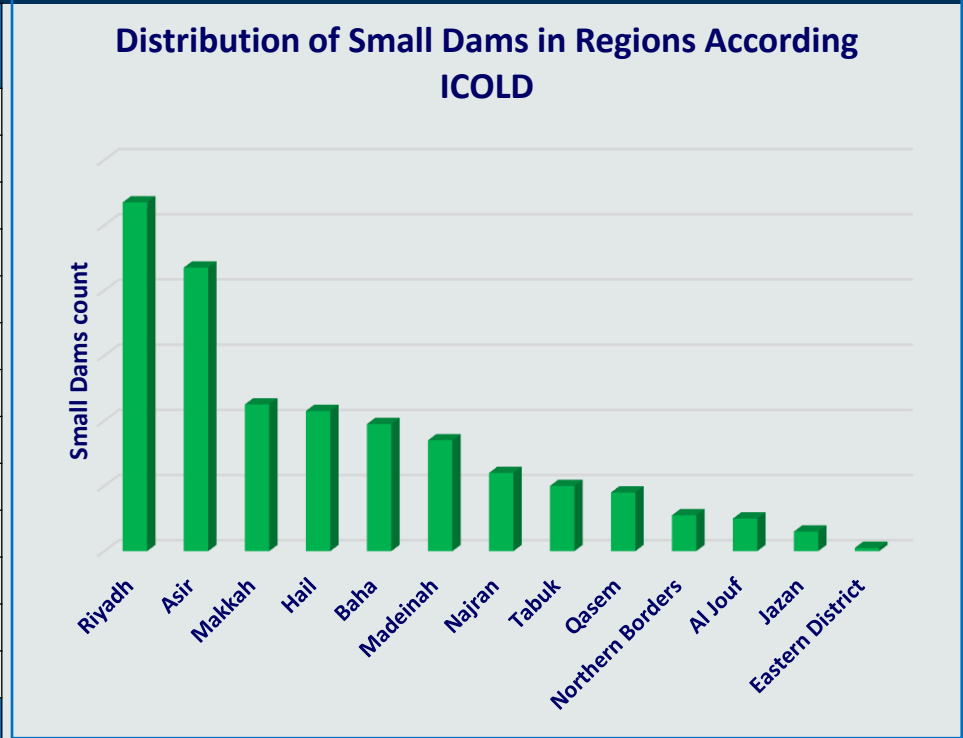
Large Dams In KSA According ICOLD

Region	Count of High Dams According ICOLD	Storage Capacity M.m3
Asir	35	558.6
Makkah	33	971.5
Baha	18	180.3
Riyadh	10	44.9
Jazan	10	338.6
Madeinah	6	75.0
Tabuk	6	12.2
Najran	5	97.6
Hail	3	7.0
Al Jouf	1	1.2
Northern Borders	1	10.4
Eastern District	1	5.5
Total	129	2,302.8



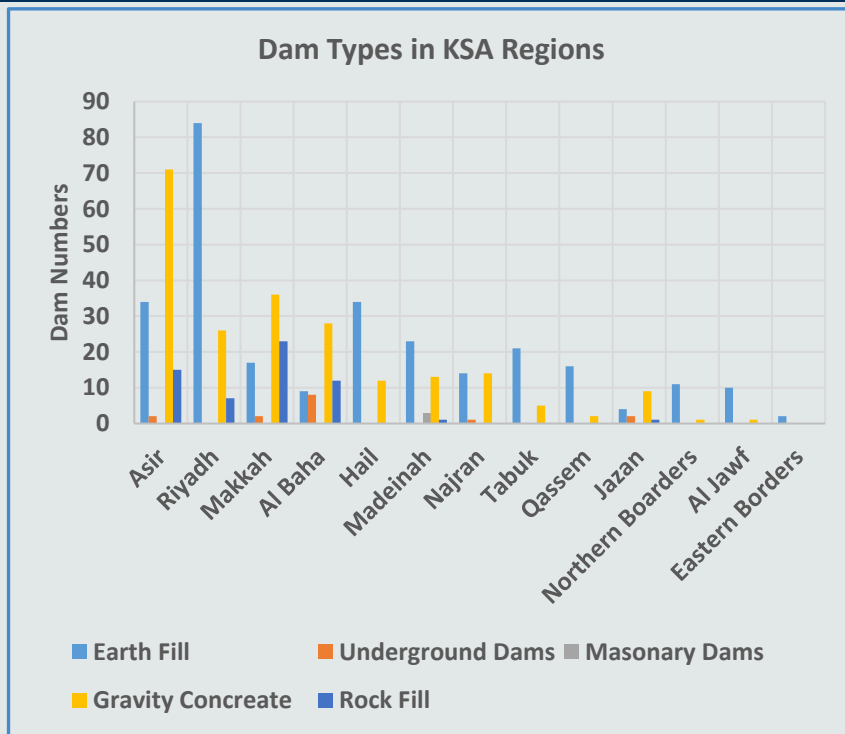
Small Dams In KSA According ICOLD

Region	Small Dams Count	Small Dams Stoarge Capacity (M.m3)
Riyadh	107	59
Asir	87	31
Makkah	45	17
Hail	43	22
Baha	39	8
Madeinah	34	43
Najran	24	10
Tabuk	20	17
Qasem	18	8
Northern Borders	11	56
Al Jouf	10	15
Jazan	6	1
Eastern District	1	6
Total	445	293



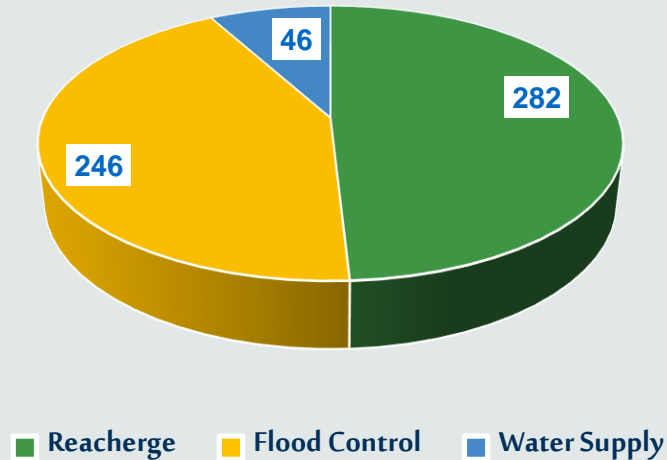
Types Of Dams

Region	Underground Dams	Gravity Concrete	Masonry Dams	Rock Fill	Earth Fill	Total
Asir	2	71		15	34	122
Riyadh		26		7	84	117
Makkah	2	36		23	17	78
Al Baha	8	28		12	9	57
Hail		12			34	46
Madeinah		13	3	1	23	40
Najran	1	14			14	29
Tabuk		5			21	26
Qassem		2			16	18
Jazan	2	9		1	4	16
Northern Borders		1			11	12
Al Jawf		1			10	11
Eastern Borders					2	2
Total	15	218	3	59	279	574

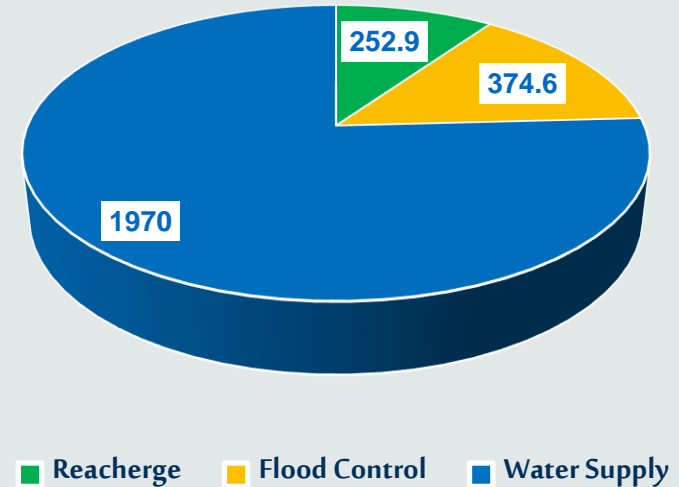


Purposes of Dams In KSA

Total Numbers of Dams According to Dam Purpose

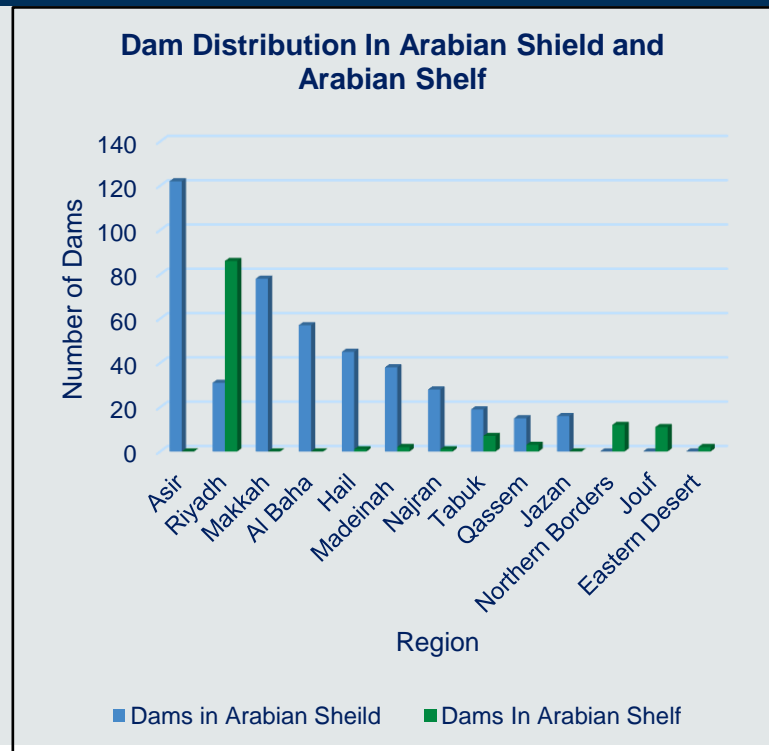


Total Capacity of Constructed Dams According to Dam Purpose (MCM)



Distribution Of In In Arabian Shield and Arabian Shelf In KSA

Dam Distribution In Saudi Arabia			
Region	Dams in Arabian Shield	Dams In Arabian Shelf	Total
Asir	122	0	122
Riyadh	31	86	117
Makkah	78	0	78
Al Baha	57	0	57
Hail	45	1	46
Madeinah	38	2	40
Najran	28	1	29
Tabuk	19	7	26
Qassem	15	3	18
Jazan	16	0	16
Northern Borders	0	12	12
Jouf	0	11	11
Eastern Desert	0	2	2
Total	449	125	574



King Fahd Dam- in Asir Region- The Largest Dam in KSA

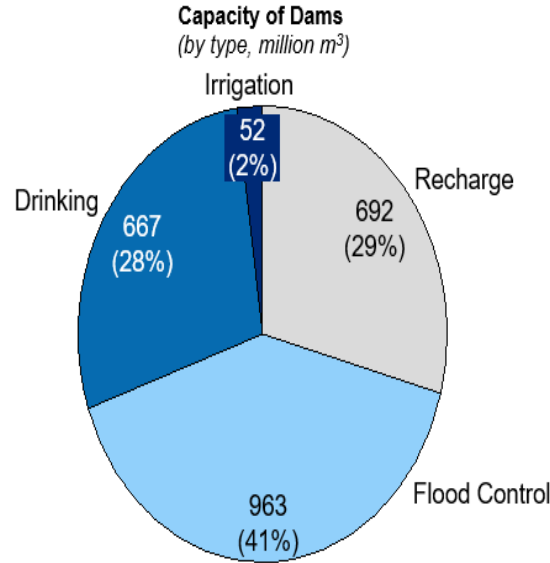


King Fahd Dam, Concrete Gravity Dam, 507m L, 68 m H, (325) M.m³ (1997)

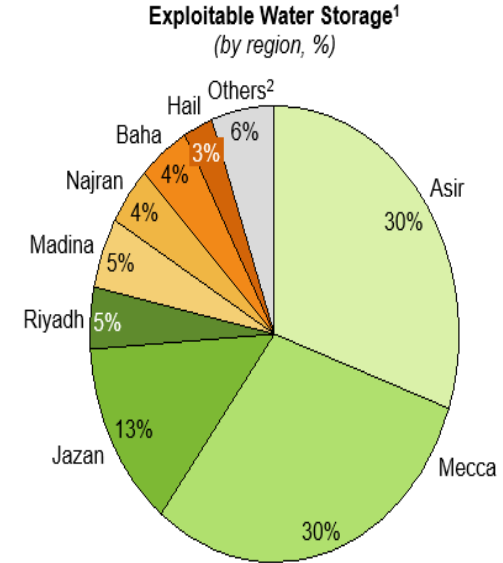
4- Annual Harvested Runoff in Dam Reservoirs

Total Runoff Harvested in Dam Reservoirs

- ❑ Total storage Capacity of dams stands at **2.6 BCM/year**.
- ❑ Total exploitable water reserves from dams stands at around **1.6 BCM/year**.
- ❑ Estimated at **67%** of dam storage capacity.



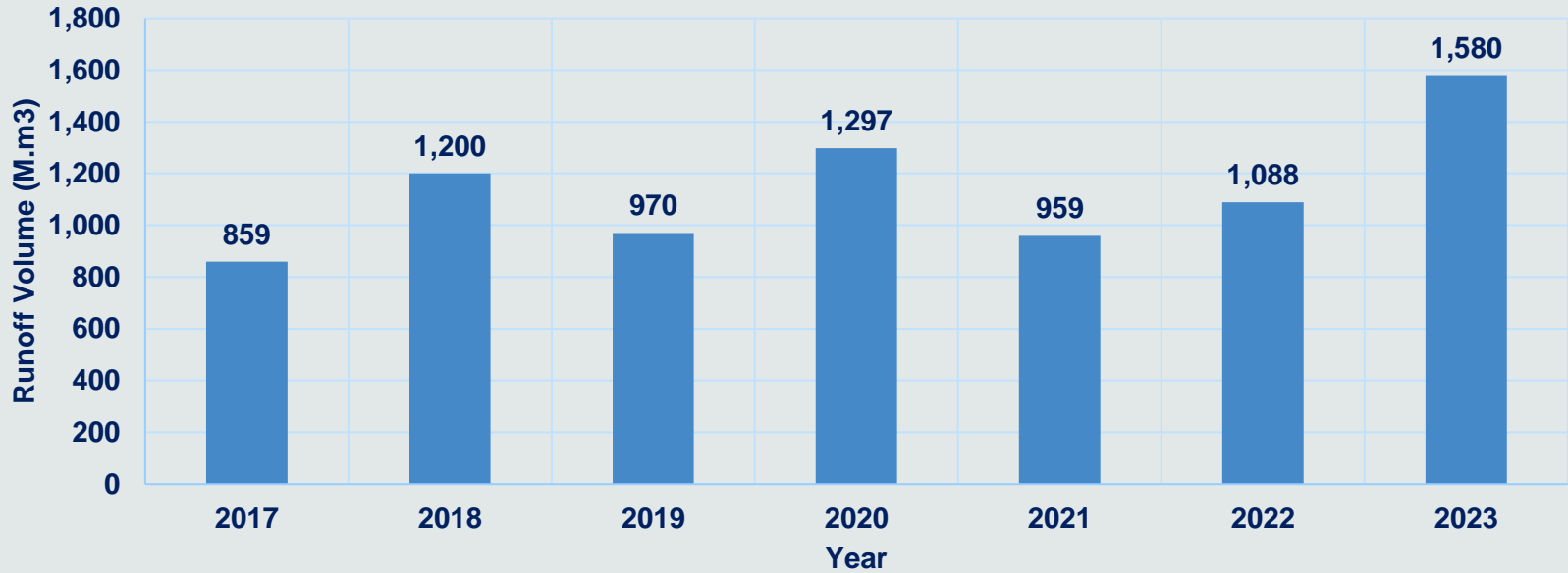
Total: 2.3 Bn m³ (502 dams)



Total: ~1.6 Bn m³ /year

Total Runoff Harvested in Dam Reservoirs From 2017-2023

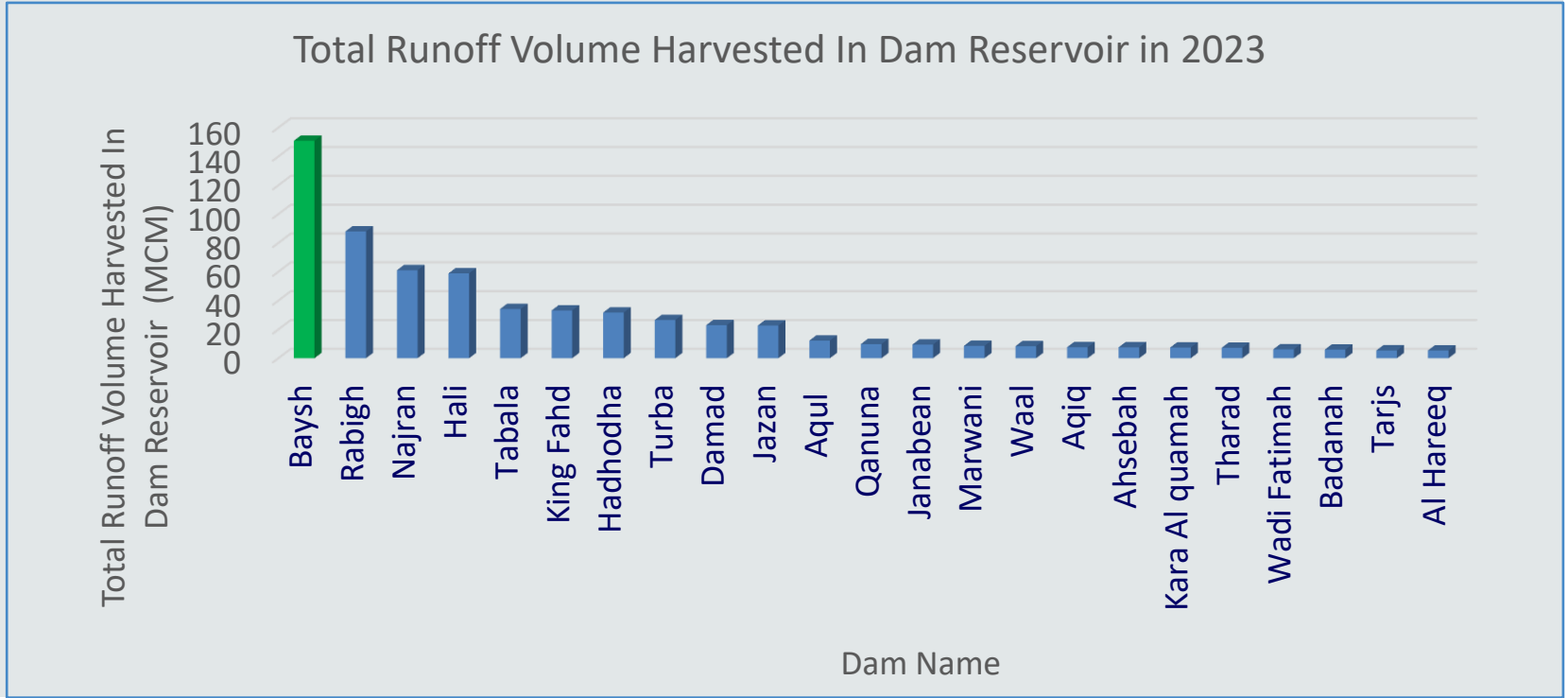
Average Annual Harvested Water Volume In Dams Reservoir From 2017-2023
(million m3)



Total Runoff Harvested in Dam Reservoirs 2023

Dam Name	Total Ruoff Harvested In Dam Reservoir in 2023 _MCM	Dam Name	Total Ruoff Harvested In Dam Reservoir in 2023 _MCM
Baysh	150.89	Janabean	9.47
Rabigh	87.94	Marwani	8.59
Najran	61.05	Waal	8.37
Hali	58.86	Aqiq	7.60
Tabala	34.12	Ahsebah	7.57
King Fahd	33.12	Kara Al quamah	7.40
Hadhodha	31.68	Tharad	7.24
Turba	26.46	Wadi Fatimah	6.14
Damad	22.93	Badanah	5.97
Jazan	22.67	Tarjs	5.38
Aqul	12.21	Al Hareeq	5.35

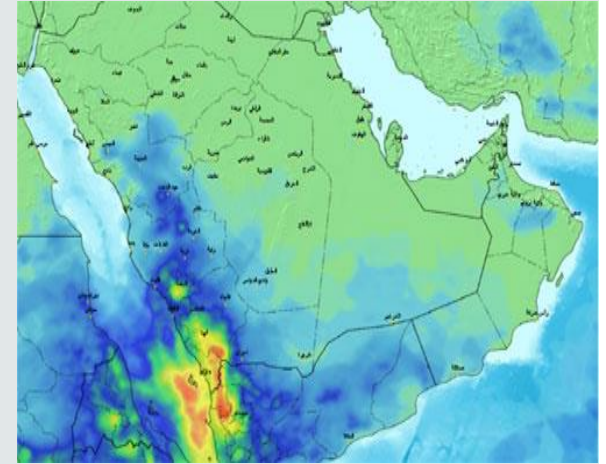
Total Runoff Harvested in Dam Reservoirs



5- Harvested Runoff in Dam Reservoirs During Weather Events

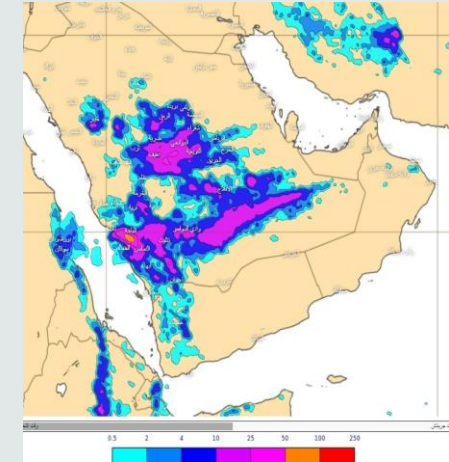
Total Runoff Harvested in Dam Reservoirs During Weather Events March _April 204

Correlation Item	Rahw 2020	Madar22	Spring Weather Event April 2024
Date started	24/7/2020	23/7/2022	27/3/2024
Date completed	10/8/2020	21/8/2022	5/4/2024
Duration (days)	18	30	10
Number of Affected Regions with the event	8	13	8
Number of dams received runoff during the event	165	189	161
Total Runoff volume received in Dam reservoirs during the event	370	294	243



Total Runoff Harvested in Dam Reservoirs During Weather Events March _April 2024

- ❑ From March 27, 2024, until Friday, April 5, 2024.
- ❑ Most of Kingdom regions have been affected with a spring Weather Events for ten continuous days.
- ❑ Heavy rains caused runoff flowed in many wadies dam reservoirs were harvested (**243 million m3**).
- ❑ The total volume of water reserve behind the dam attained (**829 million m3**),
- ❑ This is the highest volume of water reserve in dam reservoirs since the beginning measurement in 2010.

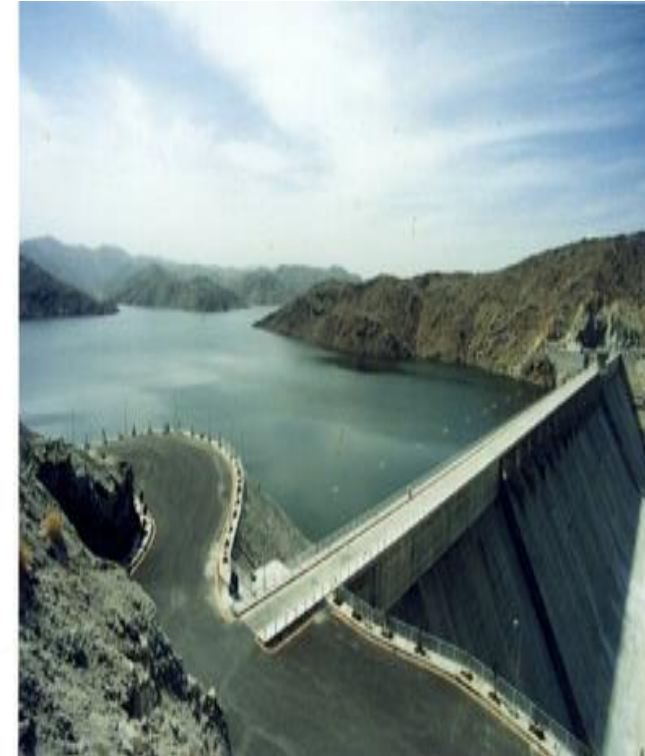
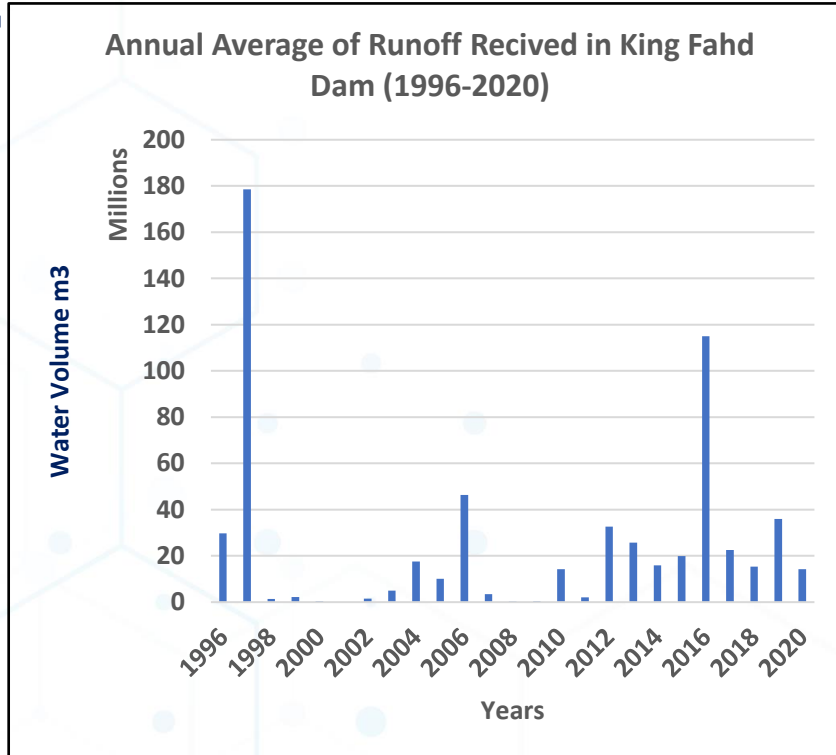


6- Water Budgets of Some dams



Water Budget: King Fahd Dam; Asir Region

Storage Capacity: 325 Mcm
Catchment Area: 7233 km²
Annual Rainfall: 160mm
Annual Runoff: 27 Mcm
Annual Evap.: 15.0 Mm³
Annual Se.: 0.500 Mm³
Released Water: 40 Mm³

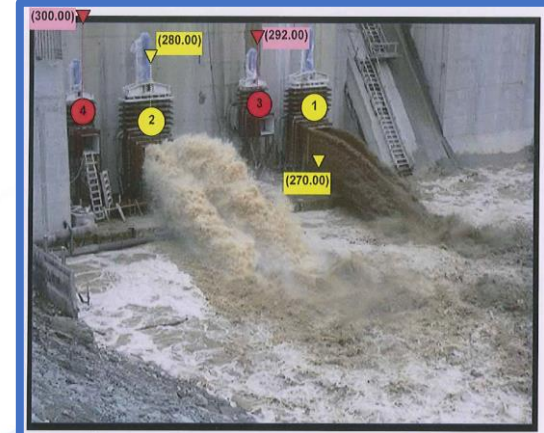
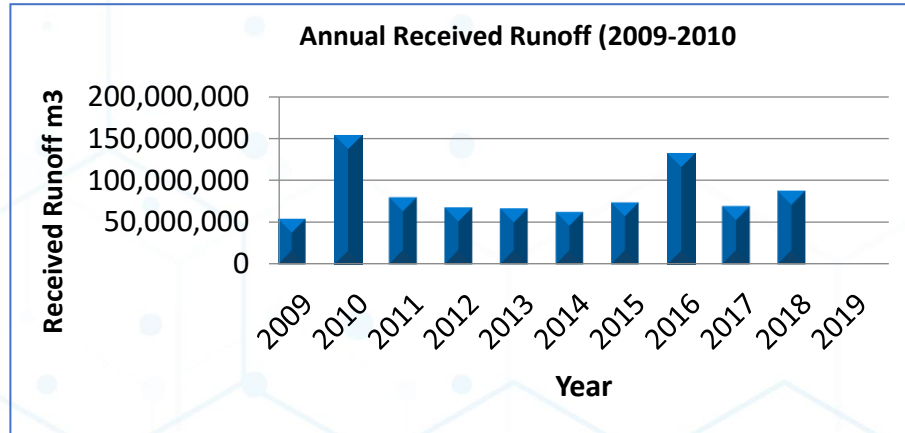
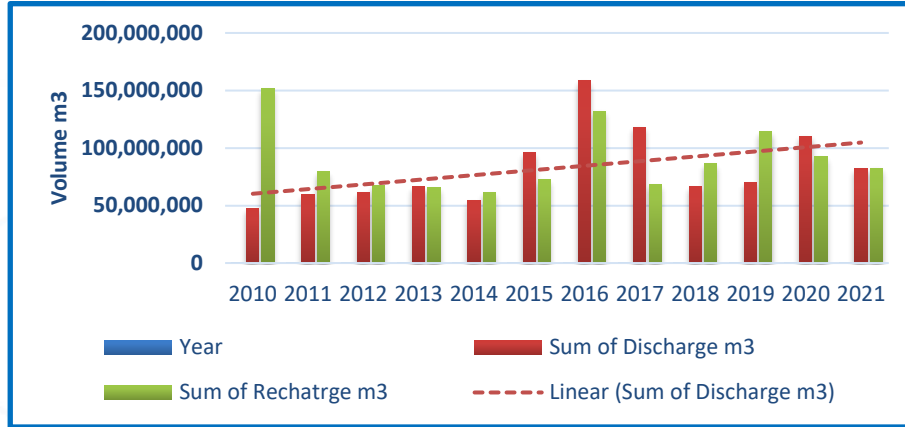


King Fahd Dam



Baysh dam; Jazan Region

Storage Capacity:
193.4 Mcm
Catchment Area: 4750
km²
Annual Precip:
360mm
Annual Runoff: 87
Mcm
Annual Evap.:15 Mm³
Annual Sed.:
500,000m³
Daily Safe Yield:
200,000 m³

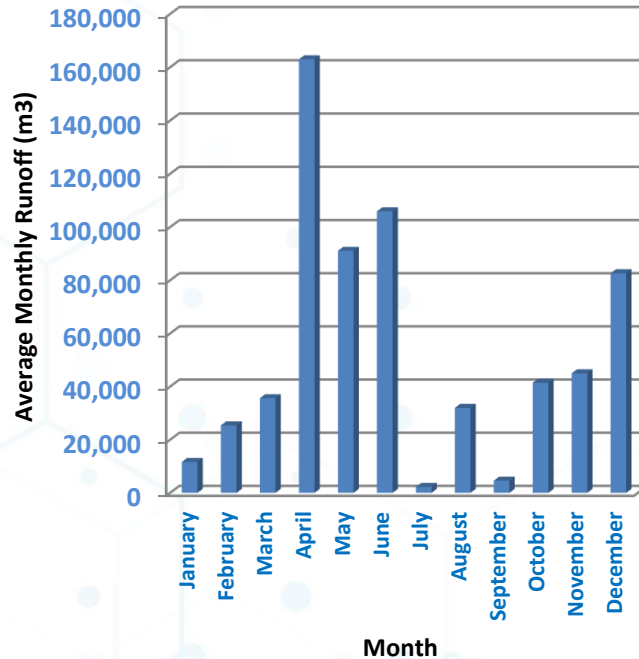




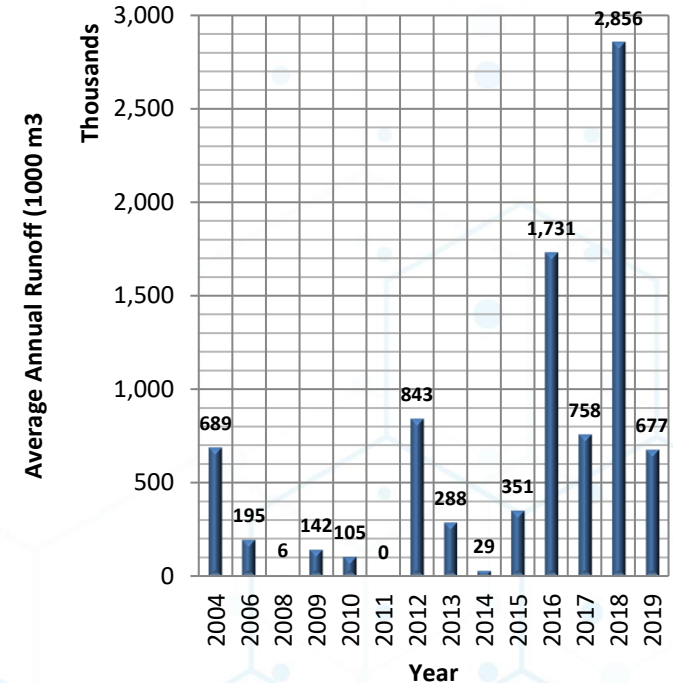
Water Budget: Abha Dam; Asir Region

Storage Capacity: 2.13 mcm
Catchment Area: 54 km²
Annual Precip: 190mm
Annual Runoff: 0.9 mcm
Annual Evap.: 250,000 m³
Annual Sed.: 15,000m³
Daily Safe Yield: 11,000 m³

Average Monthly Runoff In Abha Dam (2004-2019)



Total Annual Runoff in Abha dam (2004-2019)





Releasing Water From Hali Dam; Makkah Region

The positive impact of water releasing from Dam:

- 1- **Increasing** groundwater levels in farmers wells along Wadi average of **(7.5 m)**.
2. Water flowing in Wadi Hali along more than **20 km** downstream dam.
3. Improving **groundwater** quality in wells, as the average **groundwater quality** in wells reached (820 ppm).
4. **saturation** of alluvial deposits.



Storage Capacity: 254 Mcm
Catchment Area: 4890 km²
Annual Precip: 280mm
Annual Runoff: 60 Mcm
Annual Evap.:18 Mm³
Annual Sed.: 500,000m³
Daily Safe Yield: 100,000 m³



7- Contribution of Dams In Drinking Water Supply

System of Drinking Water Supply From Dams

Surface Dams
Underground Dams
Well Fields
Treatment Plants on Dams



Summary of Daily Yield From Well Field Behind the Constructed Underground Dams

Region	Total Constructed and Under construction Water Supply Surface Dams	Design Capacities of Constructed and Under construction Water Supply Dams m3	Total Constructed and Under construction Water Supply Dams Underground Dams	Total Constructed and Under construction Water Supply Surface and Underground Dams	Design Capacities of Constructed and Under construction Water Supply Underground Dams m3	Design Capacities of Constructed and Under construction Water Supply Surface and Underground Dams m3
Baha	7	131,634,202	8	15	44,600,000	176,234,202
Makkah	6	825,150,000	2	8	29,800,000	854,950,000
Asir	13	518,830,100	2	15	9,000,000	526,830,100
Jazan	3	303,344,000	2	5	14,200,000	317,544,000
Najran	1	86,000,000	1	2	7,000,000	93,000,000
Total	30	1,864,958,302	15	45	104,600,000	1,969,558,302

Summary of Daily Yield From Treatment Plants On Dams

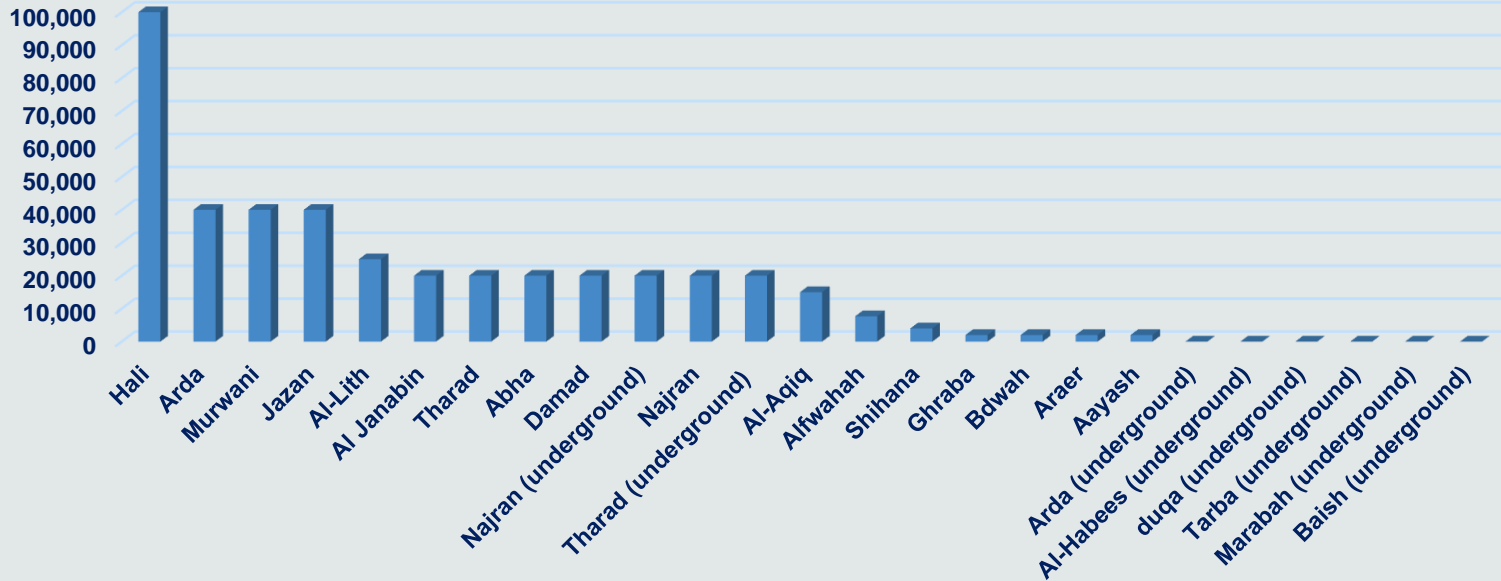
- ❑ There are **353 water treatment plants** built on dams and groundwater wells, with a total production capacity of **2.07 million.m3 /day**.
- ❑ There are **27 water treatment** plants built on dams in Makka, Baha, Asir, Jazan, Najran
- ❑ Total Design capacity of the 27 Treatment Plants on Dams **(583,500 m3/day)**
- ❑ Total Daily Actual Yield of the Treatment Plants on Dams **(294,102 m3/day)**
- ❑ There are **10 Groundwater Fields** Downstream Dams **(having 202 Well.)**
- ❑ Daily Yield From the Groundwater Fields Downstream Dams is **(136 000 m3/day)**.
- ❑ Daily Actual Yield From the Water treatment Plants and Groundwater Fields **(719,500 m3/day)**.
- ❑ Annual Actual Yield From the Water treatment Plants and Groundwater Fields **(262,616 million m3/year).=**

Summary of Daily Yield From Well Field Behind the Constructed Underground Dams

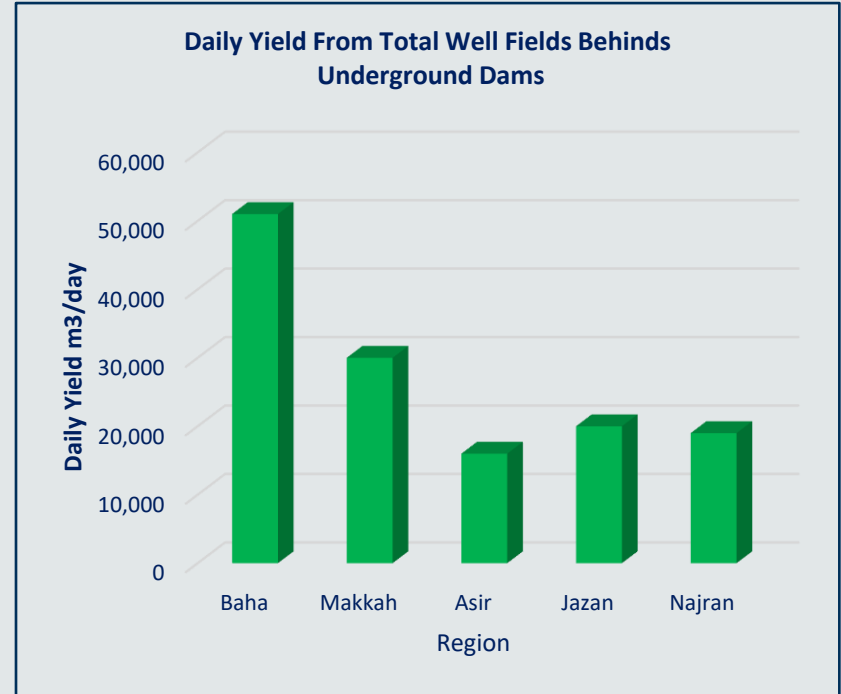
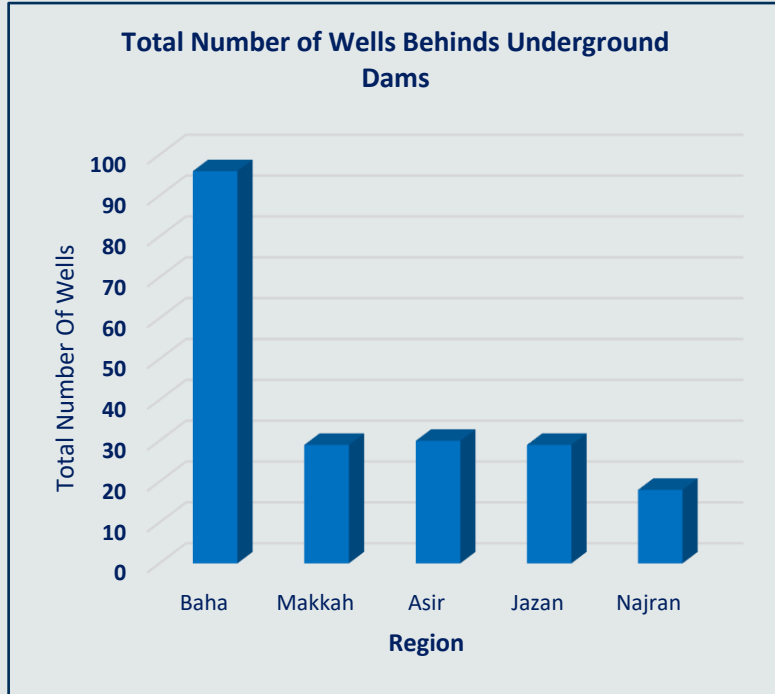
Region	Total Constructed and Underconstruction on Water Treatment Plants	Daily Yield from Total Constructed and Under construction Water Treatment Plants m3/day	Total Groundwater Fields	Total Number of Wells in Groundwater Fields	Daily Yield From Total Groundwater Fields m3/day	Daily Actual Yield From Water treatment Plants and Groundwater Fields m3/day
Baha	6	62,000	4	96	51,000	113,000
Makkah	6	194,000	2	29	30,000	224,000
Asir	11	157,500	1	30	16,000	173,500
Jazan	4	170,000	2	29	20,000	190,000
Najran	0	0	1	18	19,000	19,000
Total	27	583,500	10	202	136,000	719,500

Design capacity of The Treatment Plants on Dams in Saudi Arabia (m3/day)

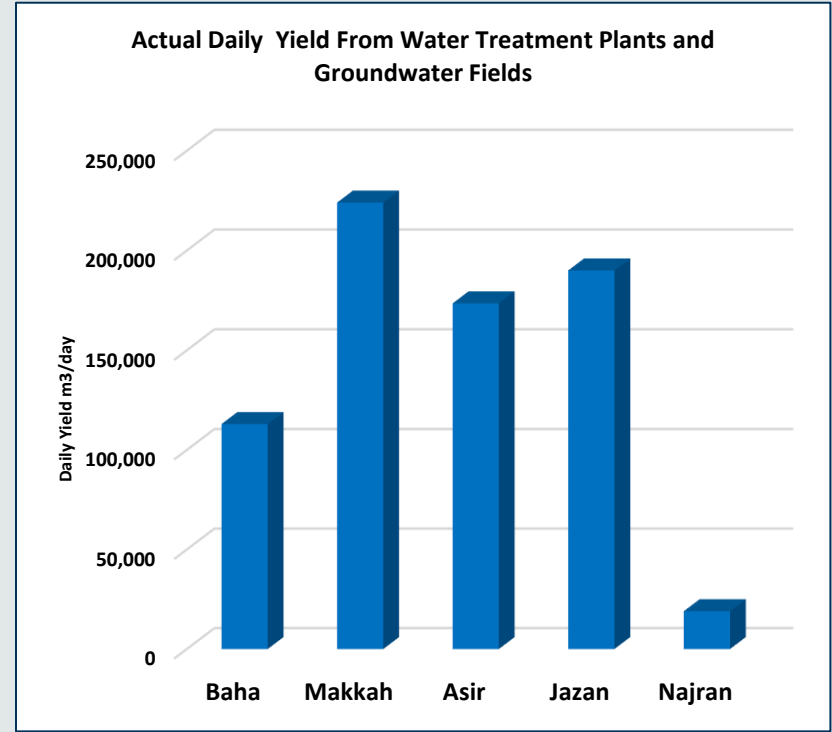
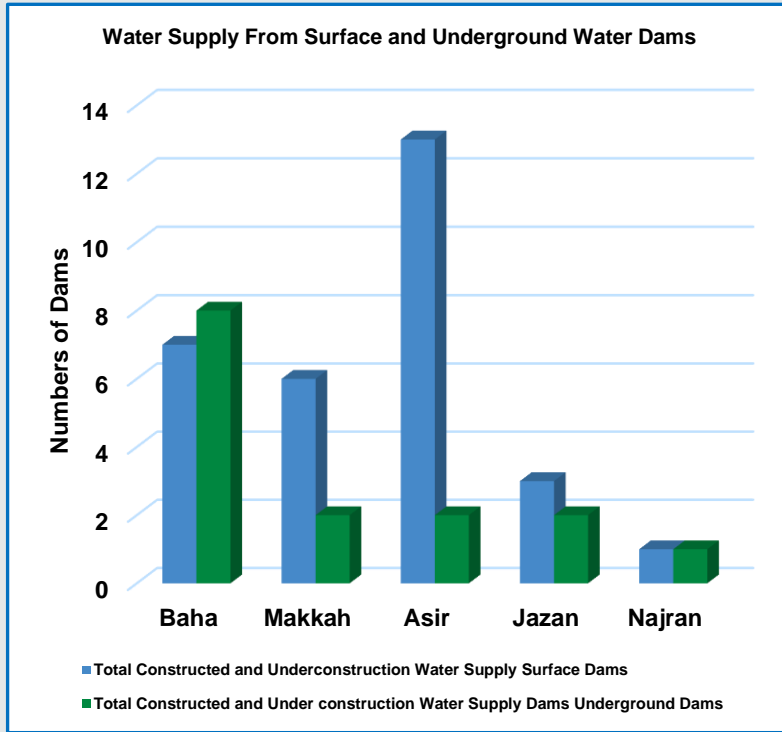
Design capacity of the Treatment Plants on Dams (in m3/day)



Summary of Daily Yield From Well Field Behind the Constructed Underground Dams

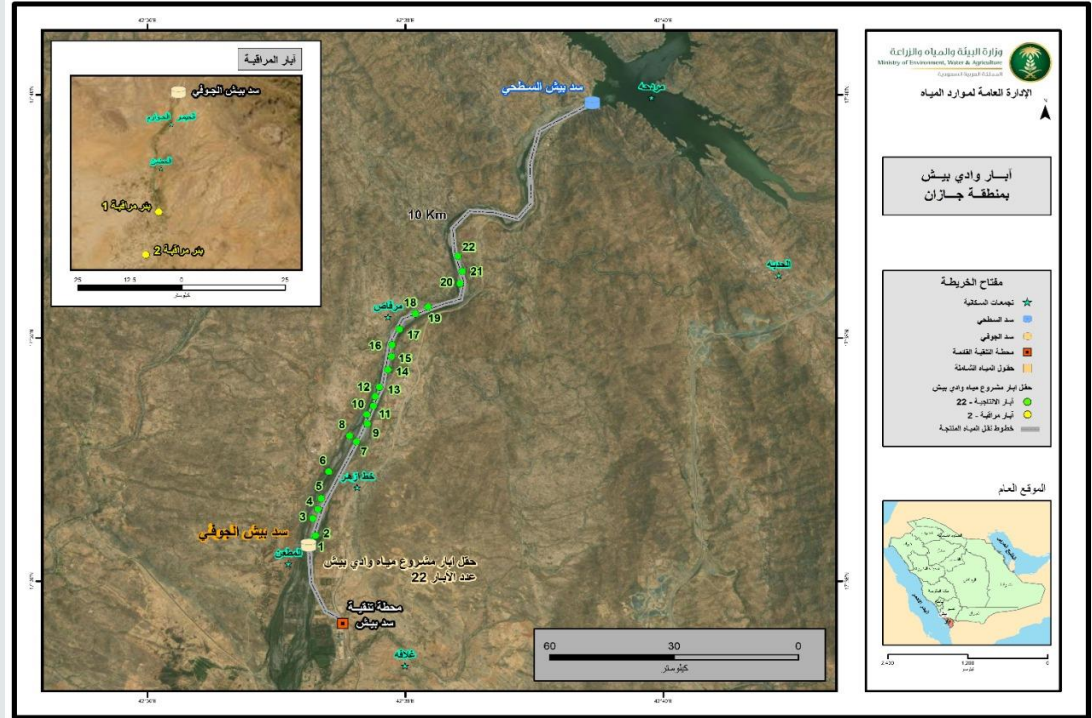


Summary of Daily Yield From Well Field Behind the Constructed Underground Dams



Water Supply Project in Wadi Jazan- Jazan Region

- (1) Surface Dams
- (1) Underground Dam
- (22) Productive Water Wells
- (13) Observation Well
- (1) Treatment Plant



Water Supply (surface/underground) dams System-Well Field

- Turba underground dam,
- (21.8) M.m3 Storage capacity
- From (18) Wells.
- Water Supply System in W.

Turbah Consists of:

Productive Wells : (18)

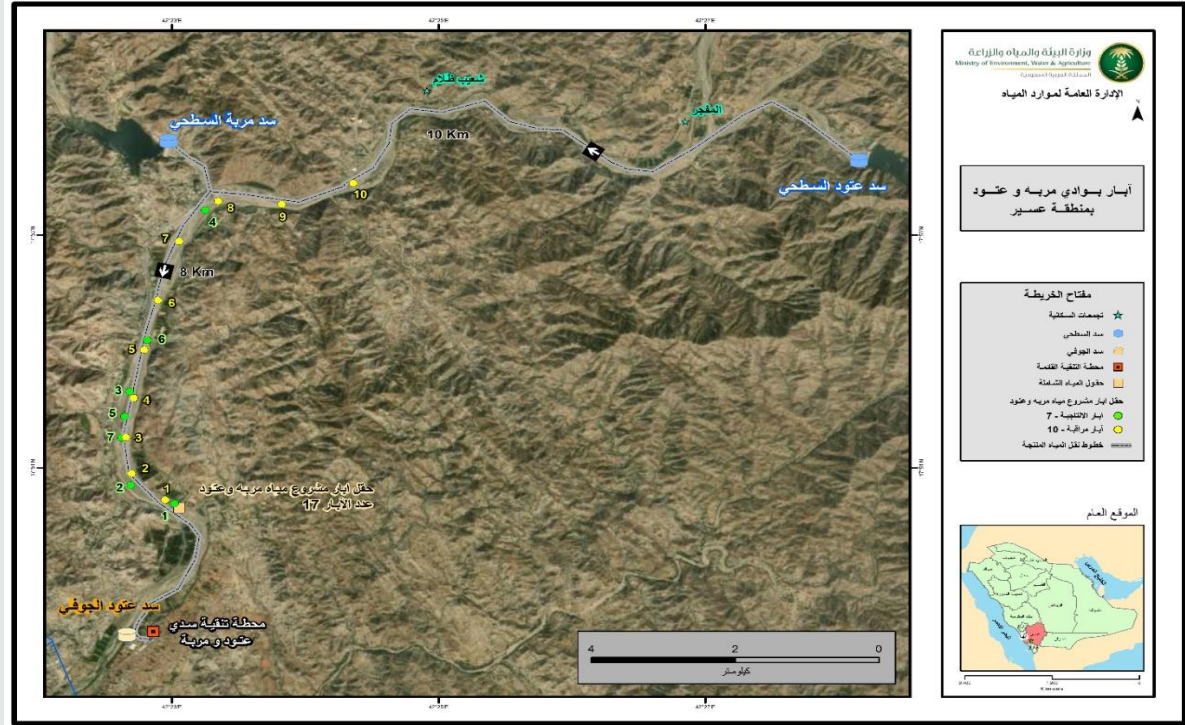
Treatment Plant: (1)

Daily Yield: (5, 000) m3 / day



Water Supply Project in Wadi Itwed- Wadi Maraba- Asir dams

- (2) Surface Dams
- (1) Underground Dam
- (7) Productive Water Well
- (10) Observation Well
- (1) Treatment Plant



Plan For Water Supply From Dams in Emergency State

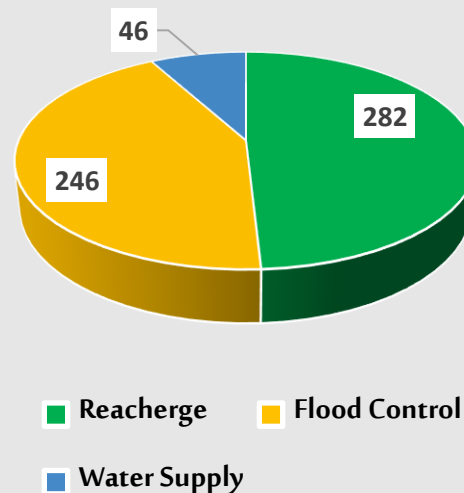
- ❑ MEWA has prepared a plan to provide additional water sources from some dams In the southwestern region in emergency state as follows:
- ❑ Benefiting from (51) dams haven't drinking water projects, in Makkah (7) dams - Asir (34). Al-Baha Dam (10) dams, to provide (35,000 m³/day) for (3) months.
- ❑ Accelerating the benefit of the under-construction treatment plants (10) projects in Makkah, Asir and Jazan with a total production capacity of (382,000) m³/day.
- ❑ Accelerating the benefits of the (414) wells recently drilled with a total daily production of (80,000 m³/day),

8- Contribution of Dams In Agriculture Development

Contribution of Dams In Agricultural Development

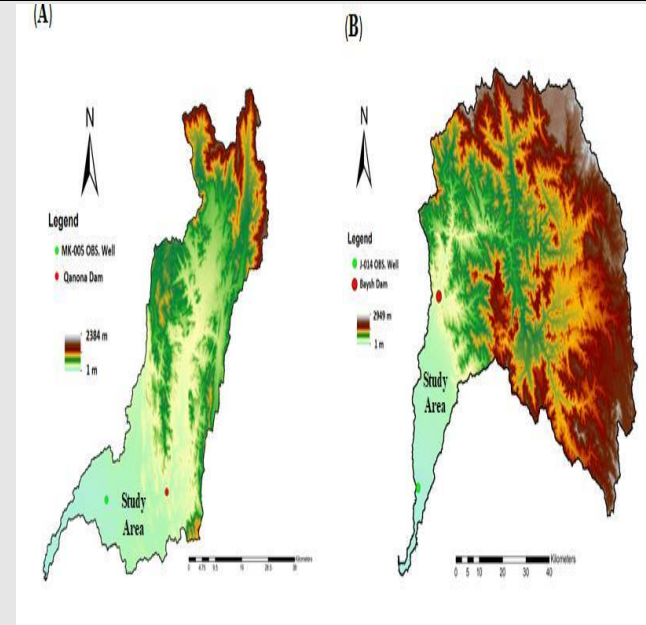
- ❑ Dams contribute effectively to achieving agricultural development goals in KSA
- ❑ Dams contribute to enhancing groundwater recharge to groundwater reservoirs in valley sediments in the Arabian Shield
- ❑ There are (282) dams having (252.9) mcm for Ground Water Recharge.
- ❑ Dam releasing will contribute to the development of vegetation cover and in accordance with the agricultural seasons in the dam region
- ❑ Dams act as an adaptive measure to mitigate the effects of climate change, drought cycles and soil degradation

Total Numbers of Dams
According to Dam Purpose



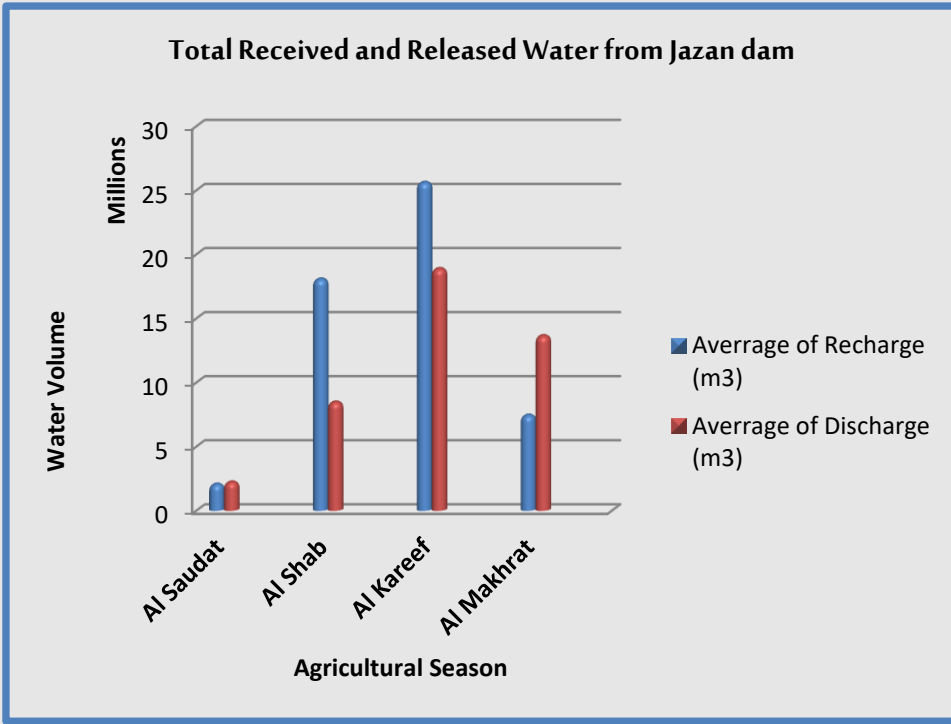
Optimizing Dam Operation in KSA: Qanuna and Baysh dams Case study

- ❑ *Identifying the optimal months for dam water release downstream to mitigate the drought impacts.*
- ❑ *Using Ground-based data and satellite-based information on precipitation, temperature, soil moisture, and humidity.*
- ❑ *Comparing monthly averages with annual averages, highlighting potential drought and groundwater recharge months.*
- ❑ *Results indicate that August is the wettest month, with June and July having the highest temperatures.*
- ❑ *Relative humidity is lowest in July, and soil moisture hits its lowest in May.*
- ❑ *Groundwater levels drop significantly in June for Qanona and July for Baysh.*
- ❑ *The study identifies June and July as optimal months for dam water release to mitigate downstream drought for Qanona and Baysh dams*



A: Catchment Area Qanona Dam
B: Catchment Area Baysh dam

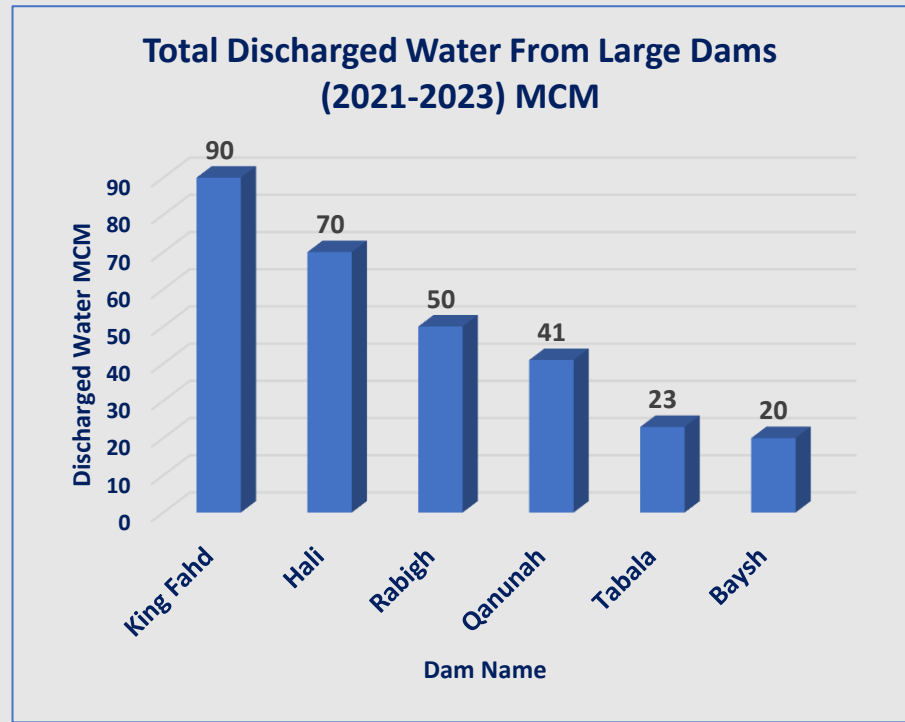
Irrigation Canals; Jazan Dams



Irrigation Canals; Jazan Dam

Total Released Water From Large Dams (2021-2023)

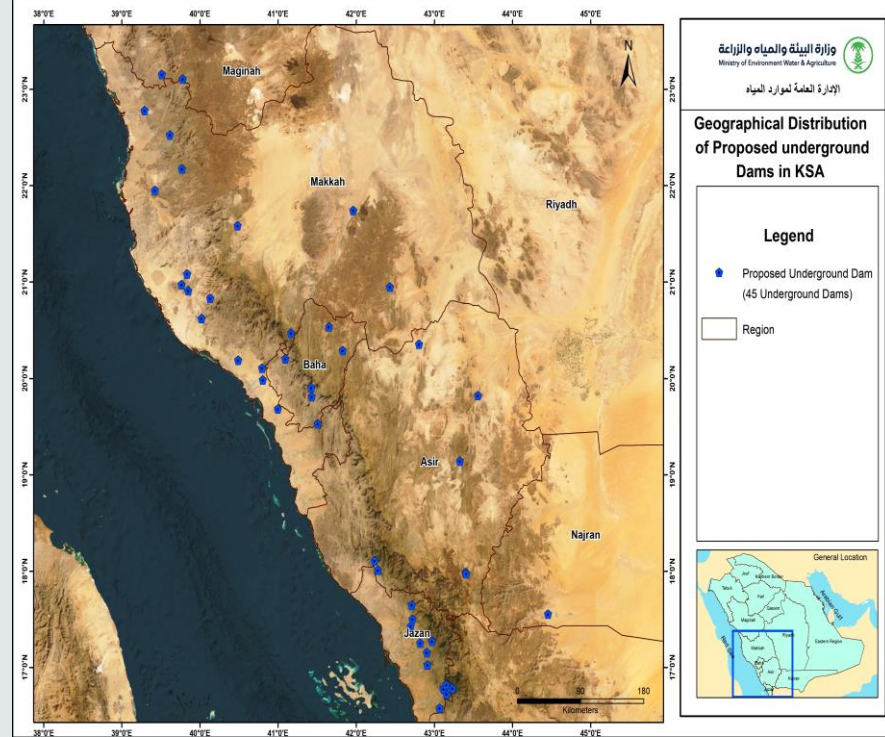
Region	Dam Name	Total Discharged Water MCM
Asir	King Fahd	90
Makkah	Hali	70
Makkah	Rabigh	50
Makkah	Qanunah	41
Asir	Tabala	23
Jazan	Baysh	20
Jazan	Jazan	10
Total		304



9- Future Dams in KSA

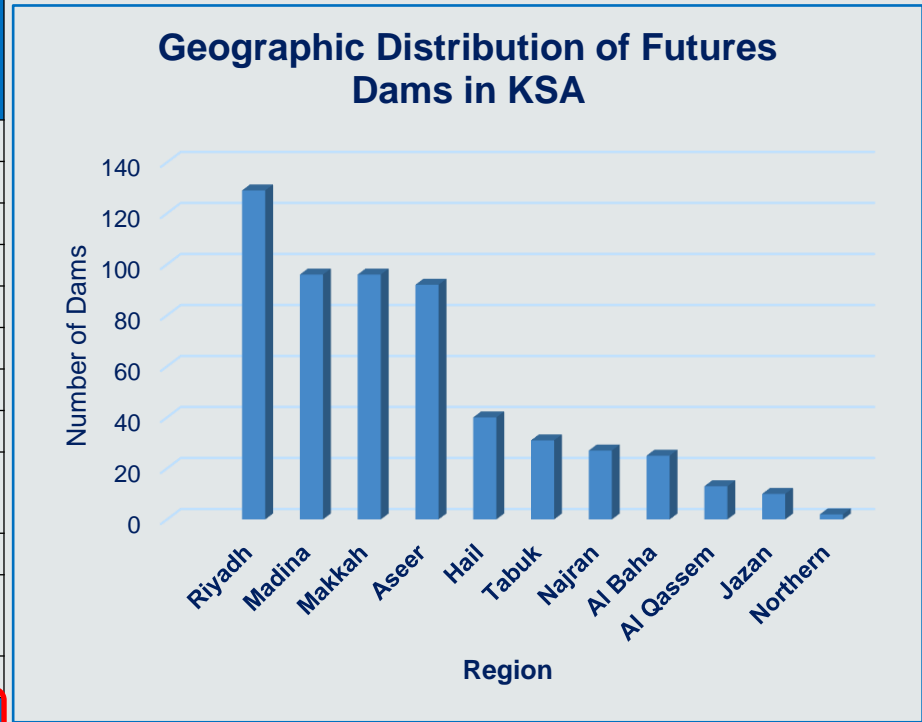
Future Dams in KSA

- MEWA already has conceptual Design for new 562 Dams.
- Also, 400 sites of dams have been studied within the project of “1000 dams”.
- 1000 dams having total storage capacities (1.450) B.m³
- The new proposed dams will contribute to enhancing the water resources sustainable development and groundwater recharge



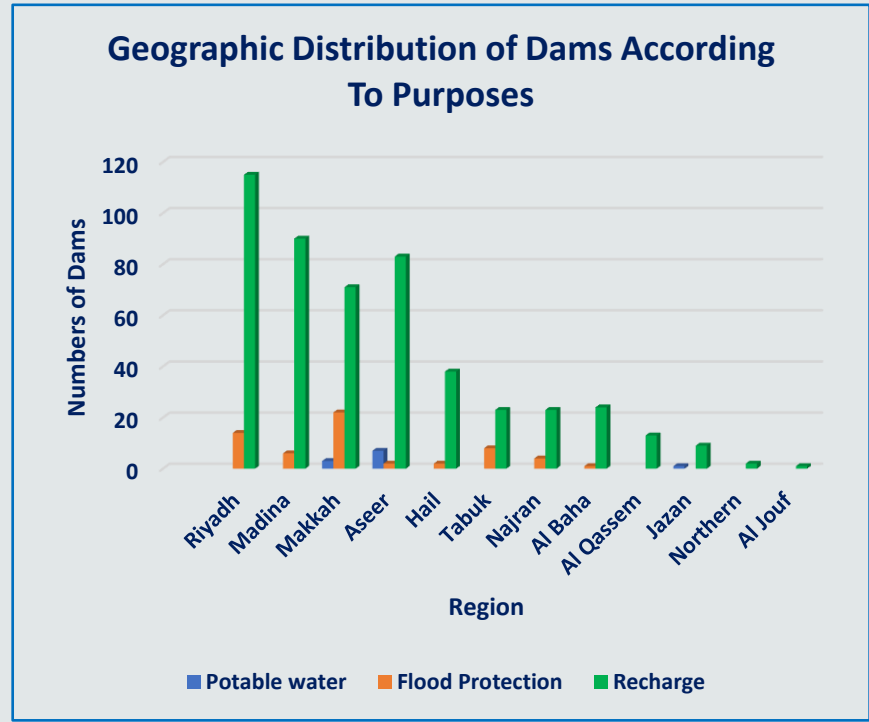
Future Dams in Kingdom of Saudi Arabia

Region	Dam Type				Total
	Concrete	Earthfill	Rockfill	Underground	
Riyadh	11	98	20		129
Madina	21	45	30		96
Makkah	40	13	35	8	96
Aseer	38	19	20	15	92
Hail	4	32	4		40
Tabuk	6	12	13		31
Najran	14	5	7	1	27
Al Baha	9	1	9	6	25
Al Qassem	1	11	1		13
Jazan	5		4	1	10
Northern		2			2
Al Jouf		1			1
Total	149	239	143	31	562



Future Dams in Kingdom of Saudi Arabia

Region	Potable water	Flood Protection	Recharge	Total
Riyadh		14	115	129
Madina		6	90	96
Makkah	3	22	71	96
Aseer	7	2	83	92
Hail		2	38	40
Tabuk		8	23	31
Najran		4	23	27
Al Baha		1	24	25
Al Qassem			13	13
Jazan	1		9	10
Northern			2	2
Al Jouf			1	1
Total	11	59	492	562



10- Summary & Conclusions

Summary & Conclusions

- Dams play an important role in achieving sustainable Development goals.
- Saudi Arabia has undertaken the expansion of the dam construction as early as 1956 and up to date, to maximize the benefit from renewable water, and to for water supply.
- Saudi Arabia has constructed (574) surface and underground dams, for different purposes, having (2.596) B.m³ total storage capacities.
- MEWA is planning to expand in the construction of underground dams for augmenting the utilization from rainfall harvesting and floods, as well as the little operational and maintenance costs comparable to the surface dams.
- (563) sites of dams have been studied within the project of “1000 dams” having total storage capacities (1.45) M.m³.
- The new proposed dams will contribute to enhancing the water resources sustainable development and groundwater recharge.

Under the Patronage of His Excellency **Eng. Abdulrahman bin Abdulmohsen AlFadley**
Minister of Environment, Water & Agriculture

منتدى المياه السعودي
saudi water forum **SWF 2024**



THANK YOU!

Dr. Yousry Mattar
Senior Advisor For MEWA & UNDP



29 April – 01 May 2024



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المؤسسة العامة لتحويل المياه المالحة
Saline Water Conversion Corporation (SWCC)



شركة المياه الوطنية
National Water Company



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Saudi Water Partnership Company



المؤسسة العامة للري
National Water Regulatory Authority
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Saudi Food & Drug Authority



منظم المياه
Water Regulator



المركز الوطني لكفاءة وترشيد المياه
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