RUNOFF COLLECTION POTENTIAL IN ABHA, SAUDI ARABIA: AN ANALYSIS WITH WATERSHED MODELING SYSTEM SOFTWARE

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Overview

- Introduction
- Study Area
- Methodology
- Analysis and Results
- Conclusions

Introduction

- Water scarcity is an issue in Saudi Arabia
- Domestic water demand 2.6 BCM/year
- Consumption of freshwater was 16.3 BCM in 2014
- DW: > 60% of DWD; New investment;
- About 3.4-25 kg CO_2 for 1 m^3 of DW
- Runoff use has co-benefit: less costly; reduce CO_2

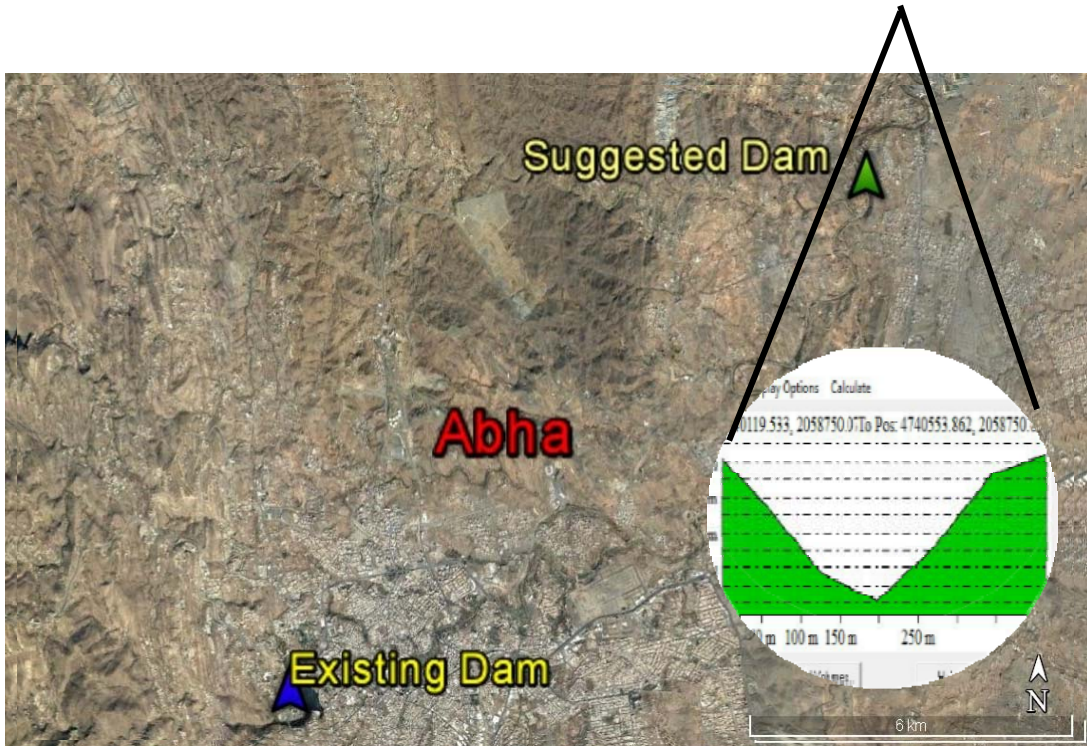
Introduction

- Countrywide average rainfall: < 100 mm/year
- Total 449 dams with 2.1 BCM capacity
- SW region has 126 dams with 760 MCM capacity
- SW region has average rainfall: 200-250 mm/year
- Seasonal flood events with thunderstorms and intense rainfall
- Scope of new dams in the SW region

Study Area

- Annual average rainfall: 215.3 mm
- Existing dam (213 MCM capacity) in SW corner
- In the NE corner, a new dam can be constructed
- Capital of Asir Province

Methodology: New Dam

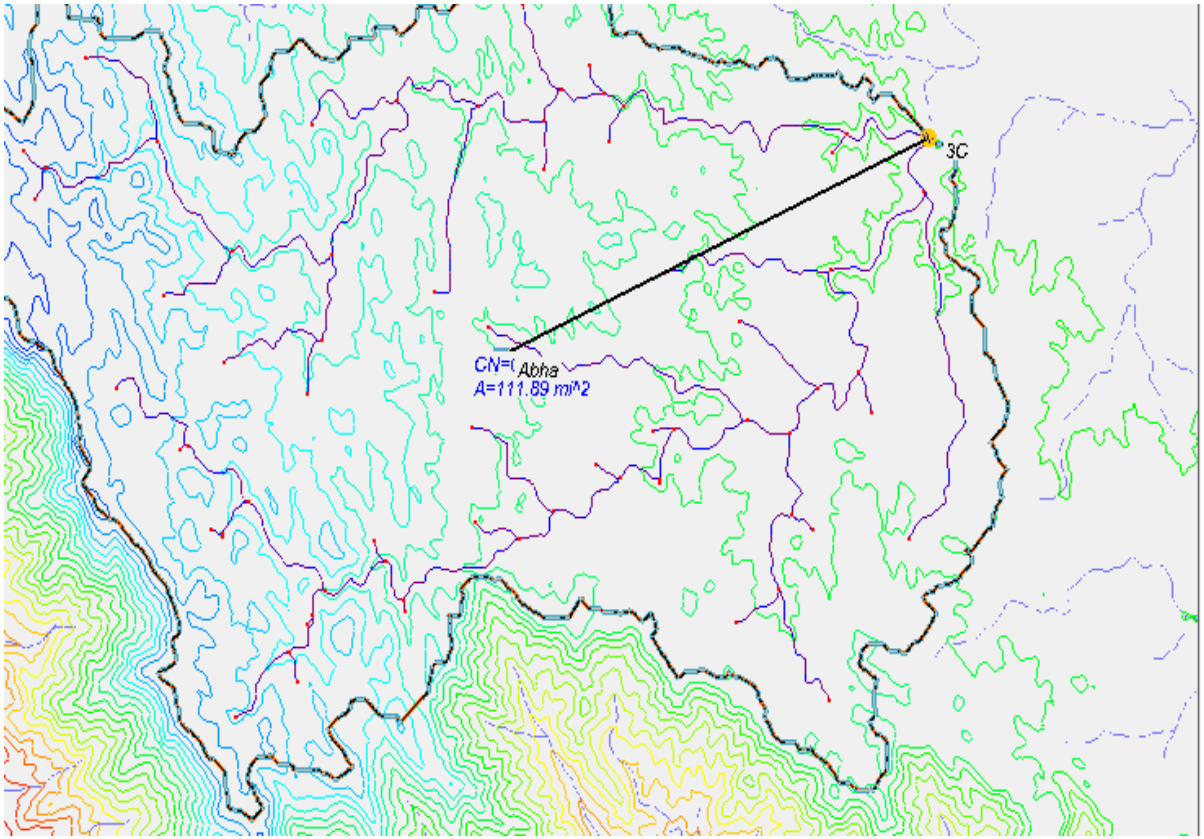


Sharp Section over Wadi

- **The location was chosen by Google-Earth software**
  - **Mild slope of wadi; Sharp section over the channel**
  - **Distance from village and road: < 15 km**

Methodology: Basin Delineation

- **WMS software was used for delineating basin**
- **The SCS method was used**



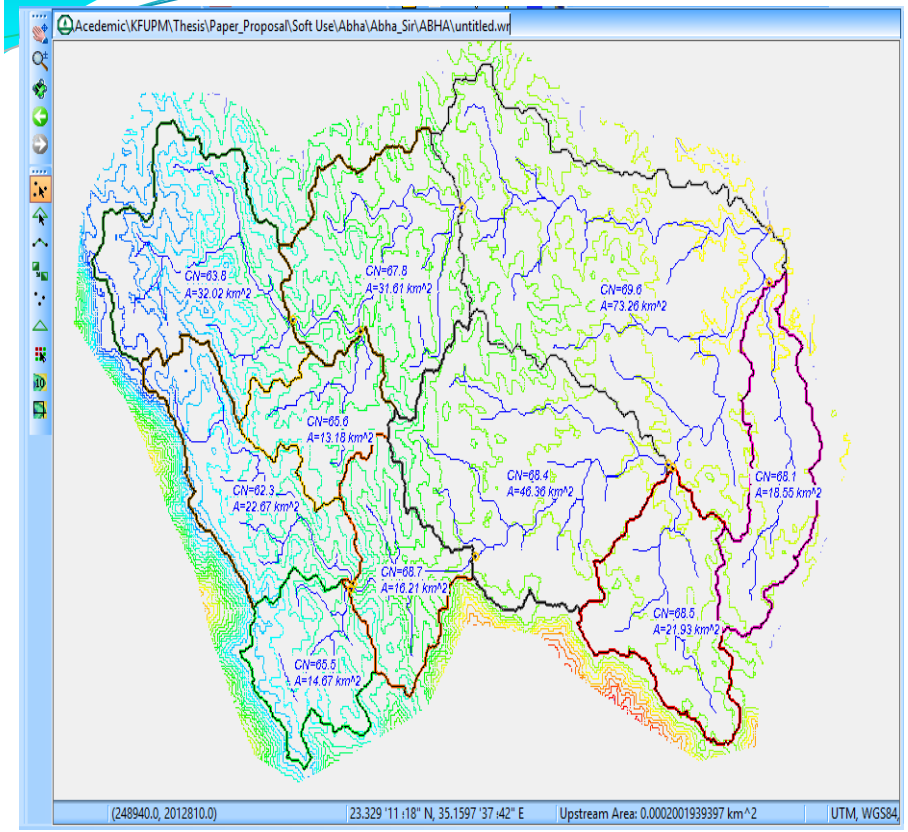
Abha Basin (Area: 112 mi^2 = 290 Km^2)

Methodology: Runoff Generation

- **HEC-HMS software was used**
- **Input parameters:**
  - **Rainfall duration: 24, 36 and 48 hours**
  - **Rainfall depth: For T of 25, 50 and 100 years with SD = 20%**
  - **Curve number: Calculated and applied with SD = 15**

Area Name	Return Periods (year)	Runoff depth (mm) from IDF	Runoff depth (mm) with 20% SD		
			ML	MIN	MAX
Abha	100	114	115	90	140
	50	100.2	100	80	120
	25	86.2	86	69	103

Methodology: CN



Basin no.	Area, Ai (km^2)	CN_i value	A_i*CN_i
12B	31.61	67.79	2142.59
13B	13.18	65.59	864.65
14B	32.02	63.77	2042.20
15B	73.26	69.61	5099.80
16B	18.55	68.13	1263.51
17B	46.36	68.39	3170.73
18B	21.93	68.53	1502.62
19B	16.21	68.70	1113.64
20B	14.67	65.52	960.92
21B	22.67	62.28	1412.21
Σ	290		19572

Area Name	Area (km2)	CN from WMS	Curve Number with '15' as SD		
			ML	MIN	MAX
Abha	290	67	**65**	**50**	**80**

Result: Runoff generation from 27 Fuzzy Rules

25 year return period

Rule (R_i)	If	Depth (mm)	and	Duration (hour)	and	CN	then	Runoff (MCM)
R1	If	69	and	24	and	50	then	0.124
R2	If	69	and	24	and	65	then	1.69
.....								
R26	If	103	and	48	and	65	then	7.8
R27	If	103	and	48	and	80	then	15.36

100 year return period

Rule (R_i)	If	Depth (mm)	and	Duration (hour)	and	CN	then	Runoff (MCM)
R_1	If	90	and	24	and	50	then	0.772
R_2	If	90	and	24	and	65	then	3.625
.....								
R_{26}	If	140	and	48	and	65	then	14.74
R_{27}	If	140	and	48	and	80	then	24.6

Result: Runoff Generation

25 year return period: Variable CN and rainfall

Curve	Runoff volume (MCM)		
number	Low	Geo. mean	High
50	0.124 (R_1)	0.79	2.58 (R_{25})
65	1.69 (R_2)	4.09	7.8 (R_{26})
80	5.2 (R_3)	9.68	15.36 (R_{27})

Rainfall	Runoff volume (MCM)		
(mm)	Low	Geo. mean	High
69	0.124 (R_1)	1.57	7.66 (R_9)
86	0.61 (R_{10})	3.47	11.38 (R_{18})
103	1.42 (R_{19})	5.75	15.36 (R_{27})

Result: Runoff Generation

50 year return period: Variable CN and rainfall

Curve	Runoff volume (mcm)		
number	Low	Geo. mean	High
50	0.4 (R_1)	1.64	4.29 (R_{25})
65	2.63 (R_2)	5.95	10.84 (R_{26})
80	6.9 (R_3)	12.53	19.53 (R_{27})

Rainfall	Runoff volume (mcm)		
(mm)	Low	Geo. mean	High
80	0.4 (R_1)	2.76	10.03 (R_9)
100	1.26 (R_{10})	5.32	14.64 (R_{18})
120	2.52 (R_{19})	8.33	19.53 (R_{27})

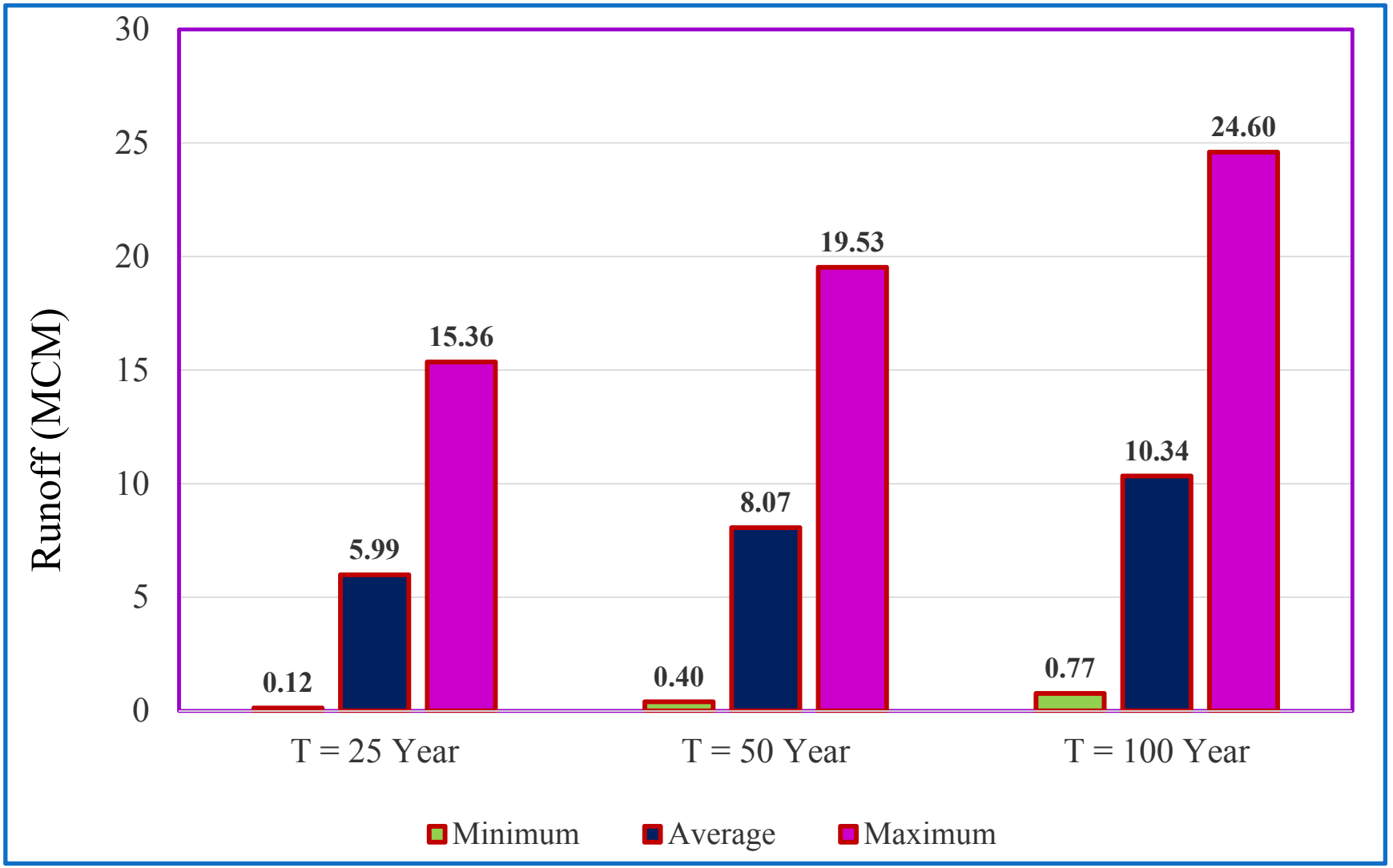
Result: Runoff Generation

100 year return period: Variable CN and rainfall

Curve	Runoff volume (MCM)		
number	Low	Geo. mean	High
50	0.77 (R_1)	2.76	6.71 (R_{25})
65	3.63 (R_2)	8.11	14.74 (R_{26})
80	8.54 (R_3)	15.66	24.6 (R_{27})

Rainfall	Runoff volume (MCM)		
(mm)	Low	Geo. mean	High
90	0.77 (R_1)	3.98	12.29 (R_9)
115	2.17 (R_{10})	7.54	18.29 (R_{18})
140	4.12 (R_{19})	11.67	24.6 (R_{27})

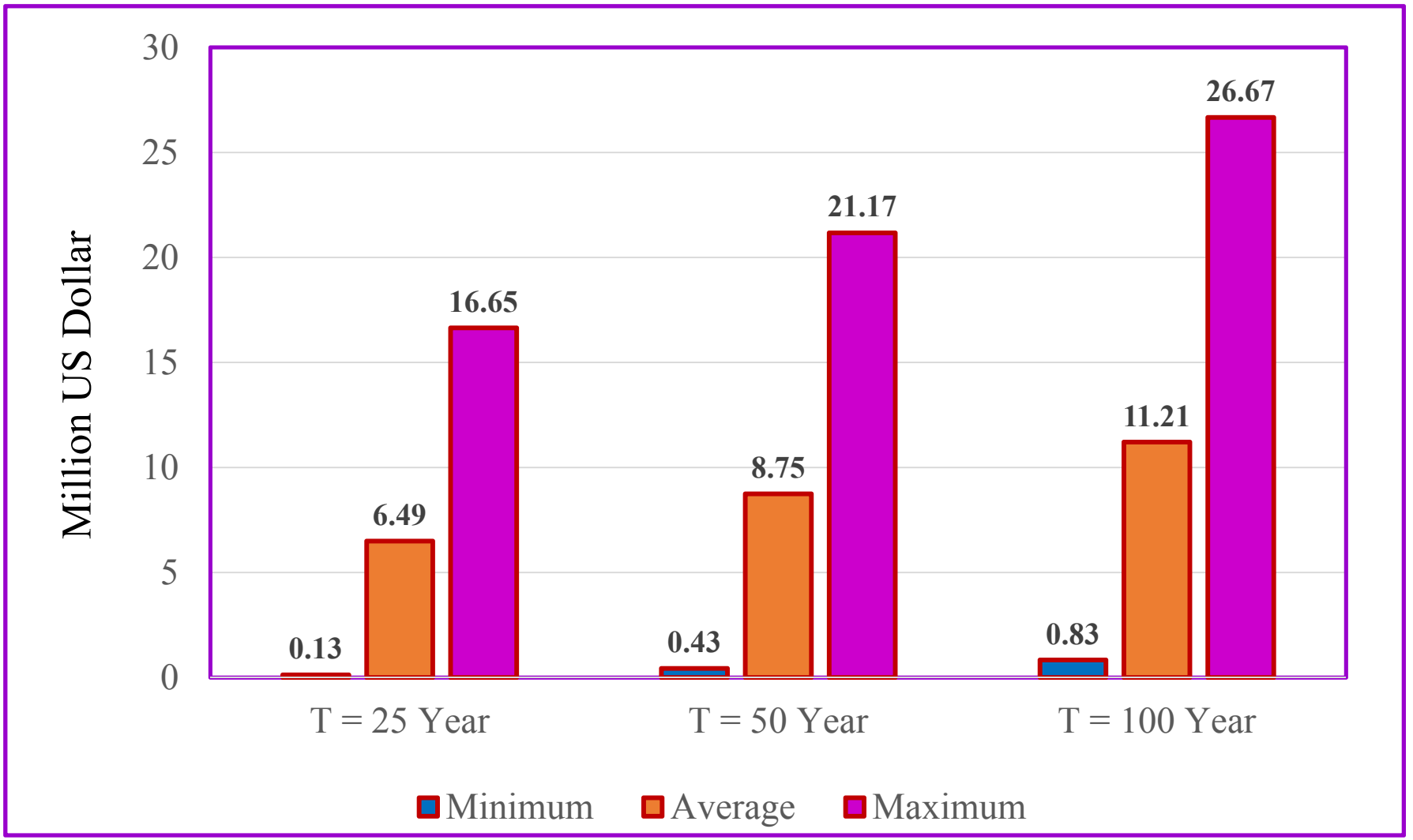
Result: Runoff Generation



Result: Runoff Use and Cost Saving

- **Return Period: T = 25, 50 and 100-years:**
- **Runoff = 0.124 – 15.36 MCM, 0.4 – 19.53 MCM and 0.77 – 24.6 MCM**
- **Cost for using surface runoff = US$ 0.756/m^3**
- **Cost savings by using runoff = US$ 1.084/m^3**
- **Use of 1 m^3 DW: Cost US$ 1.84 (1.31 - 2.37)**

Result: Runoff Use and Cost Saving

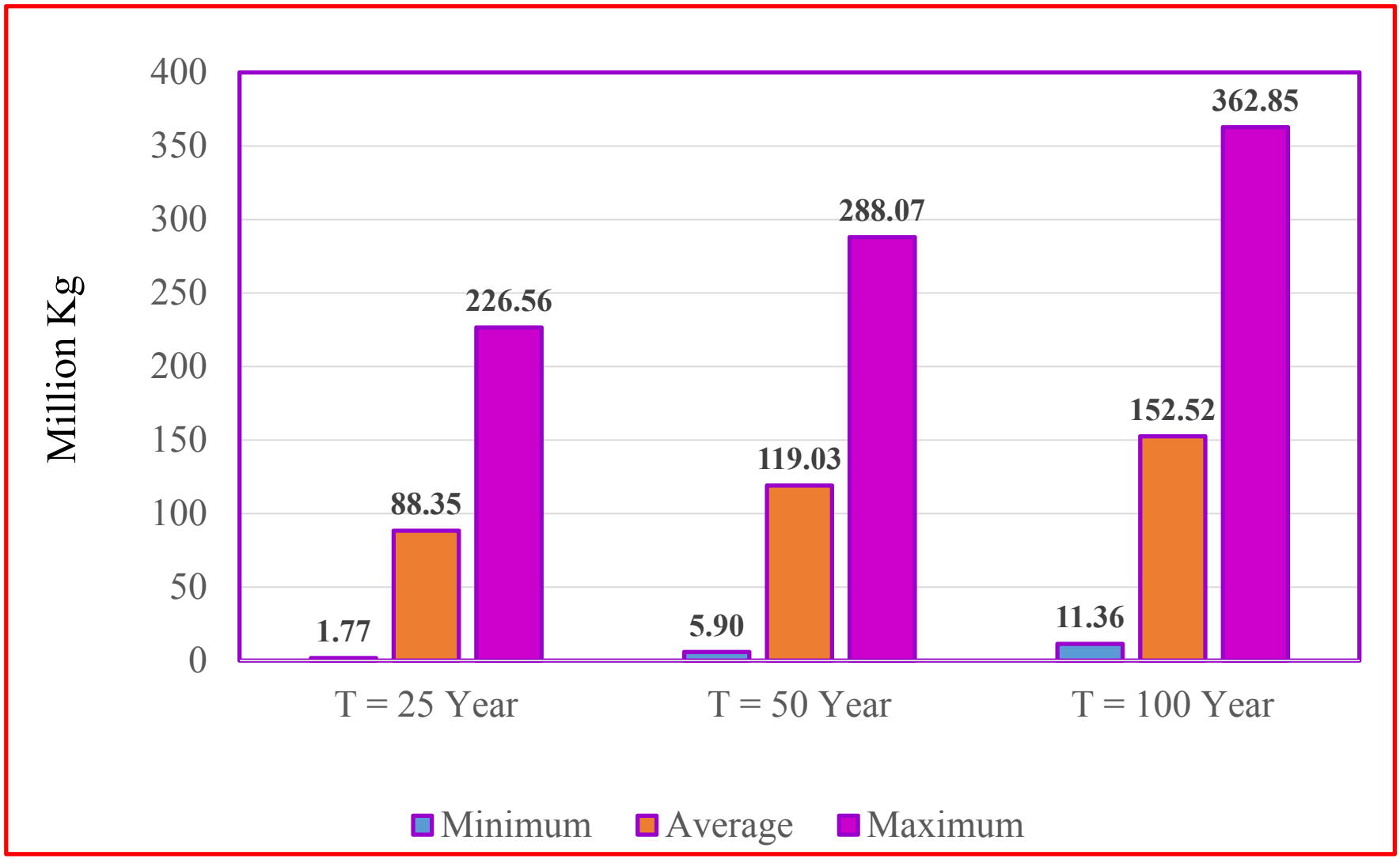


Result: Runoff Use and CO_2 Reduction

Desalination methods	CO_2 (Kg) emission for producing 1 m^3 of DW
MSF	20.4-25.0
MSF_{cogen}	13.9-15.6
MED	11.8-17.6
MED_{cogen}	8.2-8.9
RO	3.4-6.0

- Al-Shuqaiq desalination plant delivers DW to Abha
- CO2 emission for MSF_{Cogen} = 14.75 kg CO_2/m^3 DW

Result: Runoff Use and CO_2 Reduction



Conclusions/Recommendations:

- **Up to 24.6 MCM runoff can be collected by a new dam**
- **Use of runoff can save up to US$ 26.67 million**
- **CO_2 reduction can be up to 362.85 million kg**
- **Needs feasibility study for the location and cost of dam construction**

Thank You

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