



# Water Demand, Land Use, and Income Security under Conditions of Global Change in the South of Morocco

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# Water and Income in the Drâa Valley



- Water main limiting factor for land use
- Family income is generated by agriculture, livestock and small enterprises (in addition to remittances of migration ~ 69%)
- Agriculture in Drâa oases mostly for subsistence and local markets  
Exception: palm dates, spices and fragrances (roses)



# Water and Income in the Drâa Valley



- Water demand for human consumption less than 20% of the evaporation losses; irrigation highest water demand
- but irrigation / agricultural use of the oases is needed for securing basic livelihood
- Tourism and urbanization change the demand for water  
→ the region has to optimize the use of scarce and diminishing water resources.





# Importance of Tourism

## Economy and employment

- Only available alternative to farming with a certain economic potential
- Strong local / regional component:  
2/3 of all employers and 95% of all employees are from the region (between Zagora and M'Hamid)
- Incentives for other business activities in the cities

## Water demand

- Higher economic benefit as in agriculture
- Water demand mostly covered by own wells
- Constant (good) water quality and availability is required
- If tourism should further boom, there might be conflicts about (water) resources: water consumption (Ø 520 L/overnight stay)
- Although *per capita* consumption of tourists exceeds that of local households by large, it uses less than 5% of total water resources: actually similar water consumption of households and tourism



# Importance of Tourism

- Within the past 10 years, 2/3 of the capacity in the southern Drâa valley with increasing length of stay
- Concentration of touristic infrastructure at the „hot spots“ Ouarzazate, Zagora and M'Hamid/Oulad Driss
- Cause and/or consequence of enhanced urbanization
- Most important source for foreign currency in Morocco, objective: 10 millions of tourists in 2010

2005	Tours to:	Dades-Valley	Draa-Valley	Marrakesch
	Travelers per day	ca. 655	ca. 570	ca. 950
	Guided groups per day	ca. 75	ca. 85	ca. 95
	Individual travellers per day	ca. 280	ca. 140	ca. 300
	Ratio package tours to individual trips	2,6 : 1	4,7 : 1	3,5 : 1
	Cars /day	146	110	181
	Tourists per day	1010	798	1347

*C. Frank: 2005/2006*

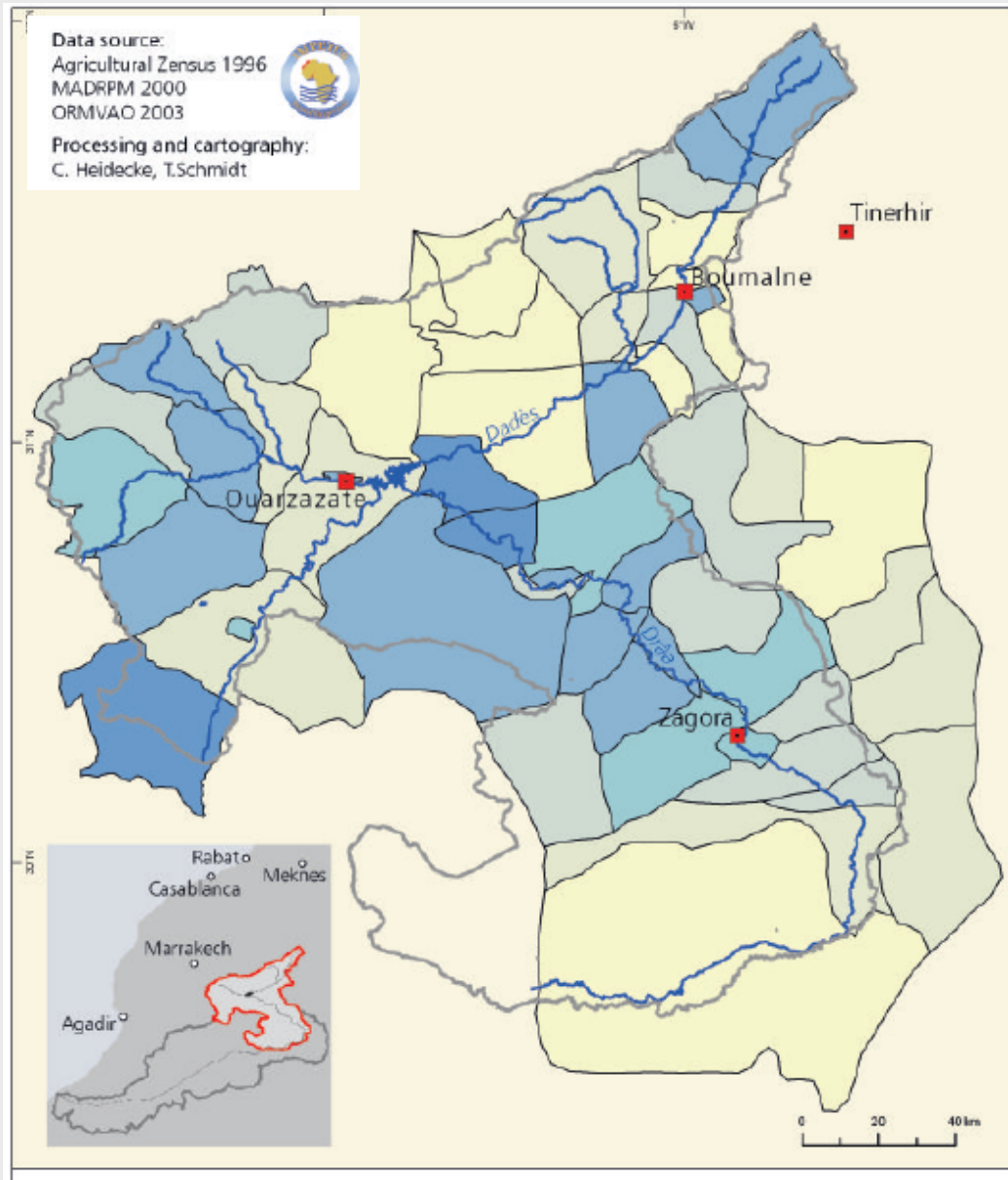


# Questions raised

- How will a change in water supply affect income generation in the Drâa valley?
- How to optimize water distribution economically?
- What are the perspectives for different economic sectors under water shortage and increased salinity (esp. in the southern oases)?



# Irrigated area in the Drâa Valley

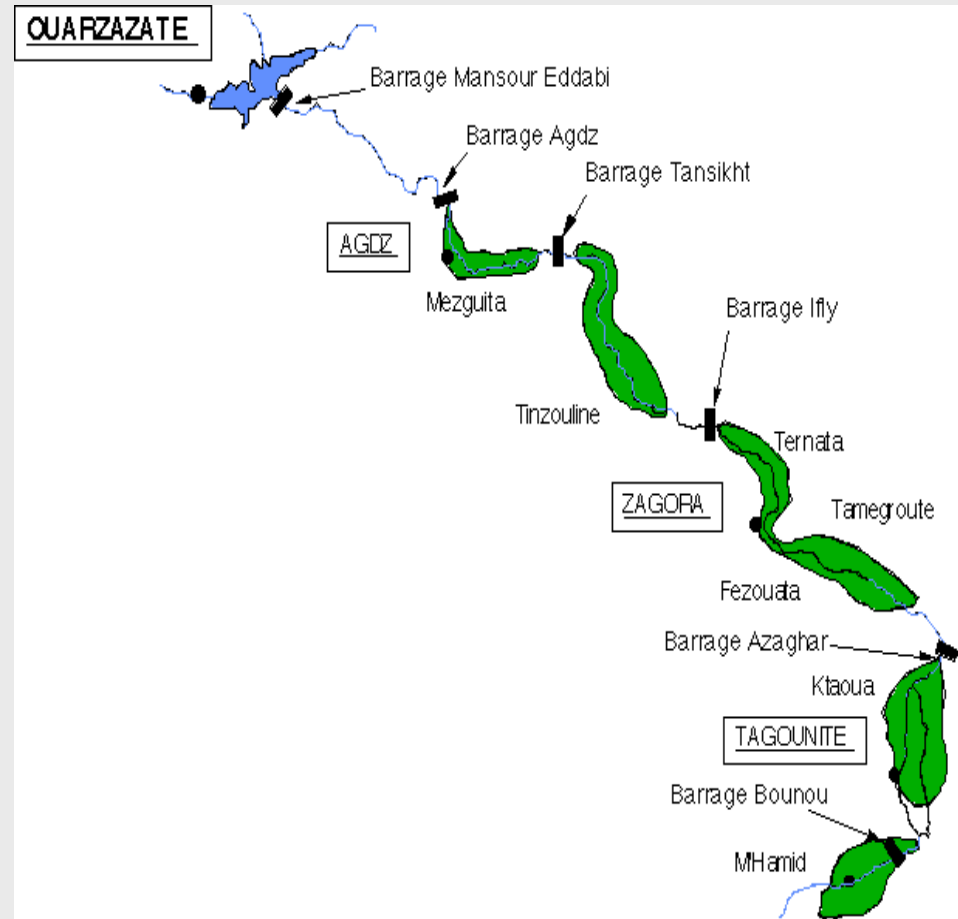


**Ratio of irrigated area to total arable land in the region of Ouarzazate**



# Water and Income in the Drâa Valley

- Management options for expected changes over the next decades  
→ SDSS MIVAD
- MIVAD allocates available water resources in the economically most feasible way
- components:
  - hydrological data
  - yield functions of crops
  - economic assessment: calculating profits from agricultural production

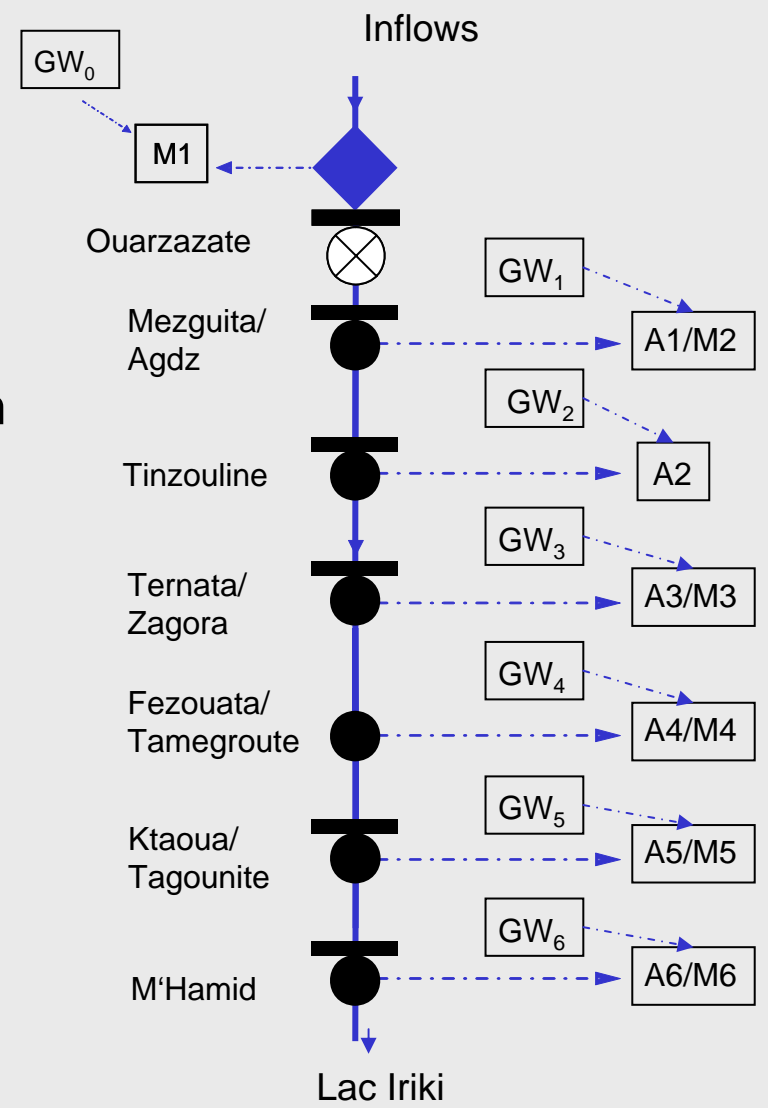






# Structure of MIVAD

- Model is configured as a network which reflects spatial relationships within the Drâa region
- Nodes are formed by river side-arms, reservoirs, and points of demand such as villages or oases
- Simulation period: agricultural year with monthly sub-periods
- Data based on ORMVAO information, literature, agro-economic survey in 2005





# MIVAD

## Model Output

- Revenues from crop production, area cultivated in total and per oasis, yields per crop (dates, wheat, barley, corn, alfalfa, henna, beans, vegetables)
- Water allocation to different crops
- Use of different water resources (ground- / surface- water)

## Use of the model for different scenarios

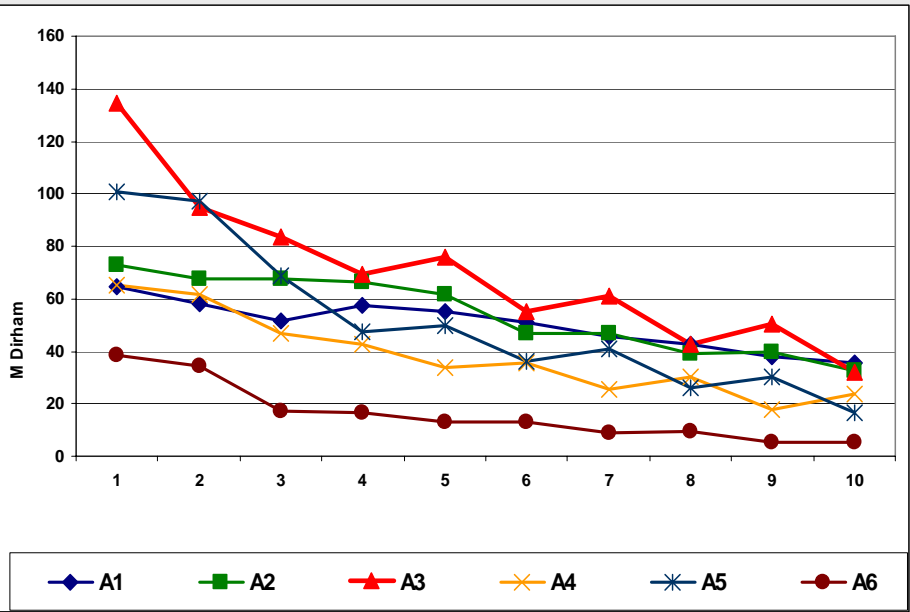
- Water resource development and land use in the coming years
- Effects of water shortages on water resources and land use pattern
- Agricultural income under different climatic conditions and changes in the future



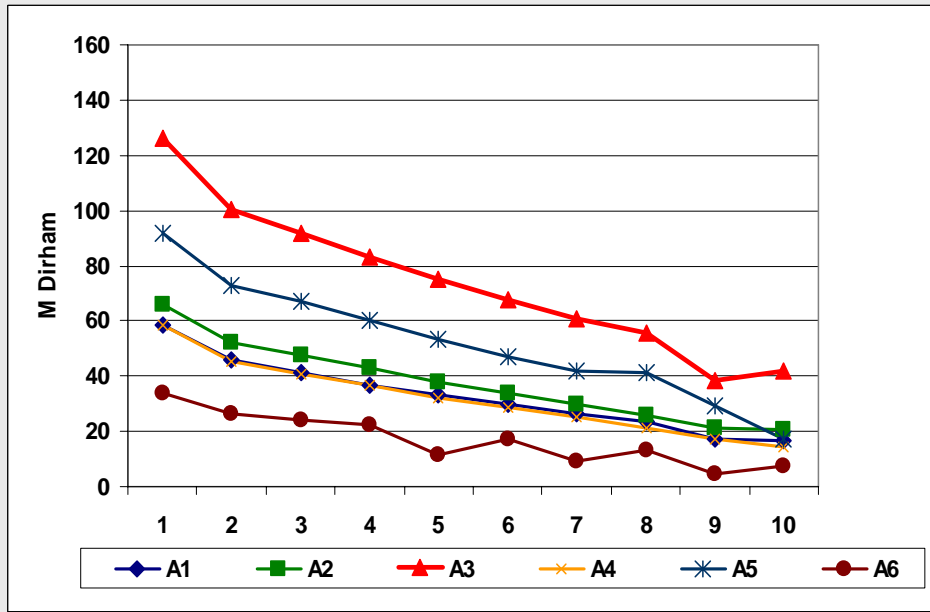
# Scenario:

## Effect of ten years drought on agricultural income

### Without charges for groundwater use



### Charge for groundwater use of 1 MAD/m<sup>3</sup>



## Agricultural income for the six oases A1 to A6

### Assumptions:

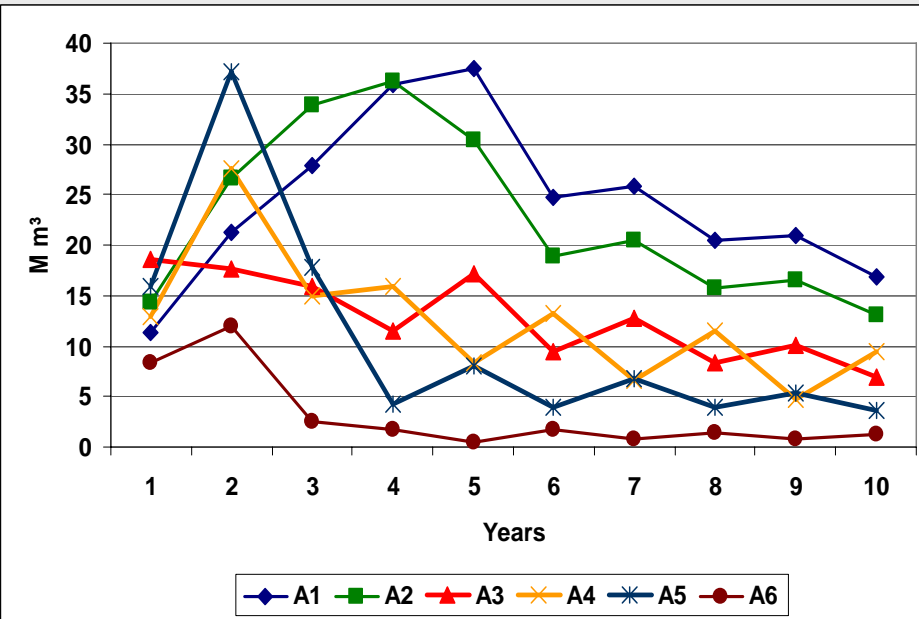
- Water availability is declining by 6% per year
- Population growth in the villages



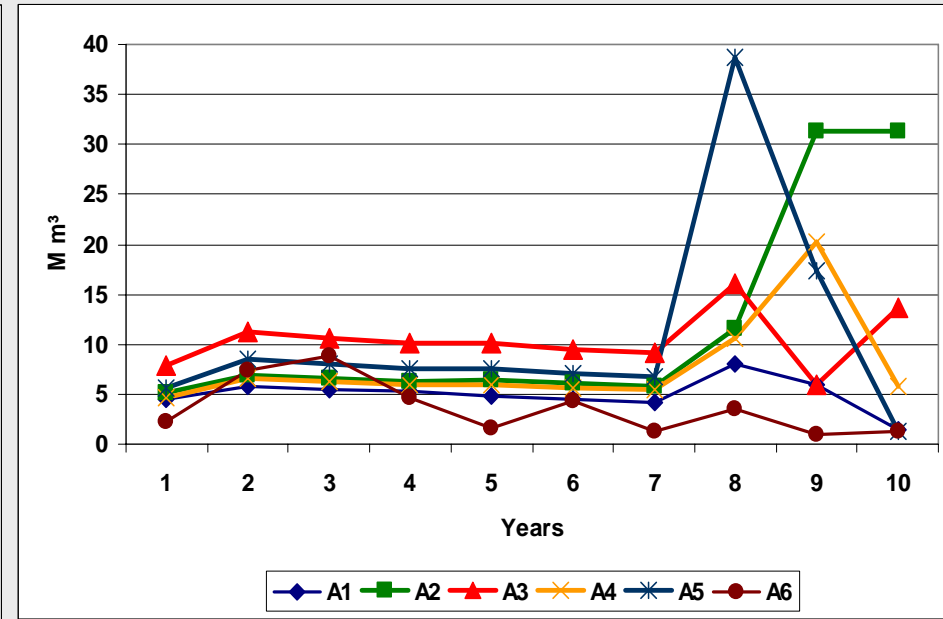
# Scenario:

Effect on of ten years drought on groundwater use

without charge



Charge for groundwater use of 1 MAD/m<sup>3</sup>



## Groundwater use for irrigation (A1 to A6)

Assumptions:

- Water availability is declining by 6% per year
- Population growth in the villages



# Exemplary results of hydro-economic modelling

- Decreasing surface water availability leads to increasing use of groundwater for irrigation  $\Rightarrow$  effect of declining groundwater tables!!

See also IWEGS

- Decreasing surface water availability can lead to declining farm income of around 400 Million Dirham to ~ 100 Million Dirham for the region
- Water pricing is an option to preserve groundwater resources and/or to make use of its buffer function



# MIVAD SDSS / Scenario viewer

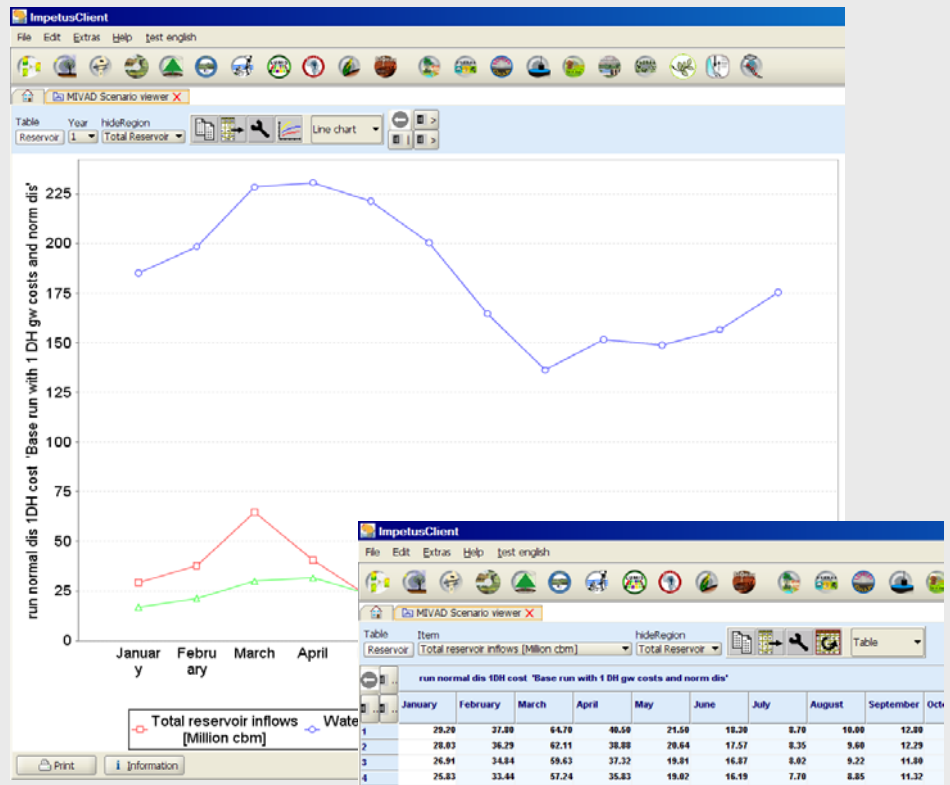
## Options:

1. Compare two scenarios
2. Upload new model results

Choice of scenarios for MIVAD-Crop X

Choice of scenarios to be compared

Scenario 1	Scenario 2
<input type="checkbox"/> Climate scenario used	<input type="checkbox"/> Climate scenario used
<i>Keine Auswahlmöglichkeit</i>	<i>Keine Auswahlmöglichkeit</i>
<input type="checkbox"/> Socioeconomic scenario used	<input type="checkbox"/> Socioeconomic scenario used
<input checked="" type="radio"/> Distribution to surface	<input checked="" type="radio"/> Distribution to surface
<input type="radio"/> Optimal distribution	<input type="radio"/> Optimal distribution
<input type="checkbox"/> Intervention or sensitivity analysis	<input type="checkbox"/> Intervention or sensitivity analysis
<i>Keine Auswahlmöglichkeit</i>	<i>Keine Auswahlmöglichkeit</i>
<input checked="" type="radio"/> A1B opt distr and high costs	<input checked="" type="radio"/> A1B opt distr and high costs
<input type="radio"/> A1B opt distr and low costs	<input type="radio"/> A1B opt distr and low costs
<input type="radio"/> A1B opt distr and normal costs	<input type="radio"/> A1B opt distr and normal costs
<input type="radio"/> A1B_area distr and high costs	<input type="radio"/> A1B_area distr and high costs
<input type="radio"/> A1B_area distr and low costs	<input type="radio"/> A1B_area distr and low costs
<input type="radio"/> A1B_area distr and normal costs	<input type="radio"/> A1B_area distr and normal costs
<input type="radio"/> B1 opt distr and high costs	<input type="radio"/> B1 opt distr and high costs
<input type="radio"/> B1 opt distr and low costs	<input type="radio"/> B1 opt distr and low costs
<input type="radio"/> B1 opt distr and normal costs	<input type="radio"/> B1 opt distr and normal costs
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<input type="radio"/> Constant reduction opt distr and normal costs	<input type="radio"/> Constant reduction opt distr and normal costs



PIVOT function for individual table design

run normal dis 1DH cost 'Base run with 1 DH gw costs and norm dis'

Item	January	February	March	April	May	June	July	August	September	October
1	29.29	37.89	64.70	40.59	21.00	18.20	8.70	16.00	12.20	
2	28.83	34.84	59.63	37.32	19.81	16.87	8.82	9.22	11.80	
3	26.91	34.84	59.63	37.32	19.81	16.87	8.82	9.22	11.80	
4	25.83	33.44	57.24	35.83	19.82	16.19	7.70	8.85	11.32	
5	24.80	32.11	54.96	34.40	18.26	15.54	7.39	8.49	10.87	
6	22.81	28.82	52.75	32.62	17.52	14.92	7.09	8.19	10.44	
7	22.86	29.59	50.64	31.70	16.83	14.32	6.91	7.83	10.02	
8	21.94	28.40	48.62	30.43	16.16	13.75	6.54	7.51	9.62	
9	21.86	27.27	46.67	29.22	15.51	13.20	6.28	7.21	9.23	
10	20.72	26.18	44.81	28.65	14.89	12.67	6.03	6.93	8.86	
11	19.41	25.12	43.01	26.93	14.29	12.17	5.78	6.65	8.51	
12	18.64	24.13	41.29	25.85	13.72	11.68	5.55	6.38	8.17	
13	17.89	23.16	39.64	24.91	13.17	11.21	5.33	6.13	7.84	
14	17.18	22.23	38.06	23.82	12.65	10.76	5.12	5.88	7.53	
15	16.49	21.34	36.53	22.87	12.14	10.33	4.91	5.65	7.23	
16	15.82	20.49	35.07	21.95	11.65	9.92	4.72	5.42	6.94	
17	15.20	19.67	33.67	21.09	11.19	9.52	4.53	5.20	6.66	
18	14.59	18.88	32.32	20.23	10.74	9.14	4.35	5.00	6.39	
19	14.00	18.13	31.03	19.42	10.31	8.78	4.17	4.80	6.14	
20	13.44	17.40	29.79	18.65	9.90	8.43	4.01	4.60	5.89	
21	12.91	16.71	28.60	17.90	9.50	8.09	3.85	4.42	5.66	
22	12.39	16.04	27.45	17.19	9.12	7.77	3.69	4.24	5.43	
23	11.89	15.40	26.36	16.50	8.76	7.45	3.54	4.07	5.21	
24	11.42	14.78	25.30	15.84	8.41	7.16	3.40	3.91	5.01	
25	10.96	14.19	24.29	15.20	8.07	6.87	3.27	3.75	4.81	



*Thank you for your attention*



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