جامعة الملك فهد للبترول والمعادن
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ANALYZING THE EFFECTS OF CLIMATE CHANGE ON CROP WATER REQUIREMENTS IN SAUDI ARABIA

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Background

- Saudi Arabia: One of the arid countries in MENA
- Limited groundwater reserves; Limited surface RO
- Agriculture sector: The highest consumer of GW
- Predicted significant change in climate in 2050
- Several crops are produced in Saudi Arabia
- Needs water conservation

Objective

- Characterize crop productions in Saudi Arabia
- Predict CWR of crops on regional basis
- Assess seasonal variability of CWR
- Analyze the effects of temperature on CWR
- Analyze the effects of growing seasons on CWR

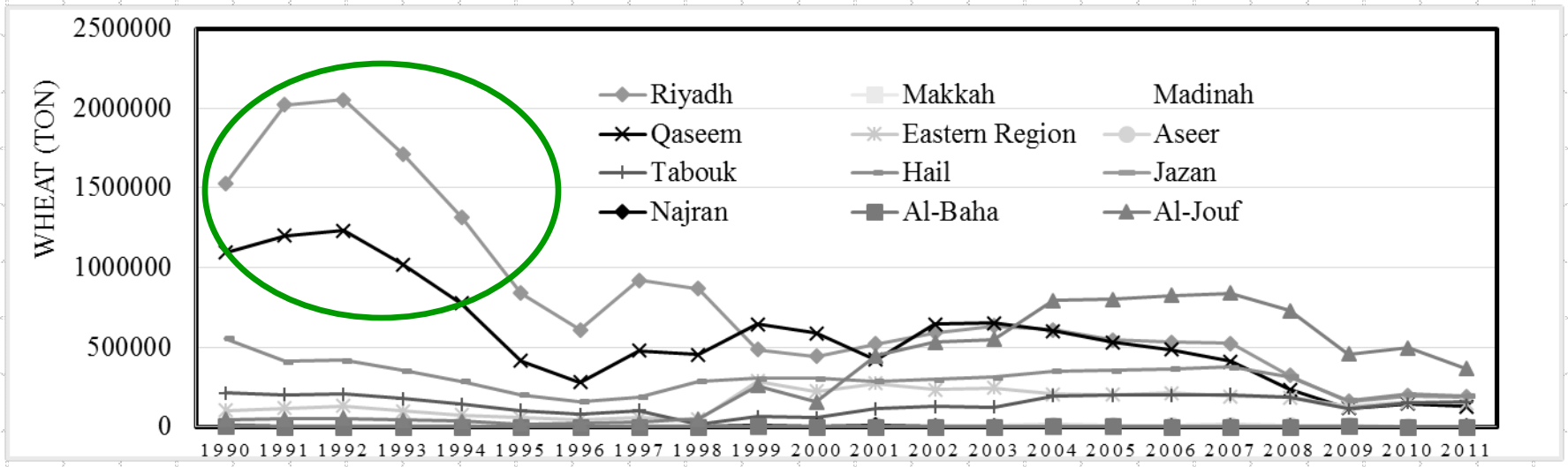
Methodology

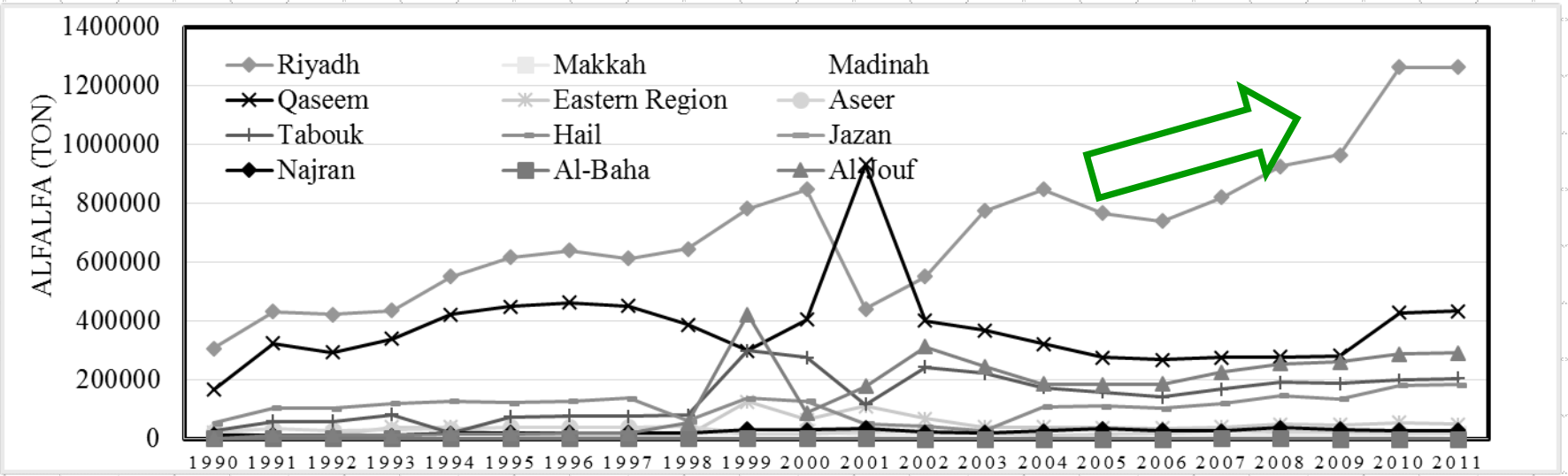
- Obtained data on area and crop productions from SSYB
- Used FAO approved CROPWAT 8.0 Software
- Applied Penman-Monteith method for predicting ET_o / ET_c
- Applied climatic conditions of 2011 and 2050 (Predicted)

Crop productions in Saudi Arabia

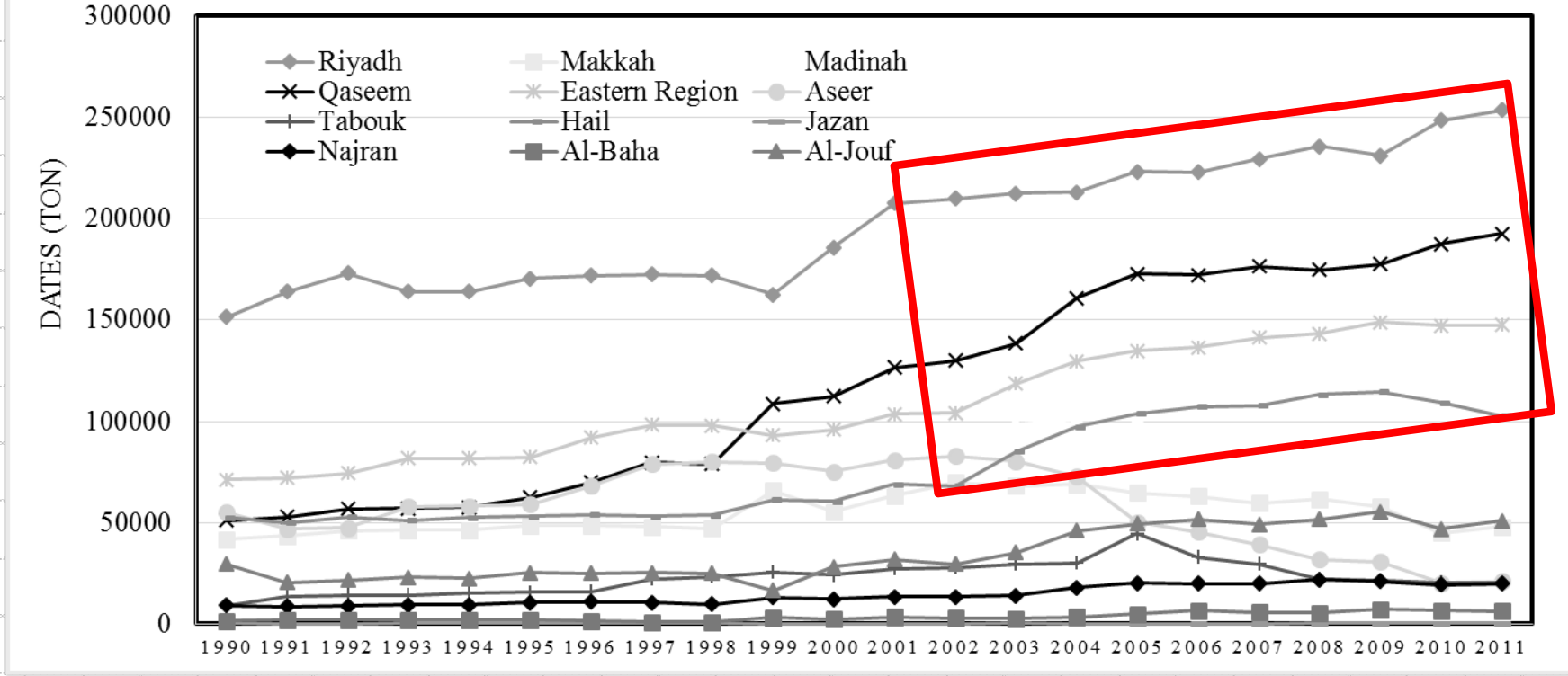
Crops	Riyadh	Makkah	Madinah	Qaseem	Eastern Region	Aseer	Tabouk	Hail	Jazan	Najran	Al-Baha	Al-Jouf	Total Area
Wheat	30896	371	194	22792	30691	3155	17889	23558		763	413	65162	195884
Millet	-	1255	2	-	-	78	-	-	2422	-	3	-	3760
Sorghum	1037	5853	-	-	-	2173	-	-	83618	-	76	-	92757
Maize	2212	619	1	5983	282	201	20	16967	935	-	99	2179	29498
Barley	652	306	12	55	226	660	278	360	16	33	60	801	3459
Tomato	4383	2041	1050	920	1605	1547	389	611	1221	540	108	693	15108
Potato	3446	172	2	3826	135	67	2342	5800	-	32	6	1837	17665
Vegetables	40879	9080	983	6671	4926	1142	1082	3885	2486	927	251	1601	73913
Alfalfa	50090	638	2485	14786	2673	1419	9008	7127	-	1914	52	11908	102100
Dates	43178	10771	18576	39303	13548	5075	2249	18743	288	3367	1395	5470	161963
Citrus	3582	1711	755	2014	820	329	1868	1350	182	1833	43	727	15214
Grapes	1378	727	3105	1058	177	434	1154	1139	-	41	194	1628	11035
Total	181733	33544	27165	97408	55083	16280	36279	79540	91168	9450	2700	92006	722356

Crop productions: Wheat, Alfalfa, Dates

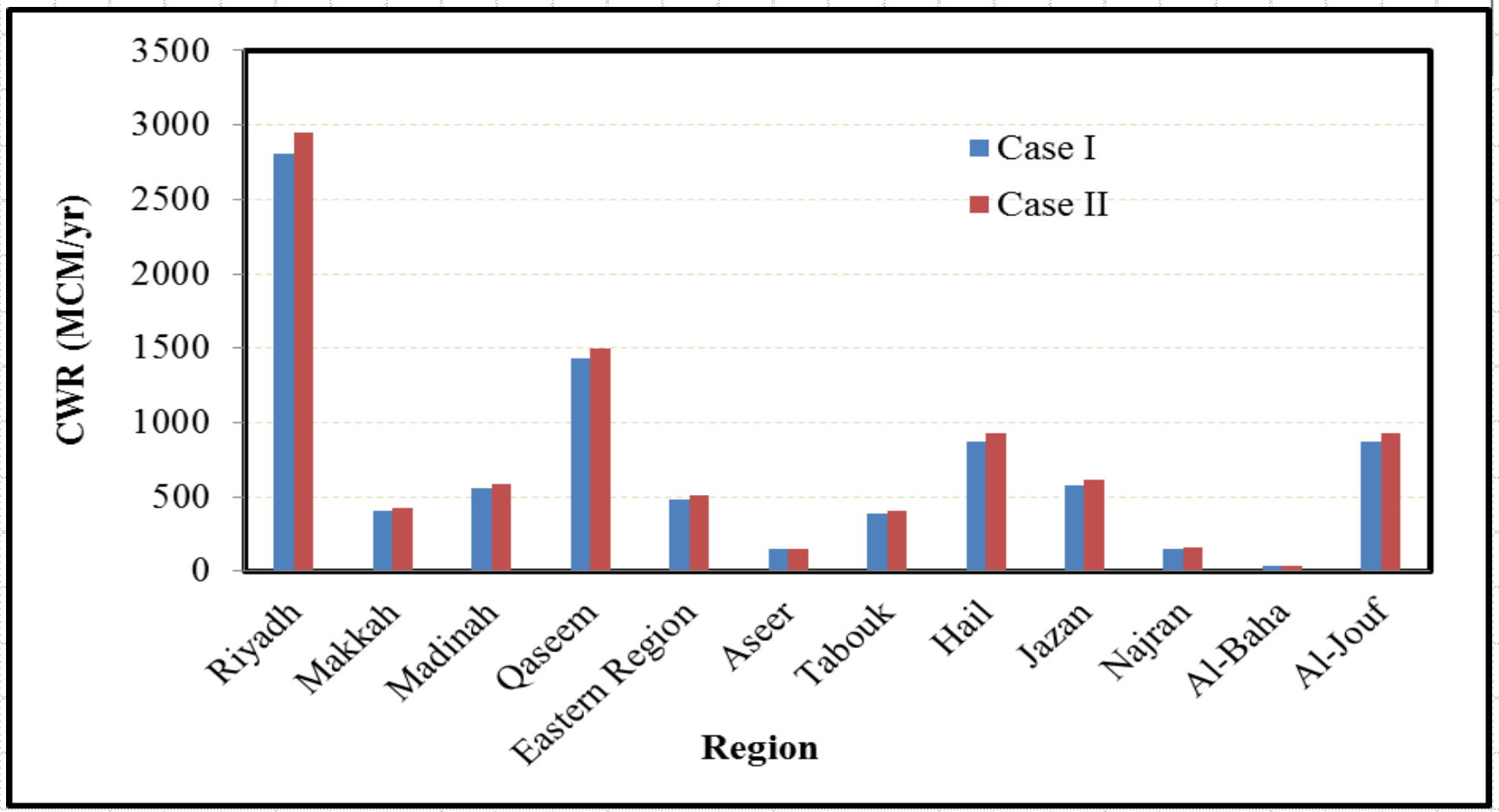




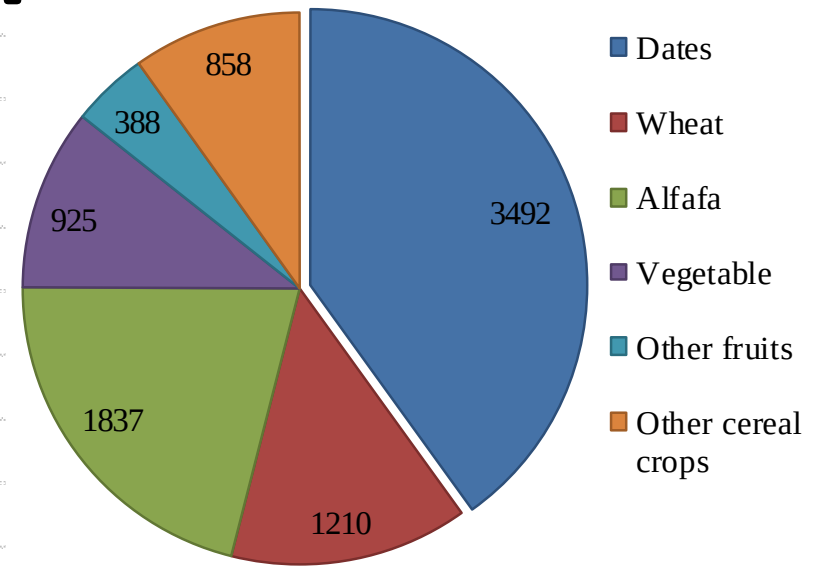
Crop productions: Wheat, Alfalfa, Dates



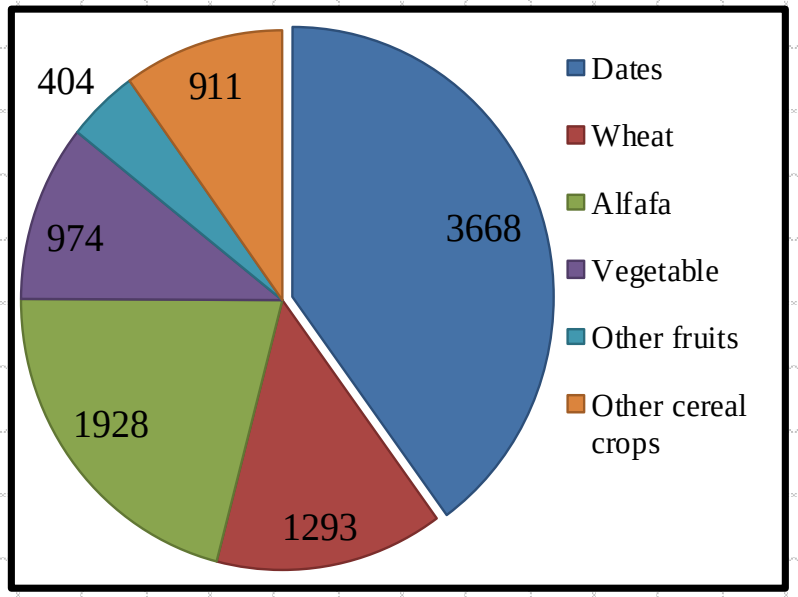
CWR of crops on regional basis



CWR on crop basis

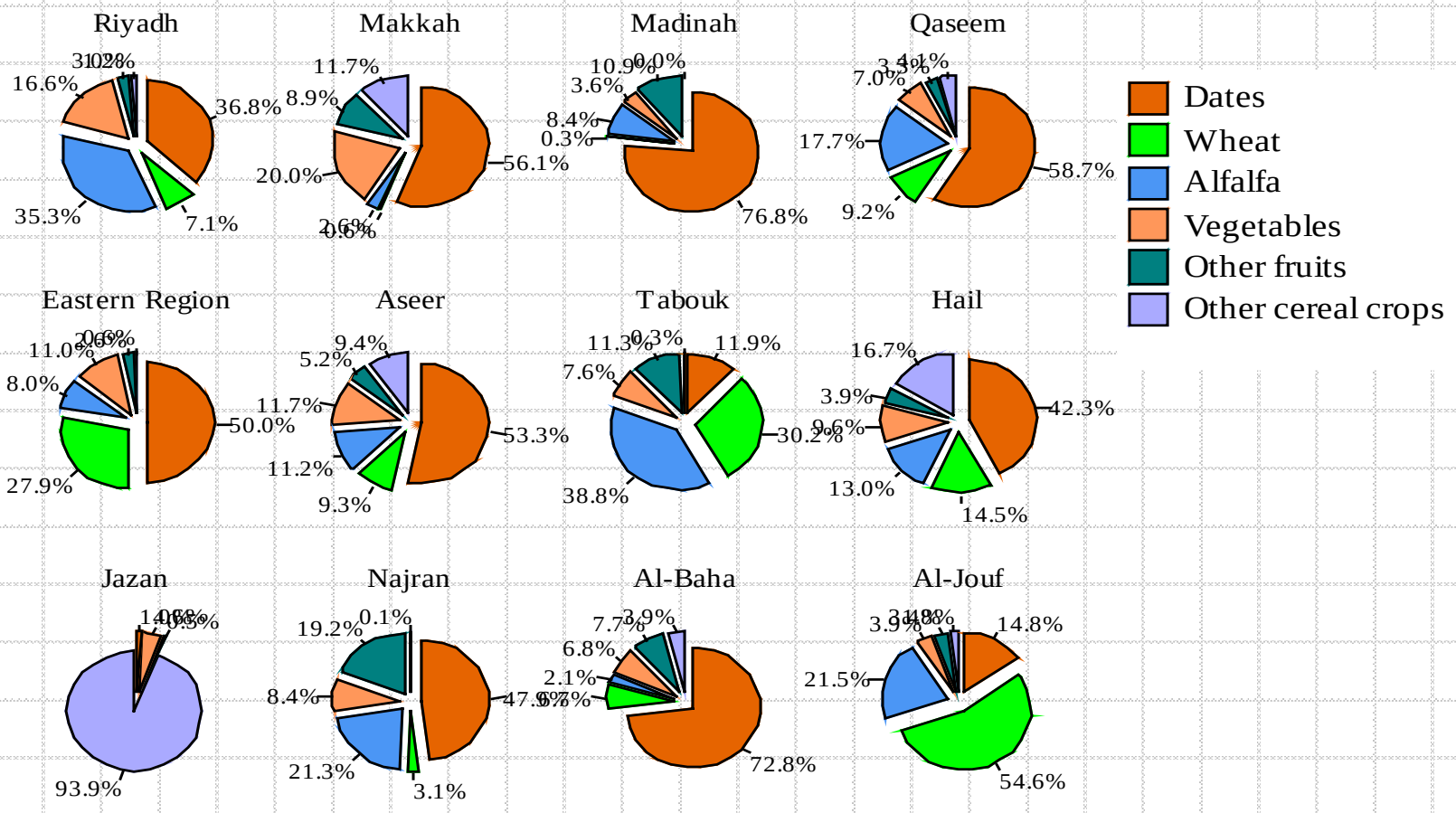


a. Case I (2011)

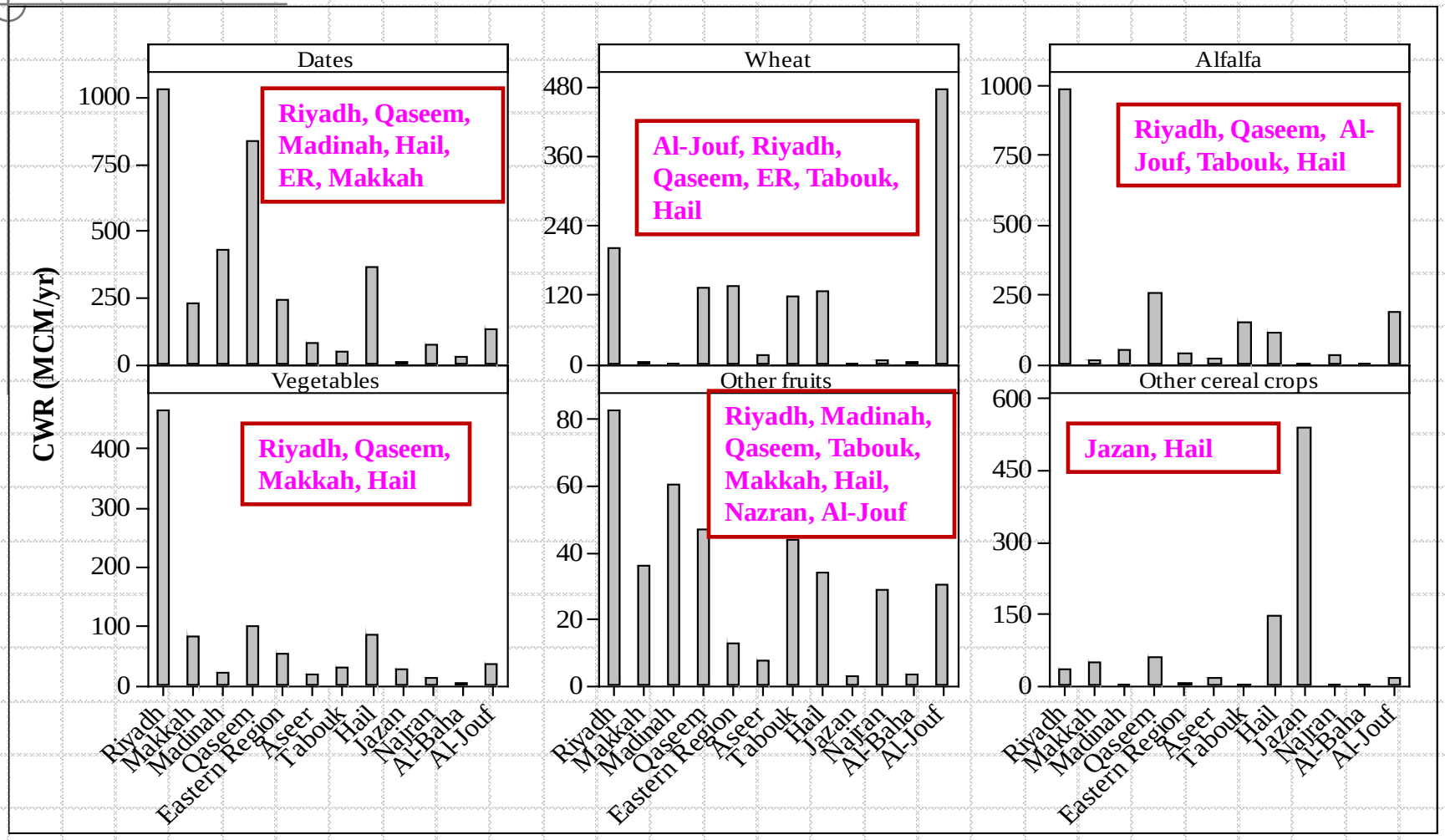


b. Case II (2050)

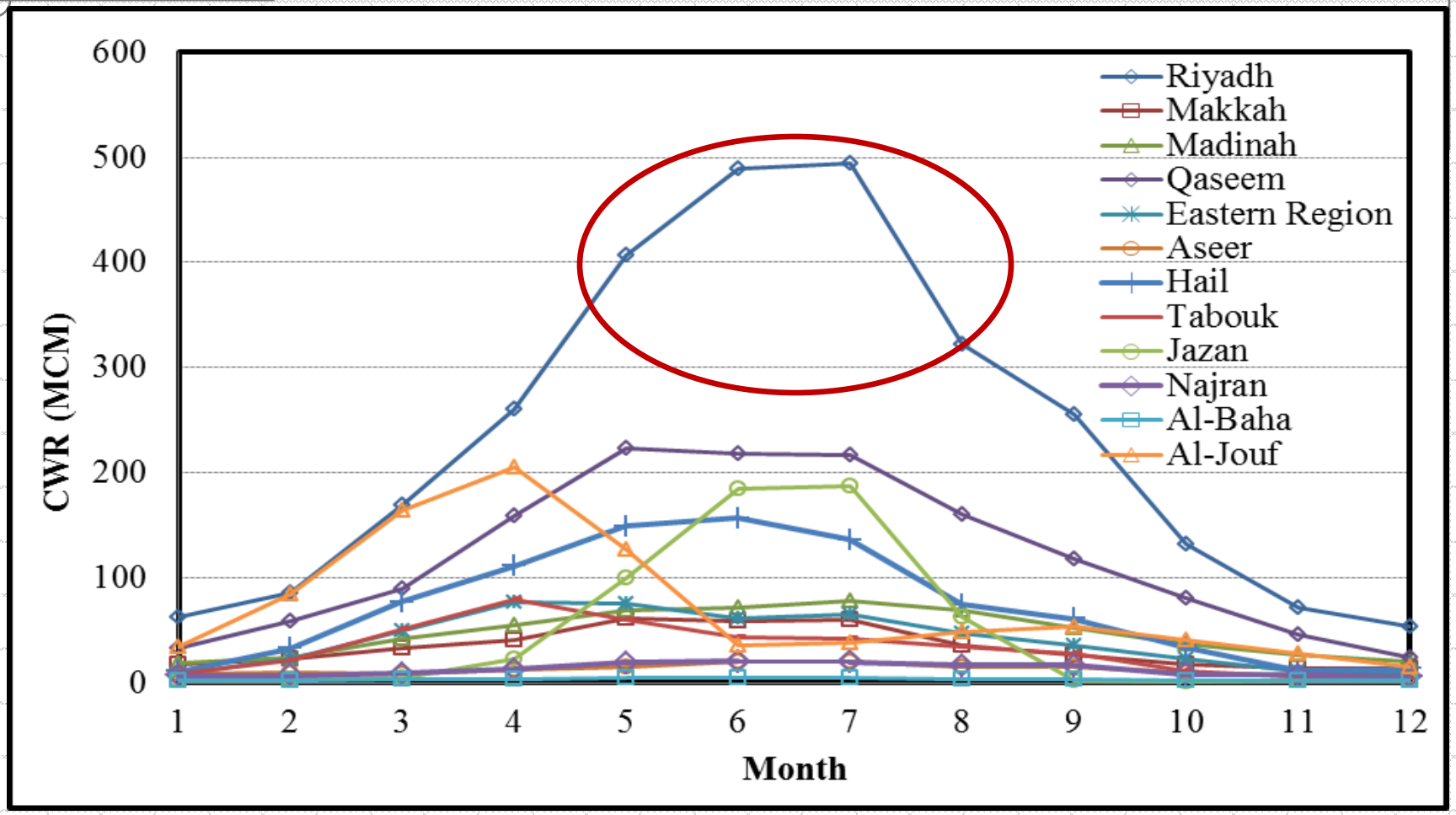
Percentile wise CWR



CWR: crops and regional distributions



Seasonal variability of CWR



Case I (2011)

Effects of temperature on CWR

- Varied Temperature by 0 – 5°C
- CWR increases from 8713 to 9716 MCM for ΔT = 5°C
- Slope of CWR = 201 MCM/°C
- CWR change = 1.9 – 2.9%/°C for dates
  = 1.9 – 3.0%/°C for alfalfa
  = 2.2 – 3.8%/°C for wheat

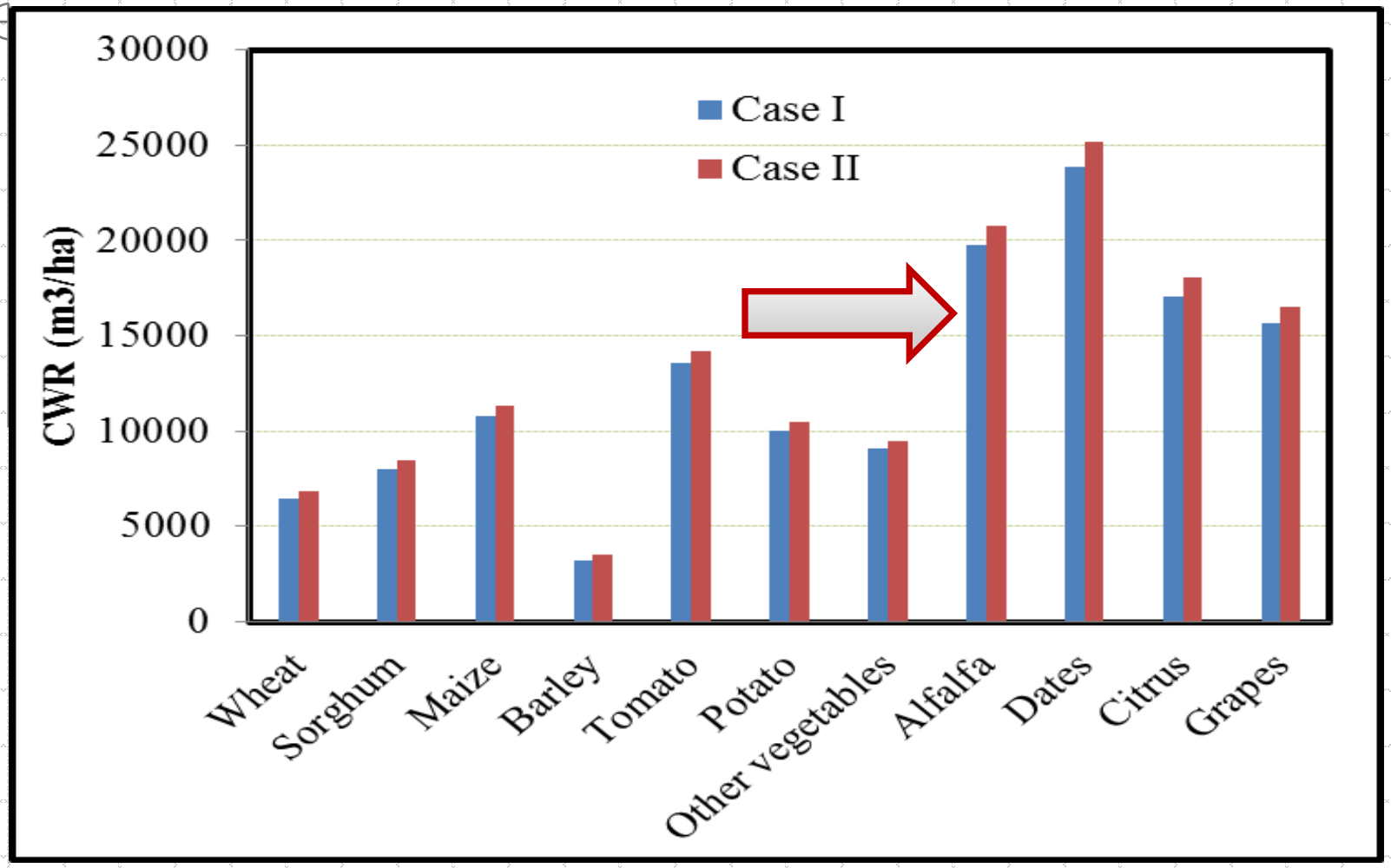
Effects of temperature on CWR

- 2011 to 2050: CWR increase : 5.8 (5.0–7.1%)
- CWR increase:
  - Wheat:
    - Riyadh = 5.8%; Al-Jouf: 6.5%
  - Dates:
    - Riyadh = 5.5%; Qaseem: 5.8%
  - Alfalfa:
    - Riyadh = 5.5%
- Overall: CWR increase = 11.9 MCM/yr ≅ 4900 tons wheat

CWR per ha of cultivation

- 1 ha land cultivation:
  - Case I:
    - Wheat: 6467 m^3/ha
    - Dates: 23896 m^3/ha
    - Alfalfa: 19742 m^3/ha
  - Case II:
    - Wheat: 6839 m^3/ha
    - Dates: 25203 m^3/ha
    - Alfalfa: 20803 m^3/ha

CWR per ha of cultivation: Riyadh



Riyadh

Effects of growing periods on CWR

- Wheat:
  - Exponential decay relationship for a shift of up to 75 days earlier
- Dates: No significant effects
- Alfalfa: No significant effects
- Sorghum: Significant effects

- Total Conservation: 731 MCM/yr: Case I
  - Wheat:
    - Shift from Jan 15 to Nov 01: Conserve: 572 MCM/yr

Effects of growing periods: Wheat

Regions	Current	S_1	S_2	S_3	S_4	S_5
Riyadh	199.8	172.6	146.1	131.5	120.7	117.4
Makkah	2.6	2.4	2.3	2.1	2	1.9
Madinah	-	-	-	-	-	-
Qaseem	131.6	109.8	88	75.2	68.6	70
Eastern Region	135.1	113.7	92.4	78.3	68.5	67.6
Aseer	13.5	12.8	12.2	11.8	11.8	12.1
Hail	125.5	108.3	90	77.8	65.2	56.5
Tabouk	117.1	102.8	85.7	73.3	63.2	58.2
Jazan	-	-	-	-	-	-
Najran	4.7	4.4	4	3.8	3.8	3.9
Al-Baha	2.6	2.4	2.2	2.1	2	2
Al-Jouf	476.2	417	347.5	301.1	265.7	248.7
Total	1208.7	1046.2	870.4	757	671.5	638.3

Current: Jan 15–May 24; S_1: (Jan 01–May 10); S_2: (Dec 15–Apr 23); S_3: (Dec 01–Apr 09); S_4: (Nov 15–Mar 24); S_5: (Nov 01–Mar 10)

Comparing water supplies and CWR

Regions	Water Supply	CWR	Water loss	% Loss
Riyadh	3786.4	2802.5	983.9	26.0
Makkah	797.3	402.3	395.0	49.5
Madinah	896.4	558.0	338.4	37.7
Qaseem	2105.7	1425.9	679.8	32.3
Eastern Region	843.6	485.0	358.6	42.5
Aseer	324.1	145.6	178.5	55.1
Tabouk	678.8	390.6	288.2	42.5
Hail	1252.0	867.3	384.7	30.7
Jazan	1889.0	574.3	1314.7	69.6
Najran	233.4	150.4	83.0	35.5
Al-Baha	111.1	38.8	72.3	65.1
Al-Jouf	1398.3	872.7	525.6	37.6

Issues on water conservation

- Water losses through percolation
- Irrigation efficiency
- High evapotranspiration
- Water loss through pipeline
- Reuse of treated wastewater
- Crop yields and product quality
- Technical feasibility
- Cost per unit production

Summary, Conclusions, Recommendation

- Understand crop yields for differed growing seasons
- Life cycle analysis for TWW reuse
- Water footprint analysis related to cattle farms
- Technology to minimize water percolation
- Full or partial green-house cultivation
- Leak detection in the pipelines
- Recycling and reuse of TWW

Thanks for listening