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Science for resilient livelihoods in dry areas

Water Resources in Arid Areas 2020

Water for Food, Water for Life: The Drylands Challenge

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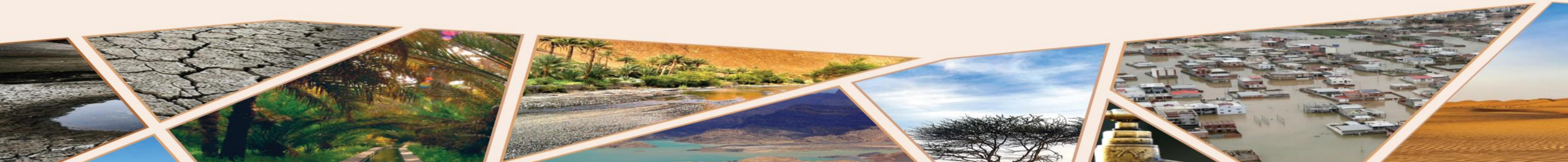
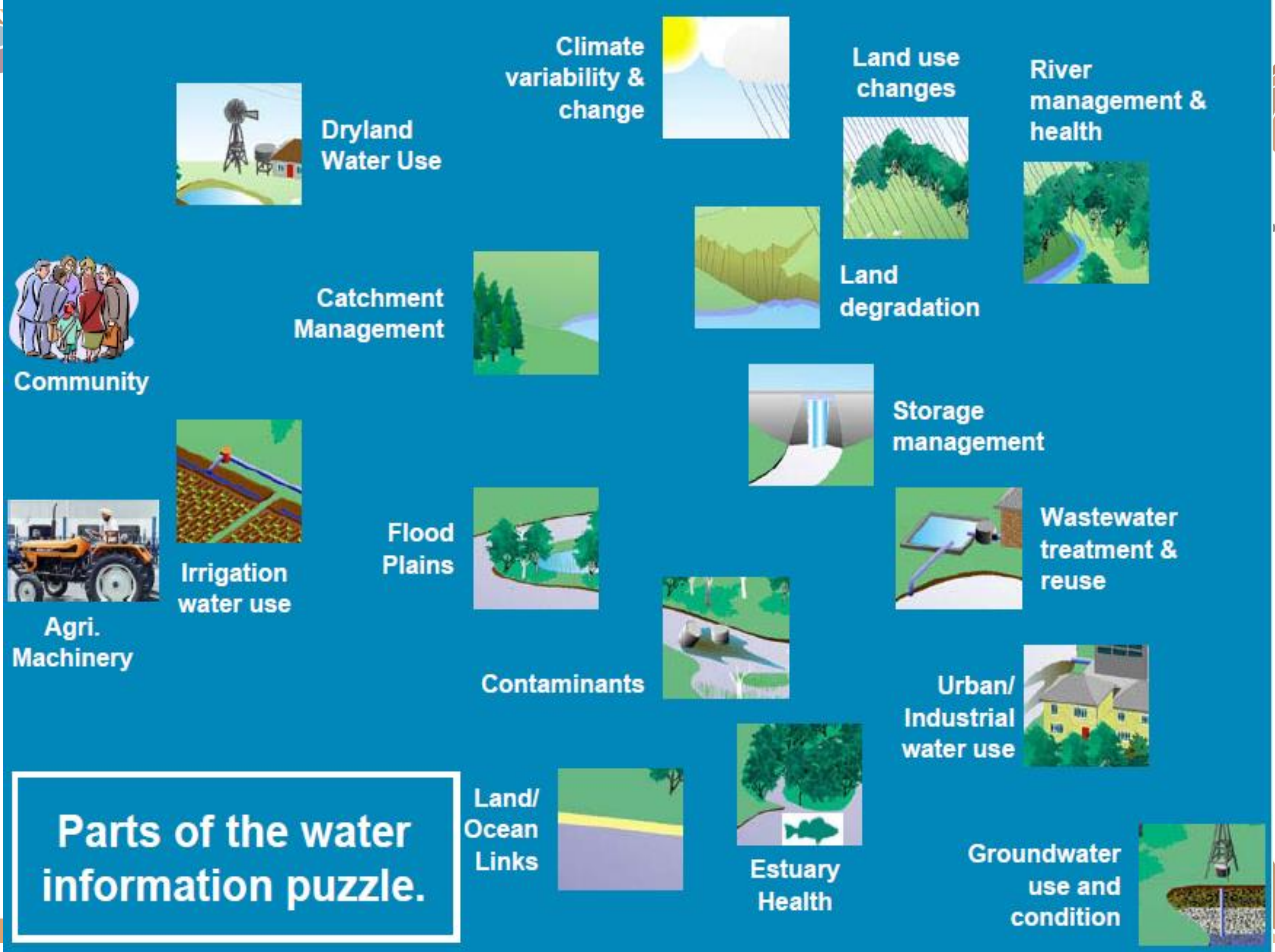


Food: A National Security Issue

- More than 100 countries import part of the wheat they consume; some 40 import rice
- Iran and Egypt imports 40% of their grain supply
- For UAE and Yemen, over 90%
- United States, Canada, France, Australia, Argentina, and Thailand—supply 90% of grain exports
- United States controls 1/2 of world grain exports
- Virtual Water Trade=1,625,000,000,000 liter/yr; 80% of it related to agricultural products



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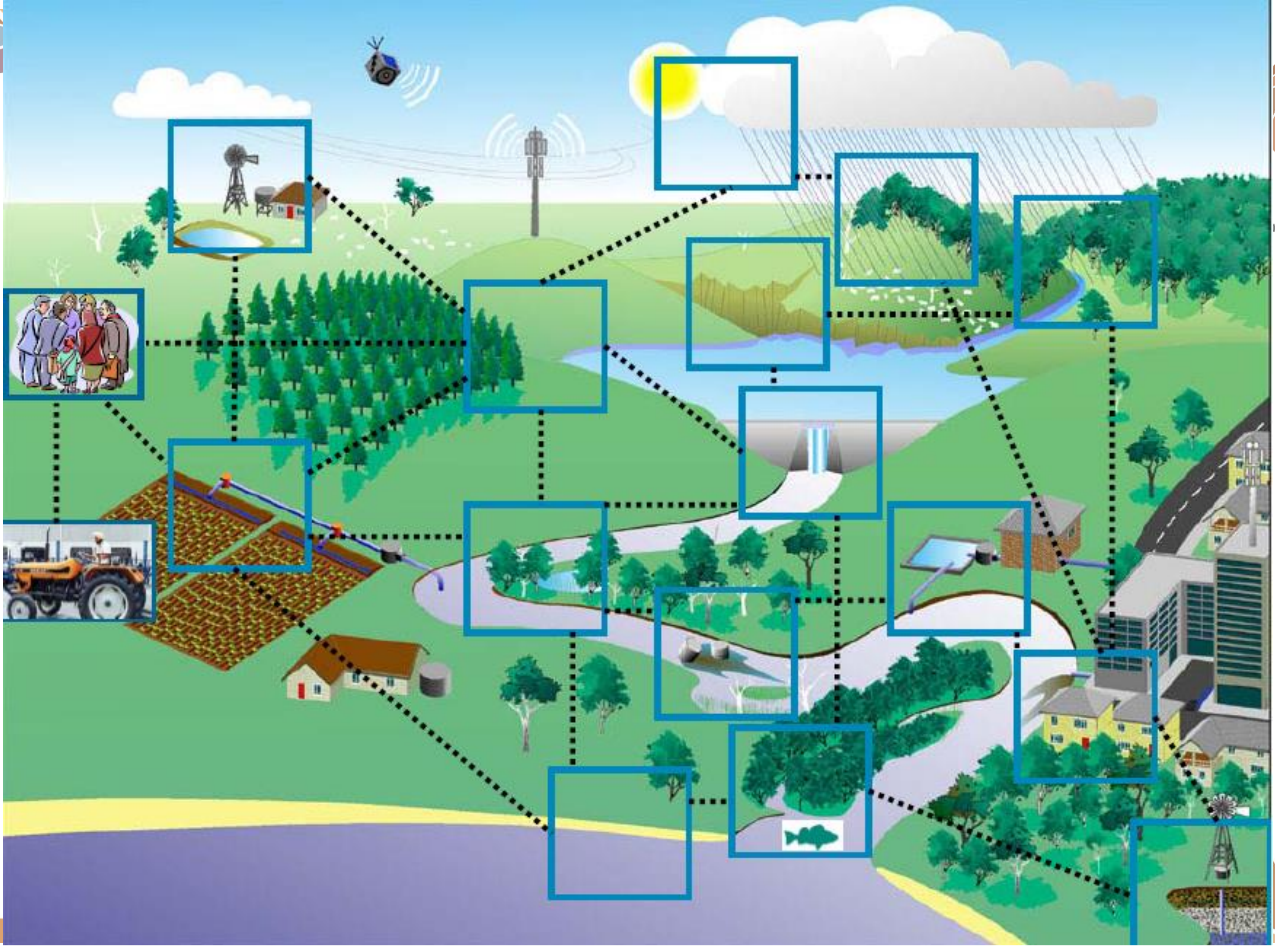

Why Do Dry Areas Matter?

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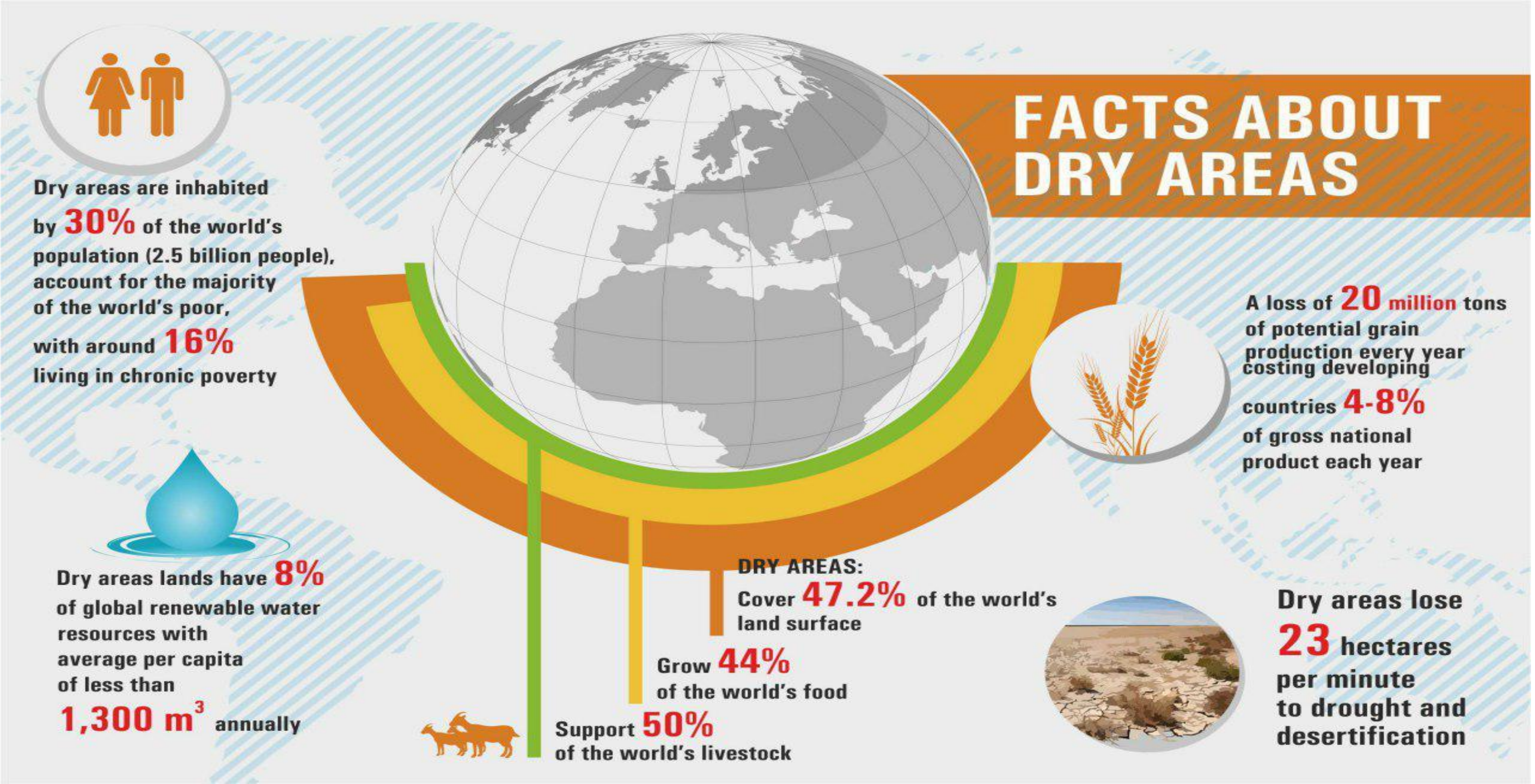
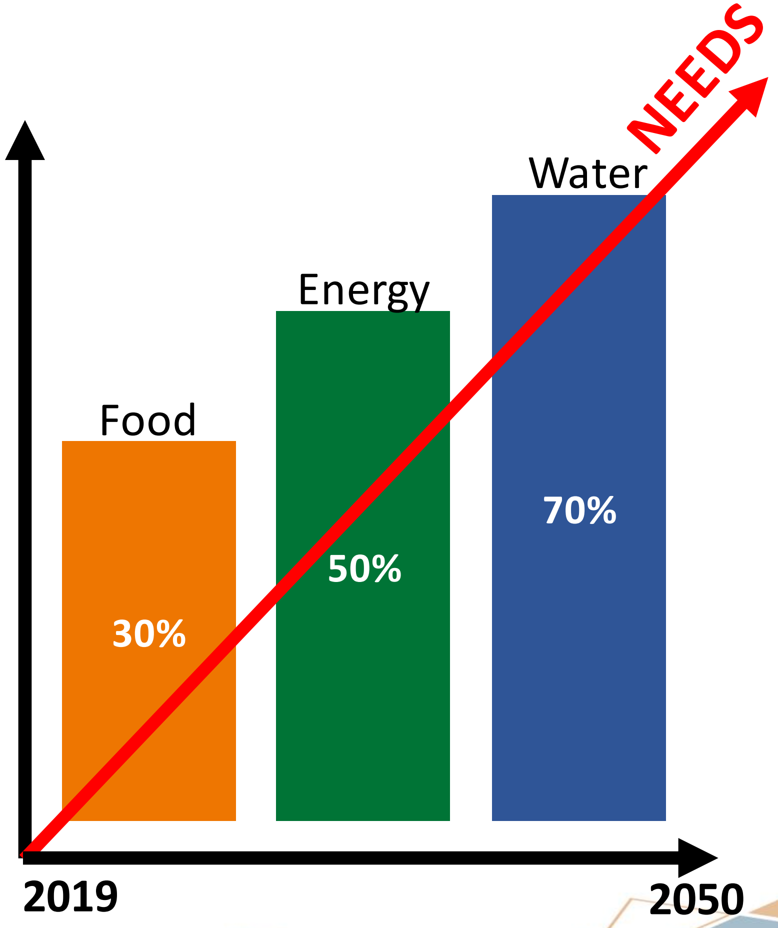


Climate change and increasing needs

- Adverse effects of climate change are **more pronounced in the arid areas**
- Leads to **vulnerable**, **unsustainable** and **unpredictable** farming
- Variability and evolution of climate, diet and demography caused by changing edapho-climatic factors



Arid Areas: Expanding with climate change

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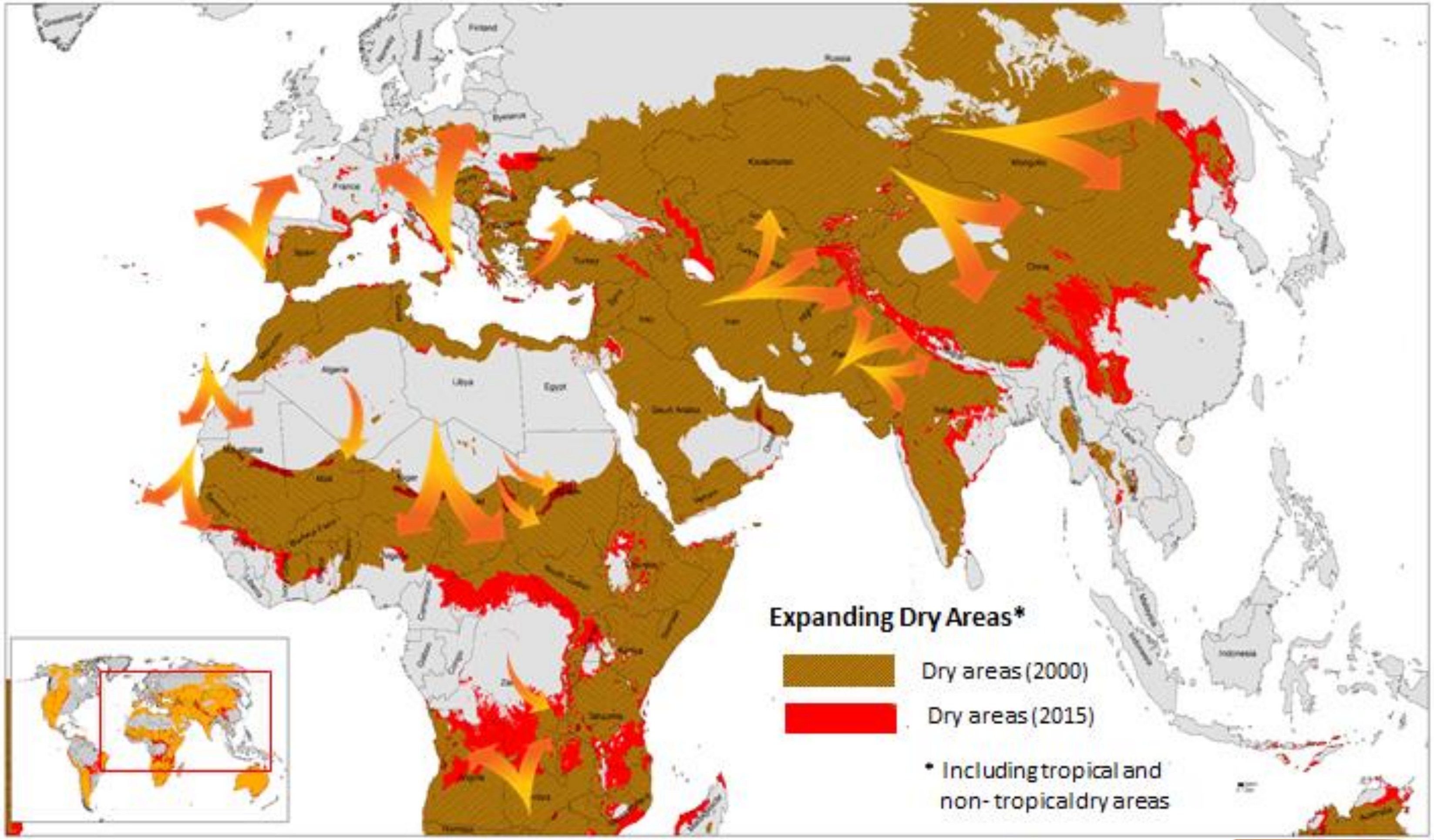

The Perfect Storm

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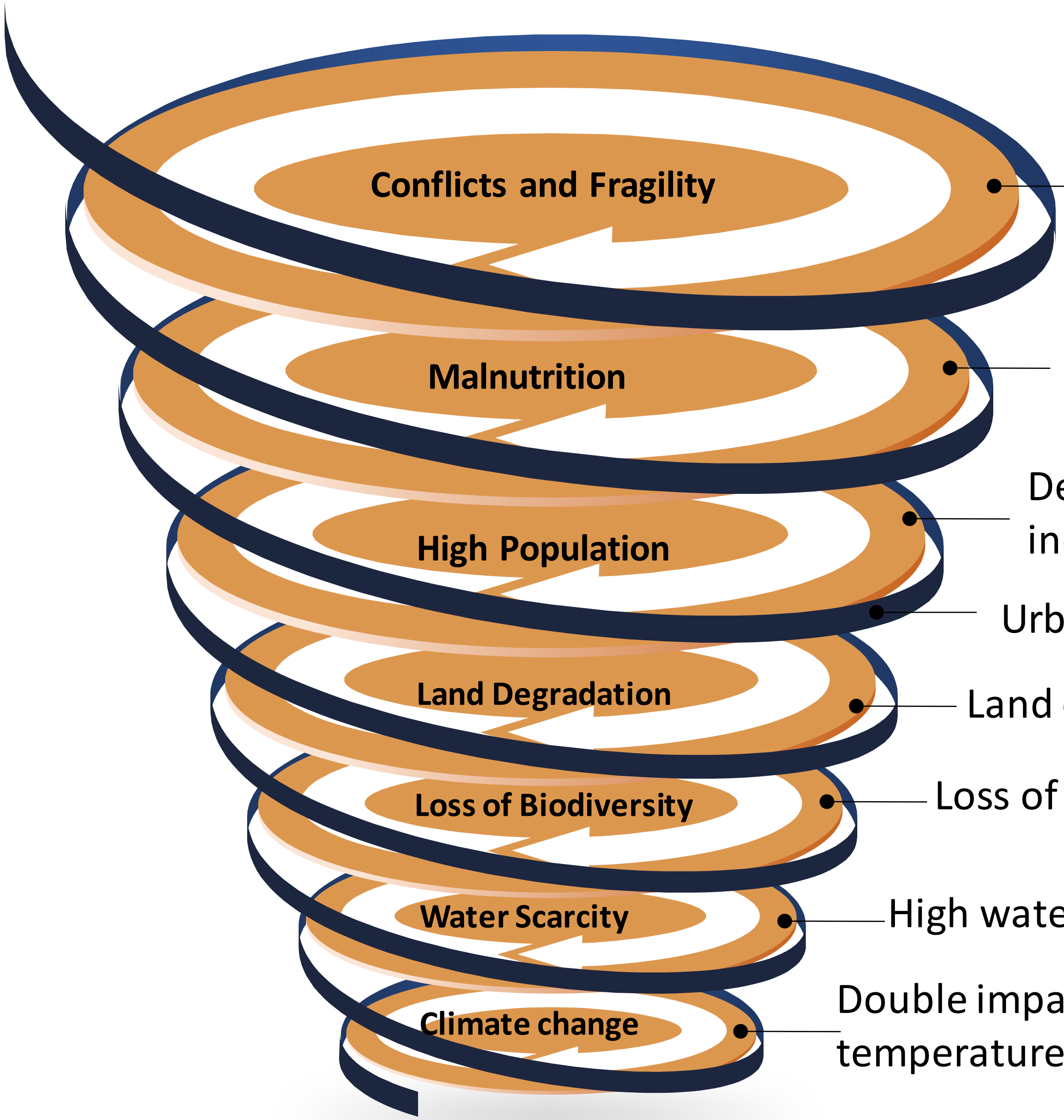


High unemployment, unrest and migration

Food and nutrition insecurity

Demographic changes, gender inequality

Urbanization and heat islands

Land degradation and desertification

Loss of agrobiodiversity

High water scarcity and low efficiently

Double impact of climate change; increasing temperature and reducing precipitation

We need to move faster

SUSTAINABLE DEVELOPMENT GOALS

2 ZERO HUNGER

1 NO POVERTY

6 CLEAN WATER AND SANITATION

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

8 DECENT WORK AND ECONOMIC GROWTH

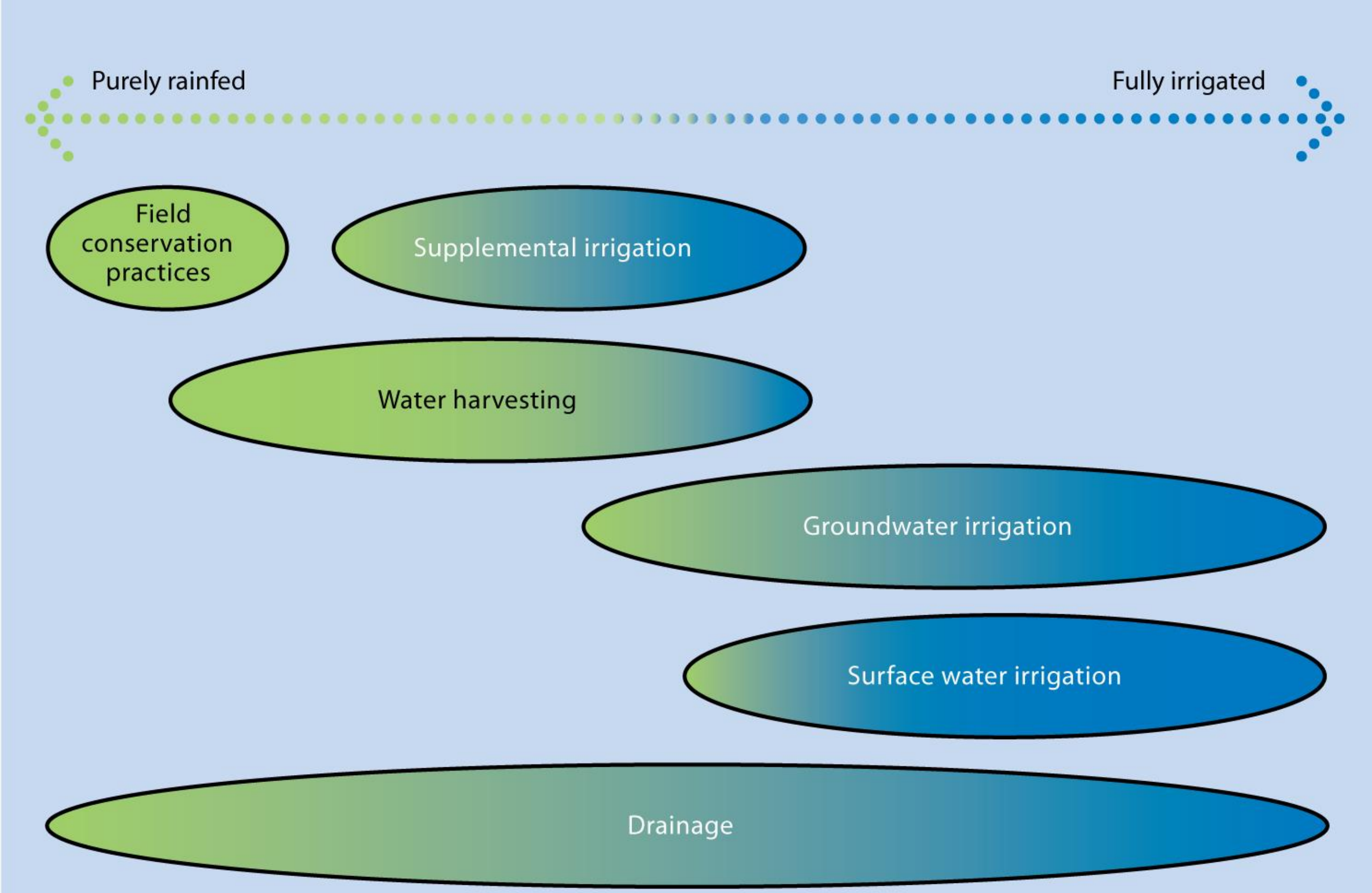
13 CLIMATE ACTION

17 PARTNERSHIPS FOR THE GOALS

15 LIFE ON LAND

Only 10 harvests before 2030

Conventional Solutions



Source: Stockholm Environment Institute, 2018

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Smart farming requires a paradigm shift

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Water Resources in Arid Areas 2020

1. Diversity for resilience (rotations/intercropping; mix farming…)
2. Nature-based solutions, technology and circularity for ecosystems services (including water productivity and trade-off management)
3. Smart knowledge (data, models, ICT) for adaptation to:
   - Variability (rainfall, soils, farms…)
   - Changes (climate, markets, demography…)
   - Capacity development of farmers

Water and livelihoods: The case of irrigated farming communities in Rajasthan (India)


STAGE I

STAGE II

Results-Economic Water Productivity

STAGE I – flood-irrigation cropping systems

Cropping system	Yield (kg/ha mm)		Return (rupees/ha mm)	
	Biological Yield	Seed Yield	Gross Return	Net Return
	Water Productivity (in terms of water applied)			
Cotton - Wheat	13.4	4.8	134.4	79.6
Cotton - Mustard	12.3	3.6	137.9	78.3
Clusterbean - Wheat	16.3	5.9	327.1	273.2
Clusterbean - mustard	15.5	4.6	383.6	323.1
Cotton – Barley	15.1	5.3	155.3	91.4
Cotton – Chickpea	12.2	3.7	151.8	91.5

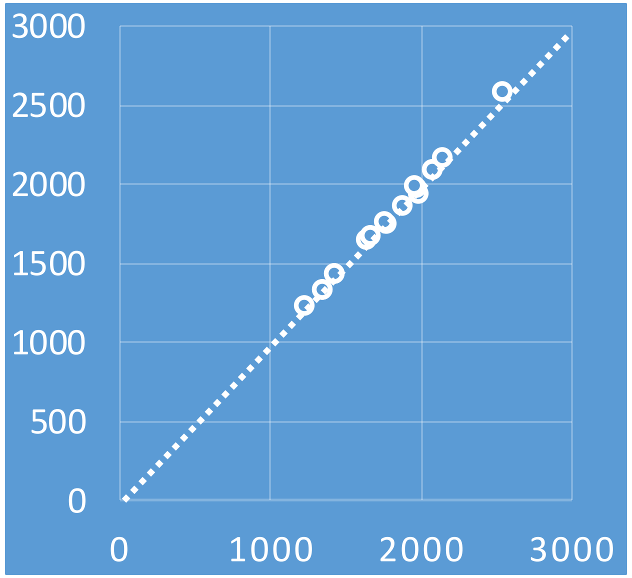
Results-Economic Water Productivity

Stage II – Solar-powered Pressurized Irrigated Cropping Systems

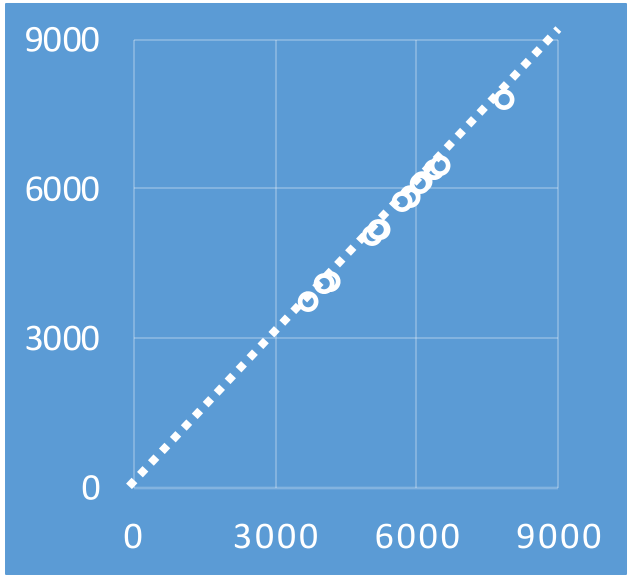
Cropping system	Yield (kg ha^{-1} mm)				Monetary return (Rupees ha^{-1} mm)			
	Biological Yield		Seed Yield		Gross Return		Net Return	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Water Use Efficiency (in terms of water applied)								
Groundnut - Wheat	10.6	12.0	4.3	4.9	182.5	201.3	124.6	144.8
Groundnut - Cumin	7.7	10.1	3.0	3.9	202.4	265.1	142.6	197.7
Groundnut - Isabgol	7.7	9.4	3.1	3.7	344.5	468.1	283.5	402.7
Groundnut - Mustard	10.8	14.1	4.0	5.3	207.1	271.3	148.7	204.8
Clusterbean – Chickpea	12.2	17.1	4.2	6.3	210.5	317.4	140.1	217.2

Results-Modeling-Stage I

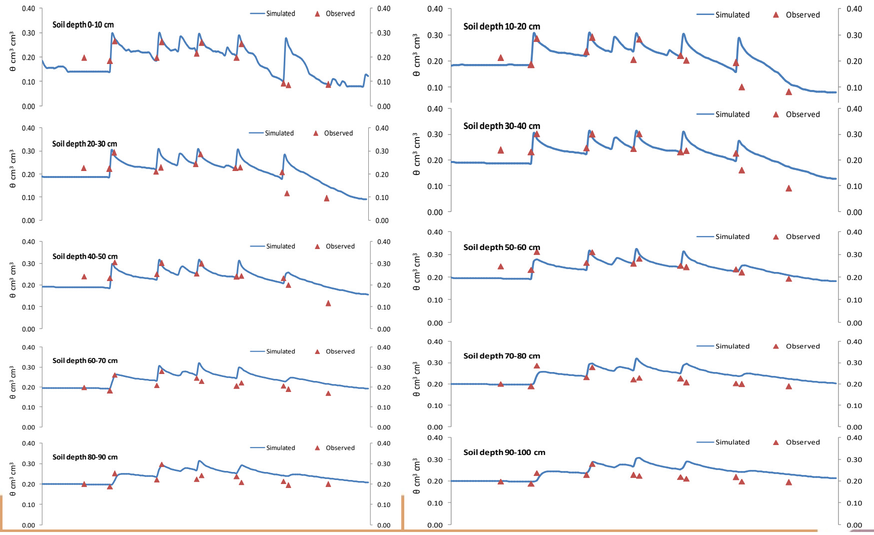
Water Resources in Arid Areas 2020



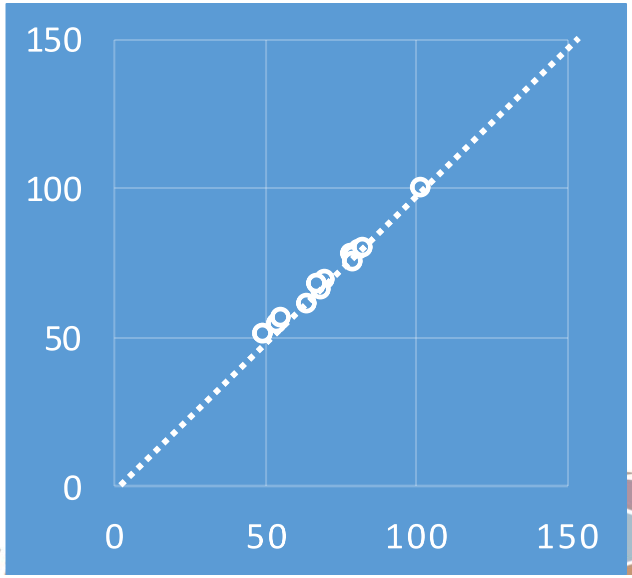
STAGE I, Mustard, AGB



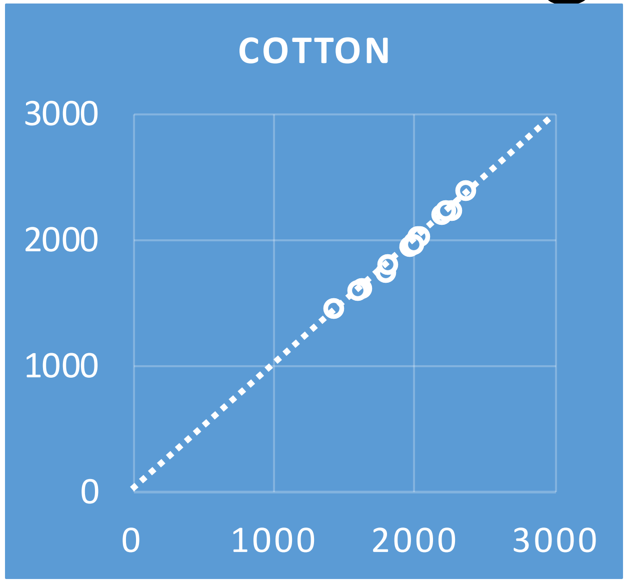
STAGE I, Mustard, Soil moisture

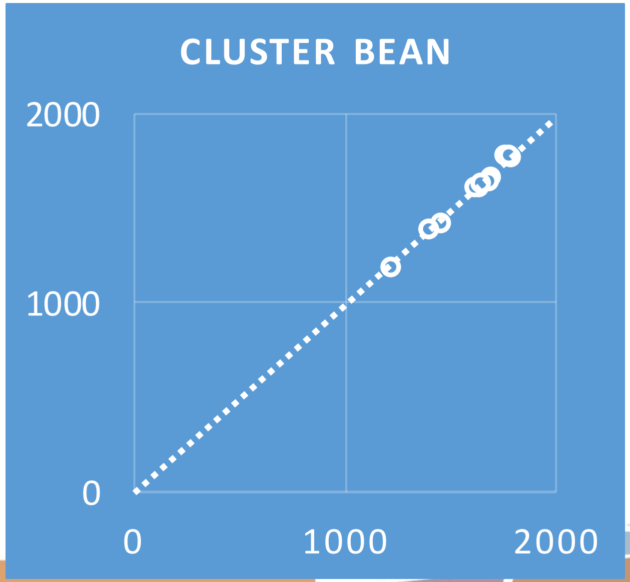


STAGE I, Mustard, N-uptake



Results-Modeling-Stage I





Results-Modeling-Stage II

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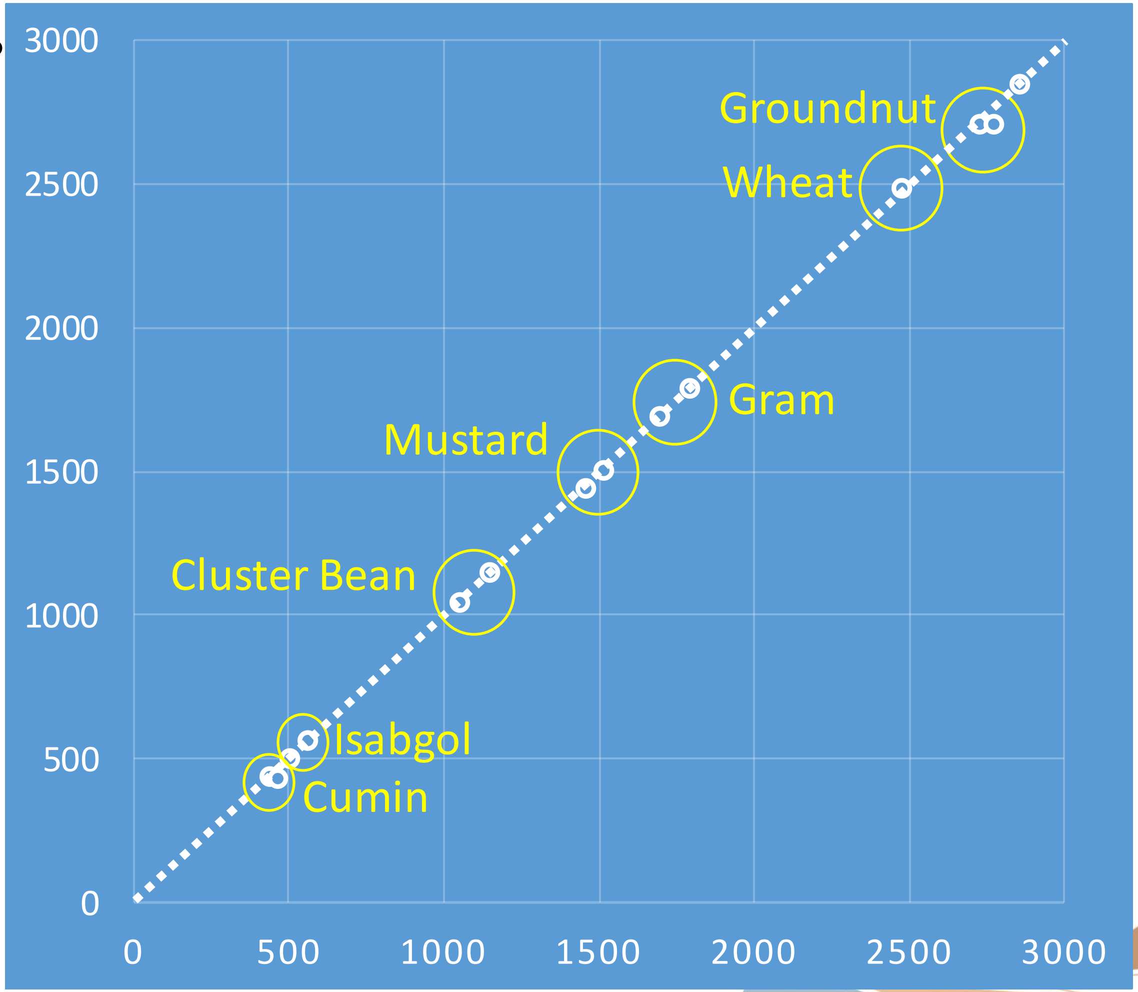
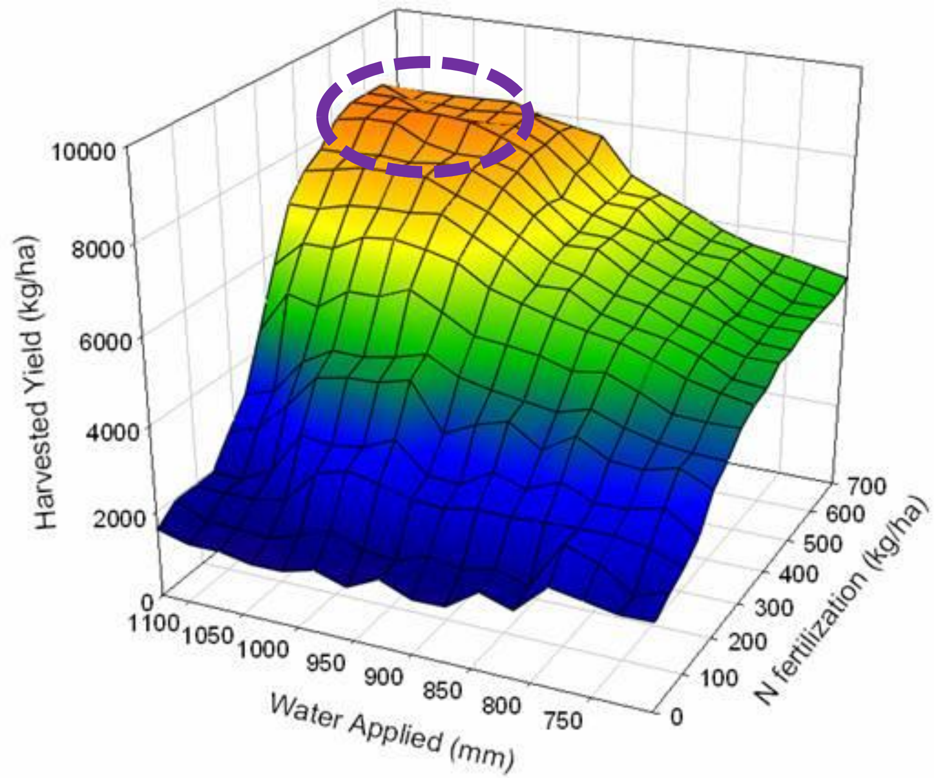
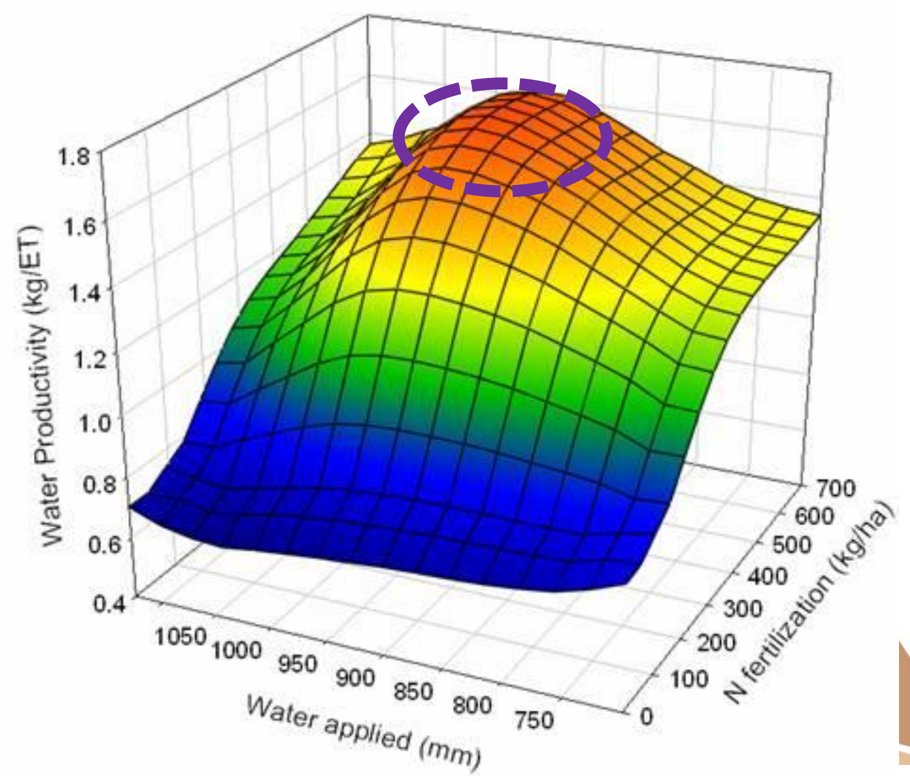


Typical Land and Water Productivity Relationship with N and Water Applied

If **land** is limiting production factor



If **water** is limiting production factor



Recommended Packages-Stage I

Crop	Farmer N	Farmer Irrigation	Farmer Yield	Farmer WP	Recommended N	Recommended Irrigation	WP	% WP increase
Wheat	100	500	3900	0.79	160	400	1.36	72
Cotton	100	400	2050	0.50	150	300	0.72	44
Mustard	60	300	1750	0.55	100	200	1.53	178
Cluster Bean	60	100	900	0.90	100	100	1.53	70

Recommended Packages-Stage II

Crop	Farmer N	Farmer Irrigation	Farmer Yield	Farmer WP	Recommended N	Recommended Irrigation	WP	% WP increase
Cluster bean	20	200	1700	0.47	60	100	1.27	290
Mustard	60	350	1800	0.51	100	250	1.03	102
Wheat	100	550	1600	0.29	160	400	0.58	100
Groundnut	40	550	400	0.07	60	400	0.15	114

rid Areas 2020

Solar-powered Ultra-Low Energy Drip Irrigation for MENA Countries

Jain Irrigation Systems Ltd.

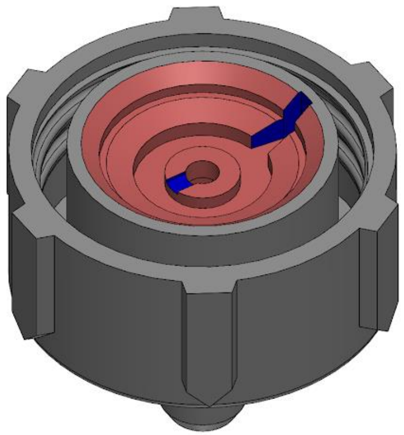
USAID

من الشعب الأمريكي

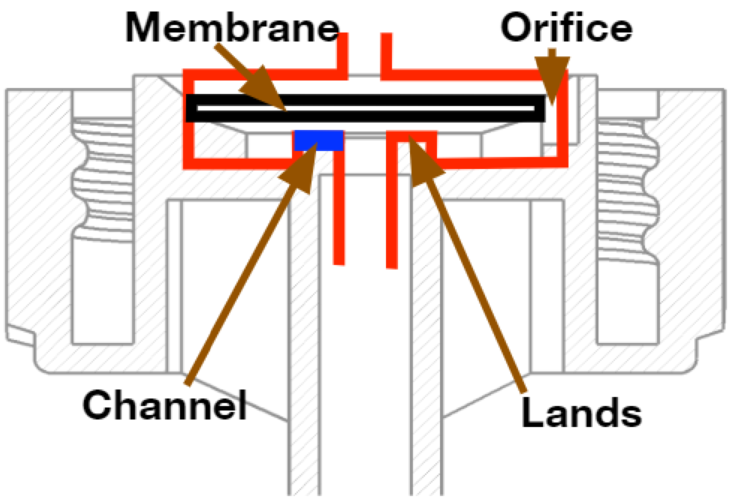
المعهد الوطني للبحث الزراعي

Institut National de la Recherche Agronomique

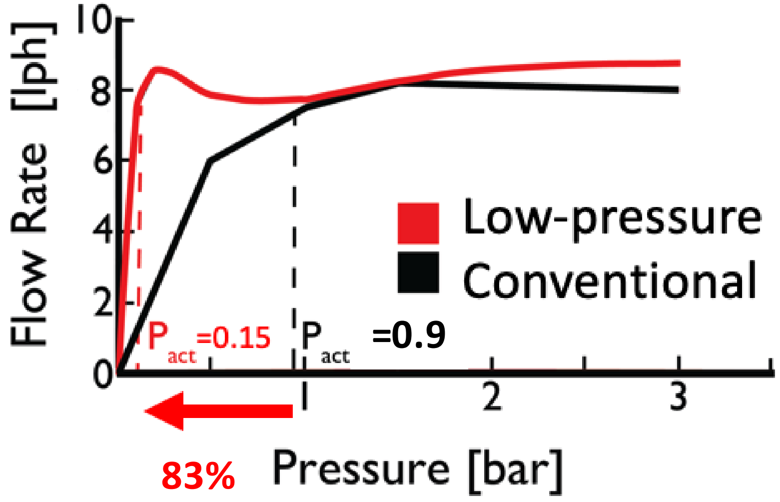
ICARDA introducing drippers to reduce activation pressure bv 83%



Emitter design was based on commercially-available emitters to ensure they could be **easily manufactured** at the same cost

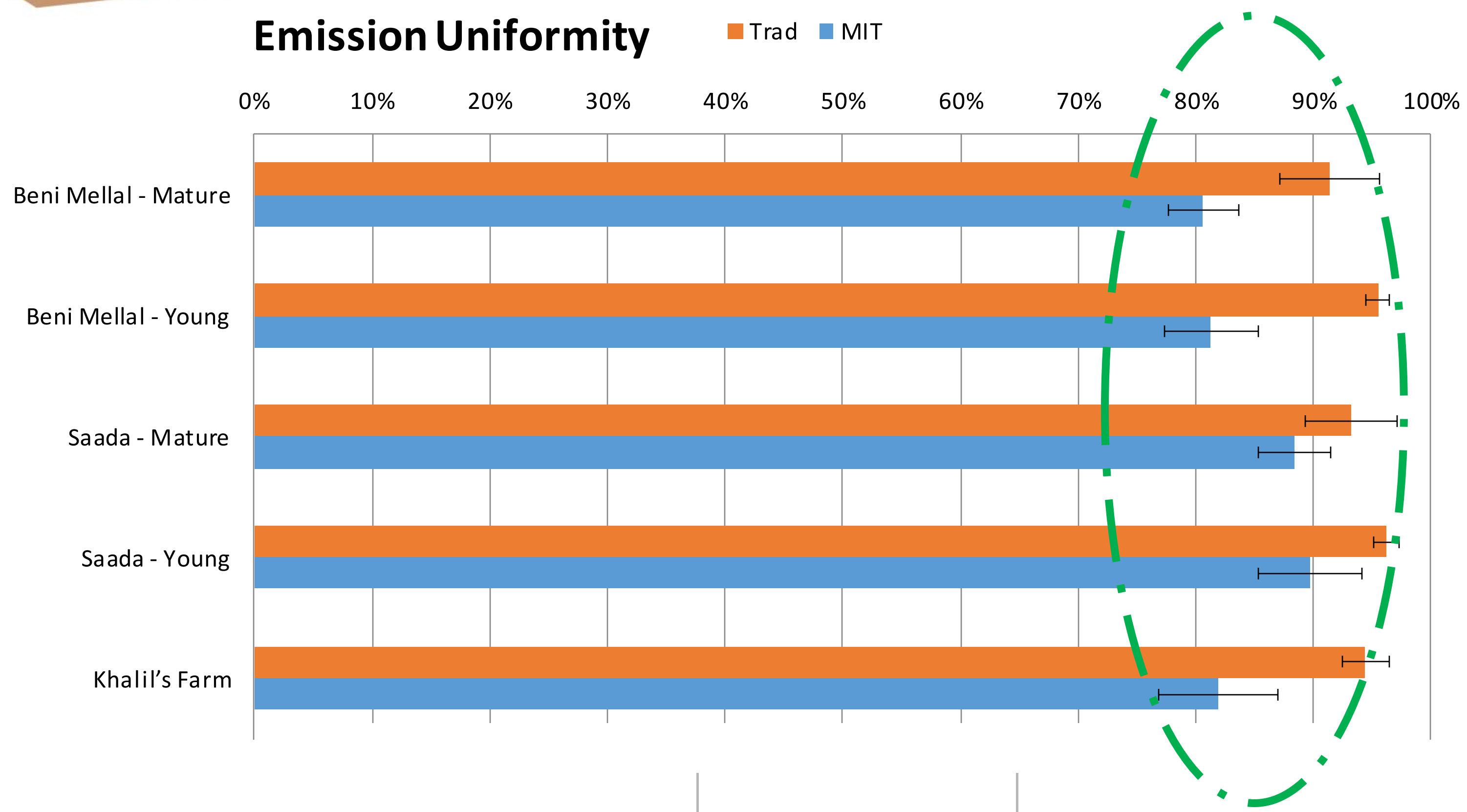


The important **flow** and **structural geometries** were characterized analytically. A **genetic algorithm** was used to adjust geometry for lower P_{act}

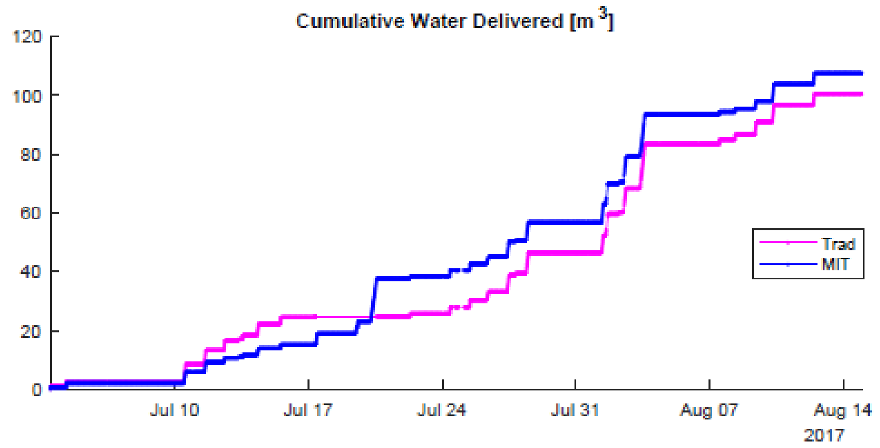


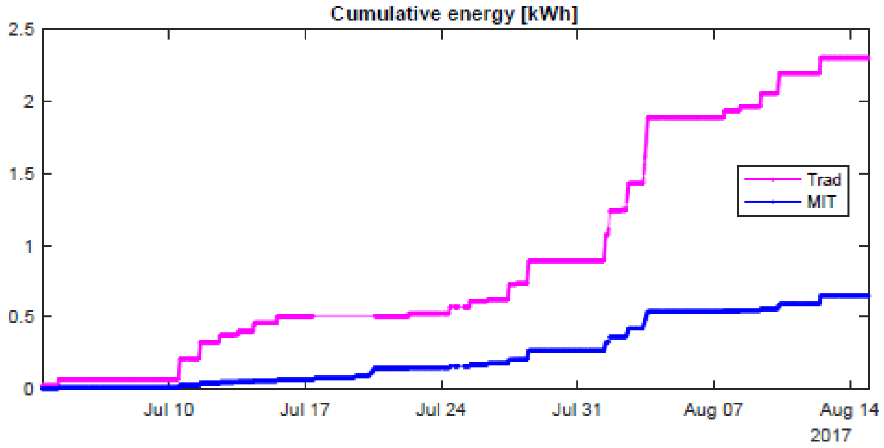
Lower P_{act} can reduce cost of off-grid drip system by **up to 40%**

Shamshery, P., Wang, R. Q., Tran, D. V., Winter, A., 2017. PLoS One. 12:e0175241
Shamshery, P., Winter, A. G., 2017. Journal of Mechanical Design. 140:35001-35007



Mean ± SD (m^3/h, bar)	MIT	Trad
F1	1.70 ± 0.78	1.96 ± 0.81
P1	0.14 ± 0.13	0.76 ± 0.38





	Trad	MIT	Diff (%)
Total water delivered (m^3)	100.6	107.5	6.9%
Total energy used (kWh)	2.30	0.65	-71.7%
Energy/vol water (Wh/m^3)	22.90	6.05	-73.6%

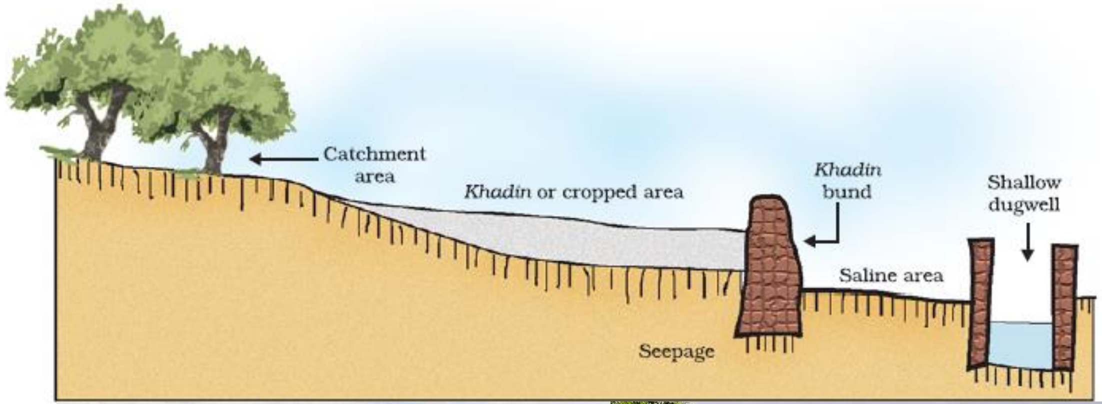
Improving Economic Water Productivity in *Khadin* Systems in Rajasthan

Context

- ***Khadin*** is an indigenous water harvesting practice for ***in-situ* soil moisture conservation.** But this practice allows for growing marginal crop that can withstand soil-water deficit
- We are conducting a study in **Jodhpur** in which we harvest rainwater into a small reservoir for **supplemental irrigation to grow cash crops to maximize economic water productivity**

Systems being Compared:

- Within *khadin*: **Rabi:** Barley, gram, mustard. **Kharif:** Water melon, musk melon, cucumber
- Outside ***khadin*** with harvested water: **Guava trees all around field**. Mung bean-barley, moth bean-gram, cluster bean-mustard rotations



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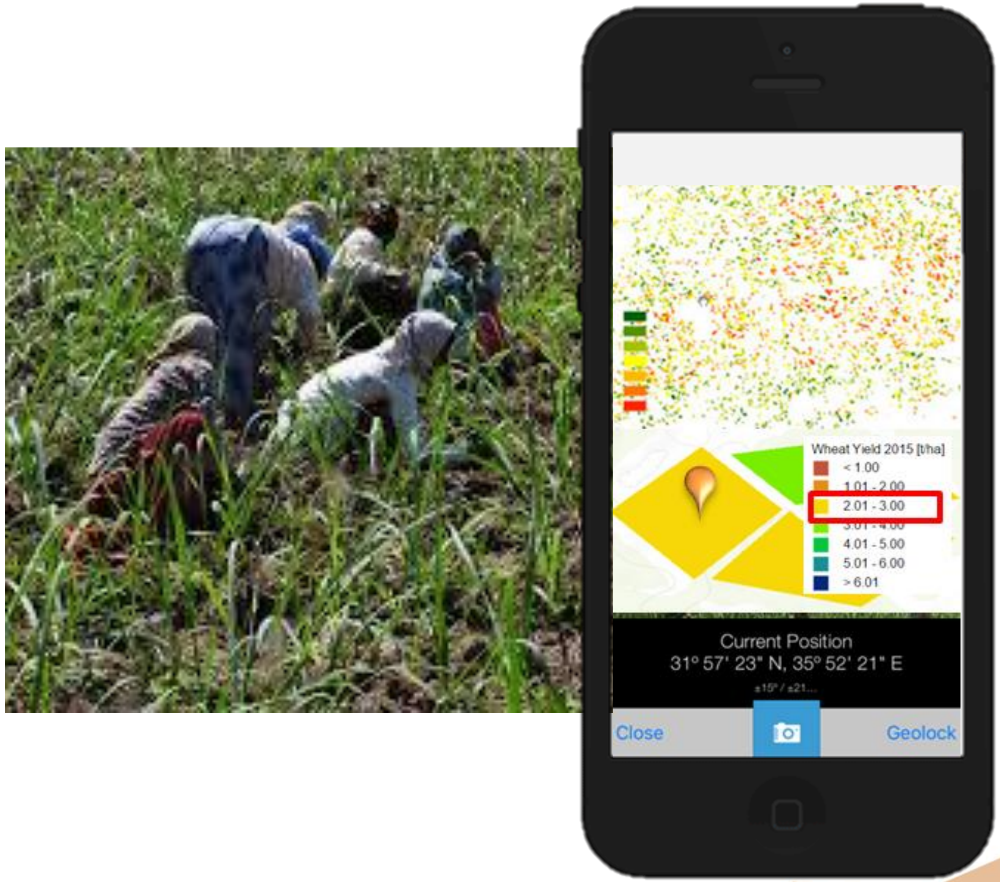
Systemic Design and Management of agro-ecosystems

Sustainability is achieved through proper combinations of appropriate technologies – not single technologies on their own

1. Water harvesting
2. Feed resources
3. Livestock management
4. Marab agriculture
5. Collective land governance

Digital advisory services

- Applications in this domain are rapidly expanding, allowing farmers and advisors to access knowledge on crops and varieties, pests and disease, input, markets and climate using their smartphone.



Multi-scale knowledge on climate variability

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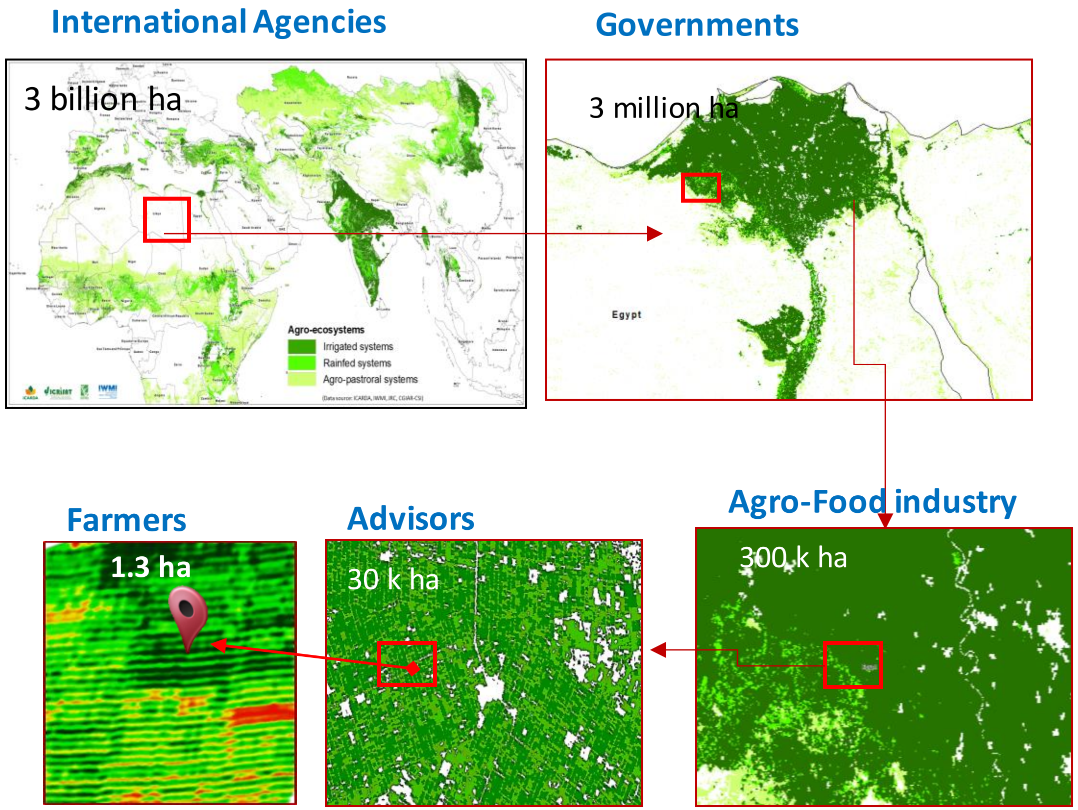
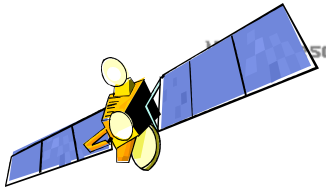
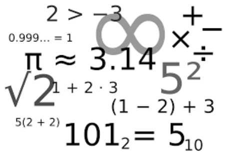
…sources in Arid Areas 2020

- Information available at different scale for different stakeholders
- High-tech to provide indicators… and field data for credibility







Concluding remarks - Some difficult choices

There will be “non-negotiable” food-environment tradeoffs, as well as negotiable ones. More land and water will be needed for food (and now bio-fuels)

Choices:

- Water storage for agriculture – water for environment
- Reallocation – over allocation
- Upstream – downstream
- Equity – productivity
- This generation – the next one (GW decline)

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