IWMI International Water Management Institute

Zentrum für Entwicklungsforschung
Center for Development Research
University of Bonn

Options of Regional Crop Specialization for Sustainable Water Use in the Aral Sea Basin

IAMO Conference, Halle (Saale), 24-26 November 2014

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Motivation/Contents:

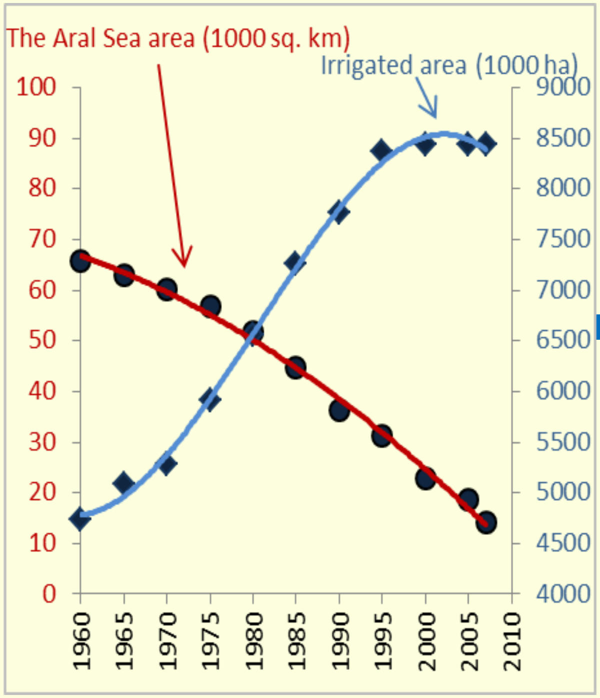
Assess potentials of cooperative coordination of limited land and water resources for optimal agricultural production in the Aral Sea Basin (ASB)

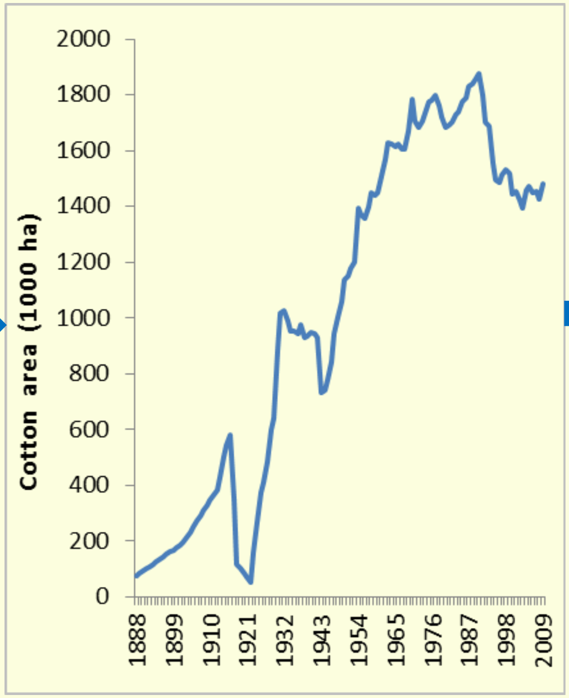
- Water use issues and cropland pattern changes over years in the ASB
- A short overview of the basinwide water and land use economic model
- **Current** vs **optimal** crop land allocation patterns
- Impact of water availability on optimal cropland patterns
- Conclusions and further research

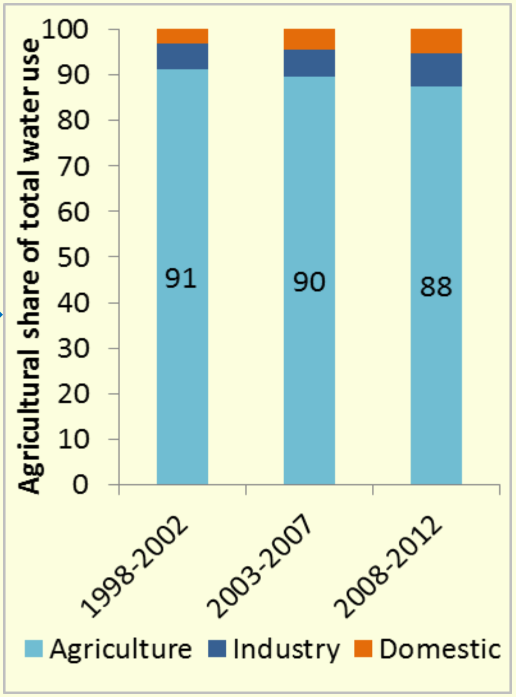
The Aral Sea Basin is One of the Largest Irrigation Zones in the World (over 8 million ha)

Source: Modified after Royal Haskoning (2010)

The Tremendous Expansion of Irrigation and Particularly Cotton Production Occurred since 1960s till 1990 and Accompanied by Enormous Diversion of River Flows Leading to the Aral Sea Desiccation

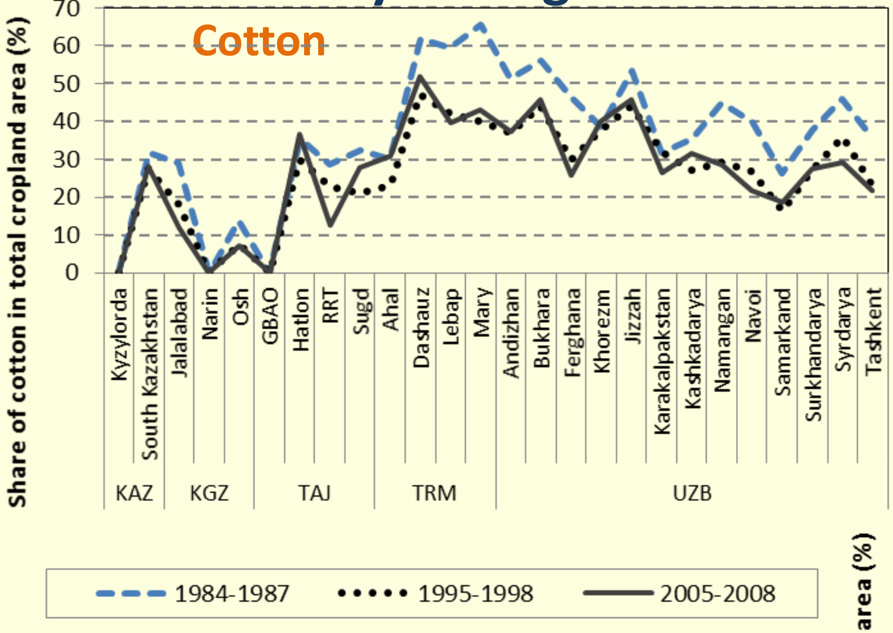


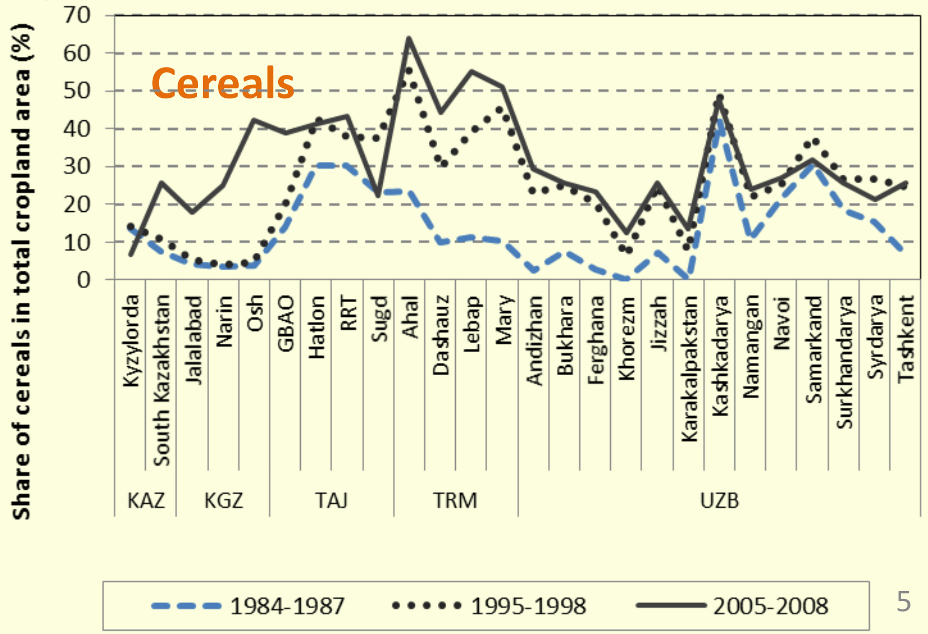




Source: Based on Micklin (2010), MAWR (2010), FAO (2013)

Cotton Areas Slightly Reduced Not to Decrease Hard-cash Revenues and Cereals Production Rapidly Expanded to achieve National Food Self-Sufficiency throughout the Basin aftermath of the Independence





Source: Based on SIC-ICWC (2010)

Method

A static hydro-economic model of IFPRI (Ringler et al 2004) modified and adapted to the case of the Aral Sea Basin

All economic costs and benefits are at price levels of 2006

Crop-specific
Inter-regional
Seasonal

Objective function:

Irrigation benefit

$$\sum_c \sum_r \sum_t \left(Revenue_{c,r,t} - Costs_{c,r,t}\right) +$$

c-crop, r-region, t-technology

Hydropower production benefit

$$\sum_h \sum_s energy\_price_{h,s} hydropower\_prod_{h,s} +$$

h-hydropower station, s-season (month)

Environmental flow benefit

$$environ\_ben\_per\_water \sum_s environ\_flow_s \rightarrow \max$$

17985 equations and 18405 variables

[For more details, see Bekchanov M. (2014): Efficient water allocation and water conservation policy modeling in the Aral Sea Basin (PhD Thesis)]

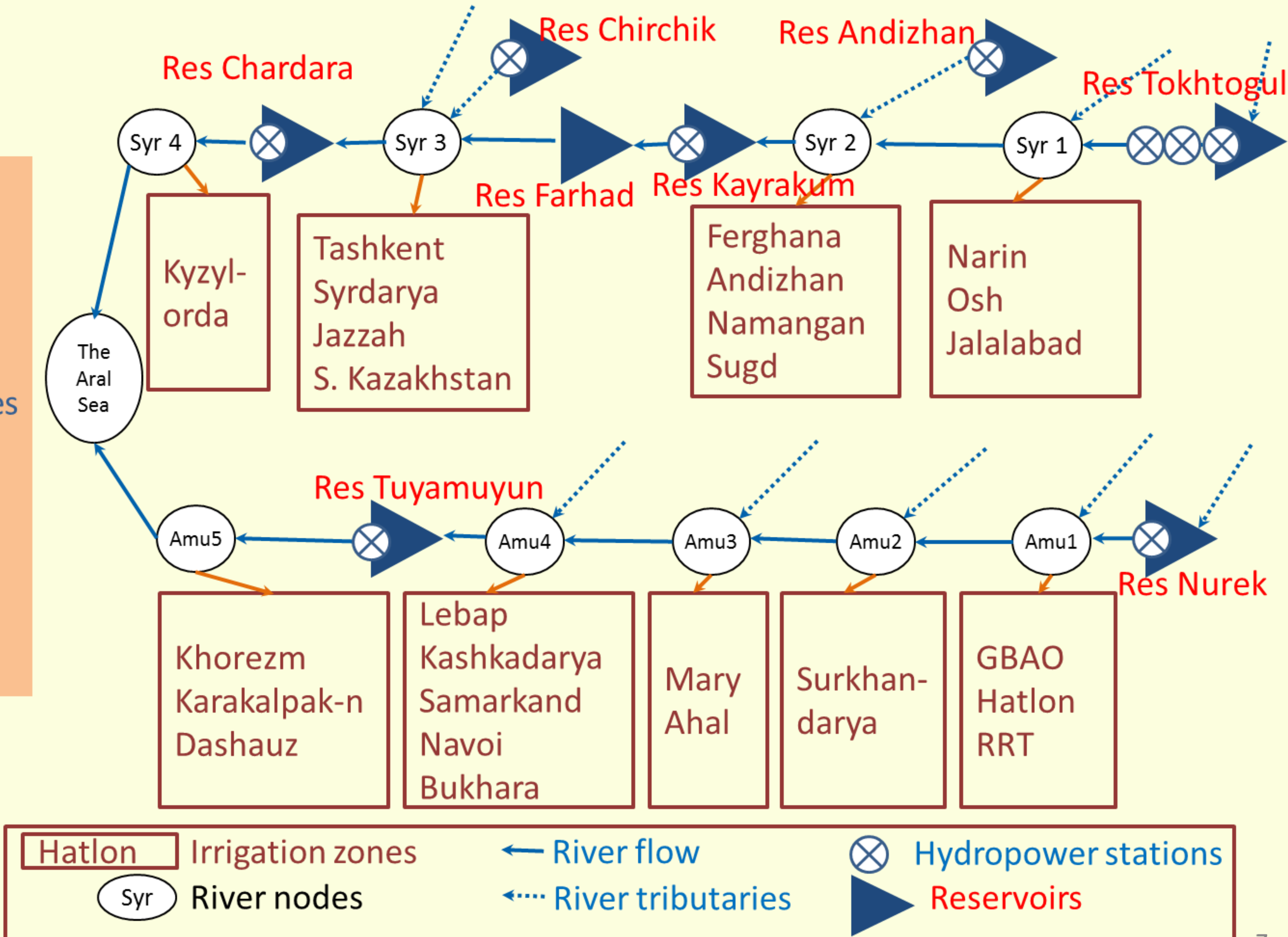
River node scheme of the Aral Sea Basin

9 river nodes

32 main river tributaries

26 irrigation zones

11 crops

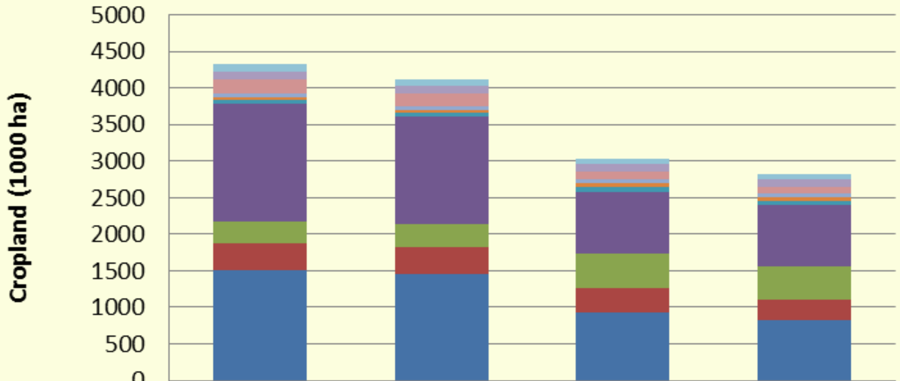


Main variables of the model:

- Crop production, crop revenue, cropland area, crop yield, crop evapotranspiration
- Water losses in field and conveyance, groundwater level change
- Water withdrawal, groundwater use, return waters
- River flow, environmental flow, environmental benefits, reservoir storage change
- Hydropower production, reservoir volume, release of water from reservoirs

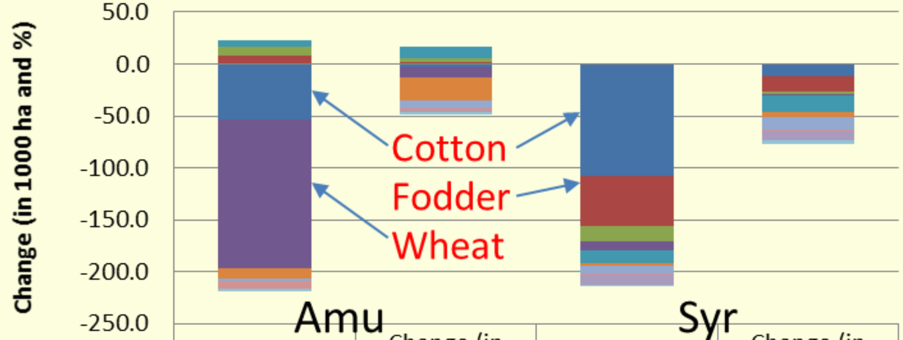
Achieving Optimal Basin-wide Gains Require Slight Reduction of Cotton, Considerable Decrease of Wheat, and Slight Increase of Fodder Production in the Amu Darya Basin, and Considerable Reduction of Cotton, Fodder Crops, and Slight Reduction of Wheat Areas in the Syr Darya Basin

Baseline vs Optimal Crop Patterns



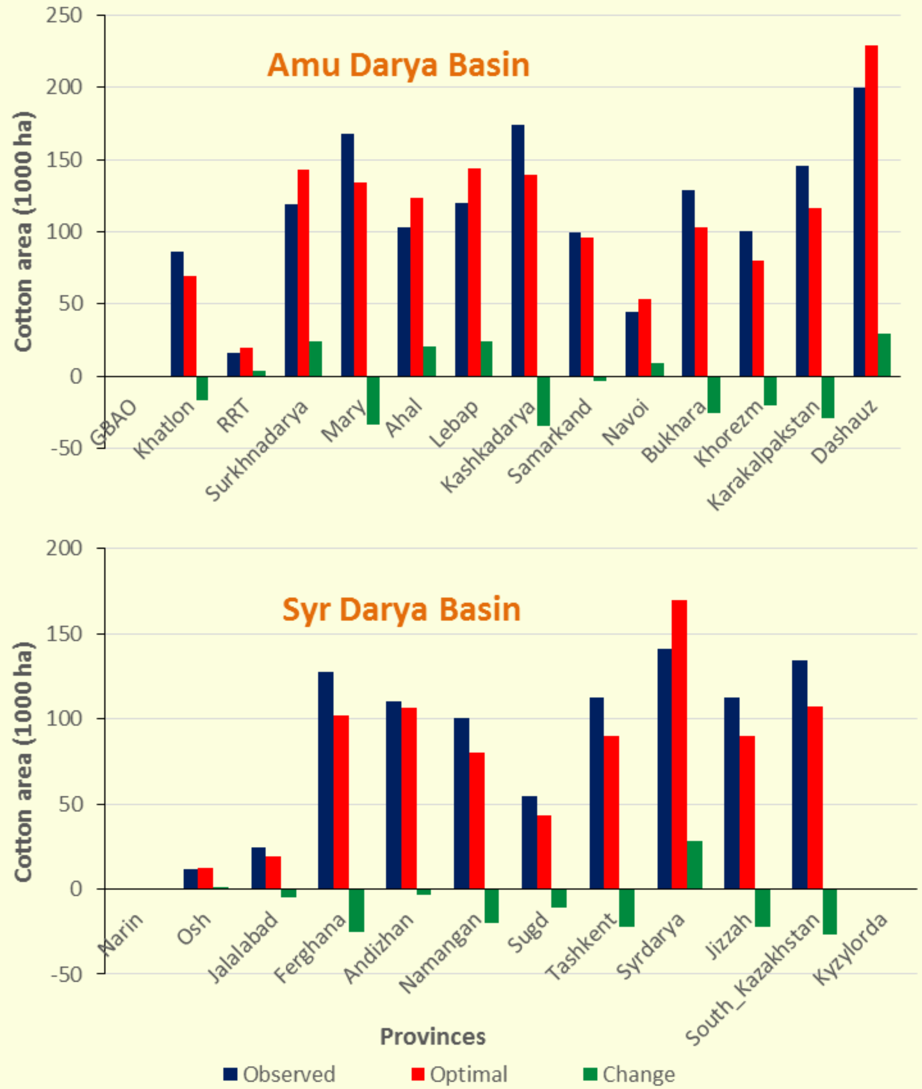
	Amu Darya basin – Observed	Amu Darya basin – Optimal	Syr Darya basin – Observed	Syr Darya basin – Optimal
Grapes	103	101	81	79
Vegetables	99	98	107	97
Beet	1	1	2	2
Rice	189	182	99	97
Potato	48	44	55	48
Cords	45	35	48	46
Maize	47	53	75	62
Wheat	1617	1475	839	831
Fruit	299	308	467	453
Fodder	368	377	337	289
Cotton	1505	1451	929	821

Crop Pattern Change under Optimization

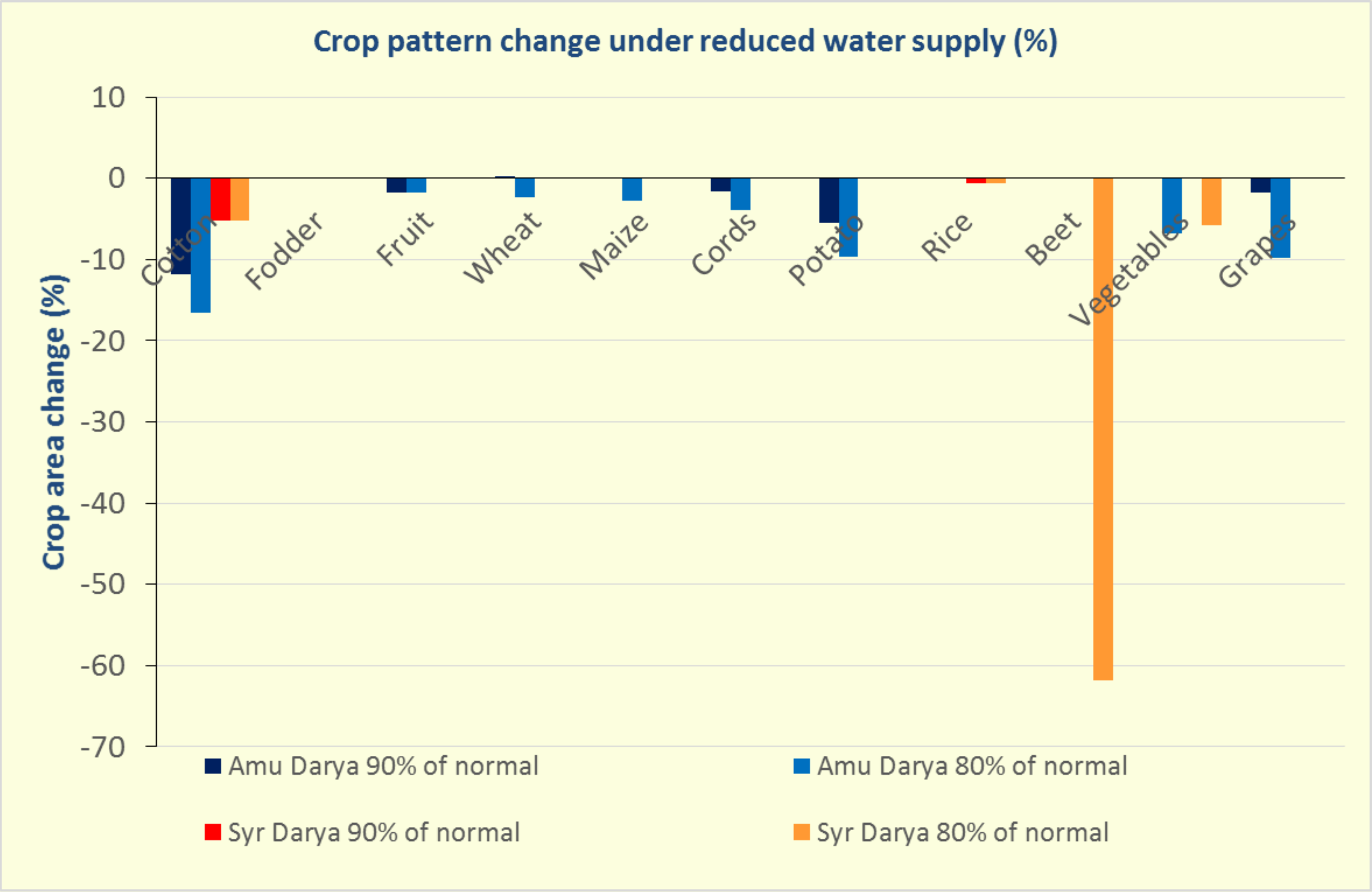


	Amu – Change	Amu – Change (in %)	Syr – Change	Syr – Change (in %)
Grapes	-2.4	-2.4	-2.2	-2.7
Vegetables	-0.6	-0.6	-9.5	-8.9
Beet	0.0	0.0	0.0	0.0
Rice	-6.8	-3.6	-1.8	-1.8
Potato	-3.5	-7.4	-7.0	-12.6
Cords	-9.9	-22.2	-1.9	-3.9
Maize	5.6	11.8	-12.4	-16.5
Wheat	-142.0	-8.8	-8.8	-1.0
Fruit	8.5	2.8	-14.5	-3.1
Fodder	8.2	2.2	-48.8	-14.5
Cotton	-54.1	-3.6	-107.7	-11.6

Cotton Area Reduction is Needed in the Provinces such as Lebap, Kashkadarya, Bukhara, Khorezm, Karakalpakstan of the Amu Darya Basin and Ferghana, Namangan, Sugd, Tahsket, Jizzakh, Kyzlorda of the Syr Darya Basin but Should be Increased in the Remaining Provinces for Gaining Basin-wide Optimal Benefits



Reductions in Natural Water Supply Requires Further Decline of Cotton, Potato, Grapes, and Beet Areas



Conclusions:

- Current cropland patterns neglect the potentials of basin-wide cooperative coordination based on regional comparative advantages

- Need for improved crop land and water allocation crops to achieve optimal basin-wide benefits through reducing the present dominance of cotton and wheat

- Need for adaptive and long-term land and water management to cope with reduced water availability

- Regional market liberalizations and establishment of institutions to facilitate inter-regional trade

Next Steps:

- A dynamic modeling framework
- Inter-regional agricultural component
- Integrated GIS and Hydro-Economic Models (HEMs)