Strategic Planning for Irrigation Development in Myanmar

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Outline

- Overview and Rationale for Irrigation
- Research Questions
- Methodology
- Results
- Economy-wide and Poverty Impacts of Irrigation Investments
- Conclusions and Policy Recommendations

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Myanmar: Overview and Rationale for Irrigation

- Land area (MOALI 2016) = 676,578 sq km
- Estimated population (MOALI 2016) = 54.36 million; 70% in rural areas
- Agriculture sector/production
  - Important economic sector (2014)
    - 30% of total GDP
    - 16% of total export earnings
    - 50% of total employment
  - Crop area = 12 million ha
    - Rice = about 7 million ha
  - Irrigation (MOALI 2016) = 2.2 million ha
    - 89% of water withdrawals are for irrigation (WB-WDI database)

- Irrigation
  - Increases yields and protects crops against inadequate rainfall and drought
  - Enables dry season cropping; creates potential to diversify to higher-valued crops
  - Expansion promotes improved technologies, higher efficiency - promising adaptation options in the face of climate change
- Effective development of affordable irrigation and water resources can
  - Improve agricultural production
  - Enhance income and food security of vulnerable, poor and subsistence farmers

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Key Research Questions

- What is the physical and economic potential for irrigation in Myanmar?
- What are the economic costs and benefits of irrigation development and the relative cost-effectiveness of alternative irrigation investments and technologies, including river and groundwater pumping for agriculture?
- What are the economy-wide and poverty impacts of irrigation investment?

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METHODOLOGY

Alternative Definitions of Irrigation Potential

- **Land suitability**: Potential for irrigation taking into account distance to surface water, groundwater availability, market access, and slope
- **Risk reduction potential**: Irrigation potential to eliminate downside yield risk in the monsoon season
- **Economic potential:** Irrigation potential with mean net economic profitability, with and without export market expansion

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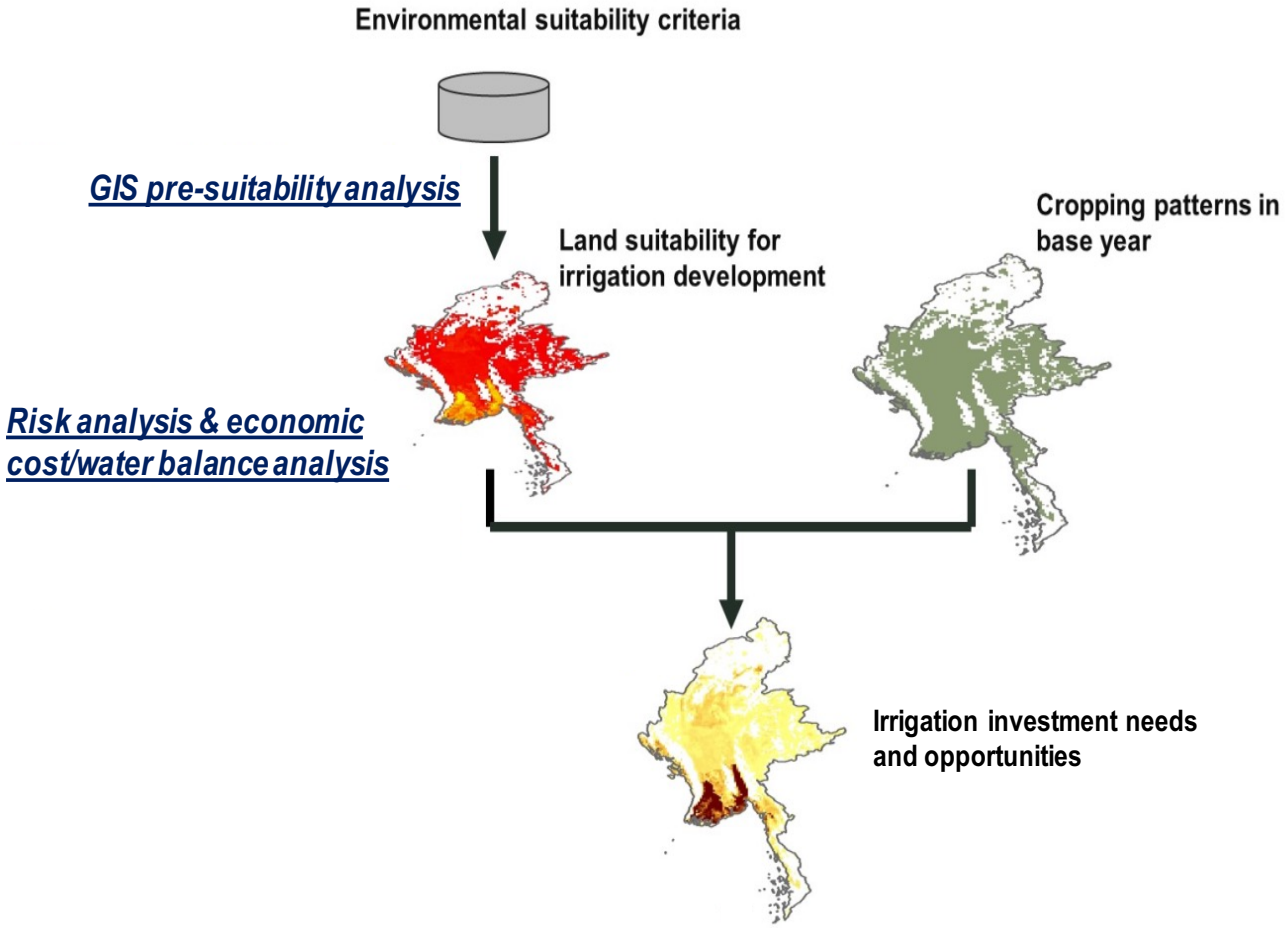
Methodology

Assessment Framework for Strategic Planning Analysis in Myanmar



- Spatially disaggregated analysis
  - to identify scale and geographic domains for irrigation development potential
  - investment needs across the country
- Combined biophysical and economic approach
- GIS pre-suitability analysis
  - followed by risk and economic/water balance analyses
  - involves the use of predictive modeling tools

Source: IFPRI

1) Pre-suitability analysis

- Conducted at pixel level using Geographic Information System (GIS) tools to establish an estimate for geographic domains with land suitability for irrigation investment

Criteria	Explanation	Suitability range
Slope	➢ Irrigation tends to occur in areas with no or gentle slopes	< 10%
Groundwater accessibility (Yes/No)	➢ Hydrogeology map - description of geological formations of aquifers in Myanmar	• Inferred from Hydrogeology map • Alluvium aquifers and aquifers with Irrawaddy formation are considered suitable for irrigation
Distance to surface water (km)	➢ To measure accessibility to surface water	< 5km
Market access (hours)	➢ Market access included as a criterion - Adoption of irrigation relies on markets both for equipment/facility maintenance and sales of crop products ➢ Characterized by travel time to nearest town over 20k population	< 6 hours
Urban area	➢ Land in urban area is excluded	

Source: IFPRI

2) Economic and water balance analysis

- Predictive modeling tools and risk analysis, cost benefit analysis (CBA) and water balance analysis techniques - generate realistic estimates for irrigation development potential and irrigation investment needs within the suitability domains identified in pre-suitability analysis
- Operational policy recommendations for irrigation development in the near future (by 2030) focusing on small-scale irrigation
- Irrigation in monsoon and dry seasons
  - *Irrigation in monsoon season*: reduces variability in food production induced by inter-annual variability of rainfall, and can be profitable under cost benefit analysis
  - *Irrigation in dry season*: drives crop production expansion, with environmentally sustainable, increased production in line with domestic food demand and trade

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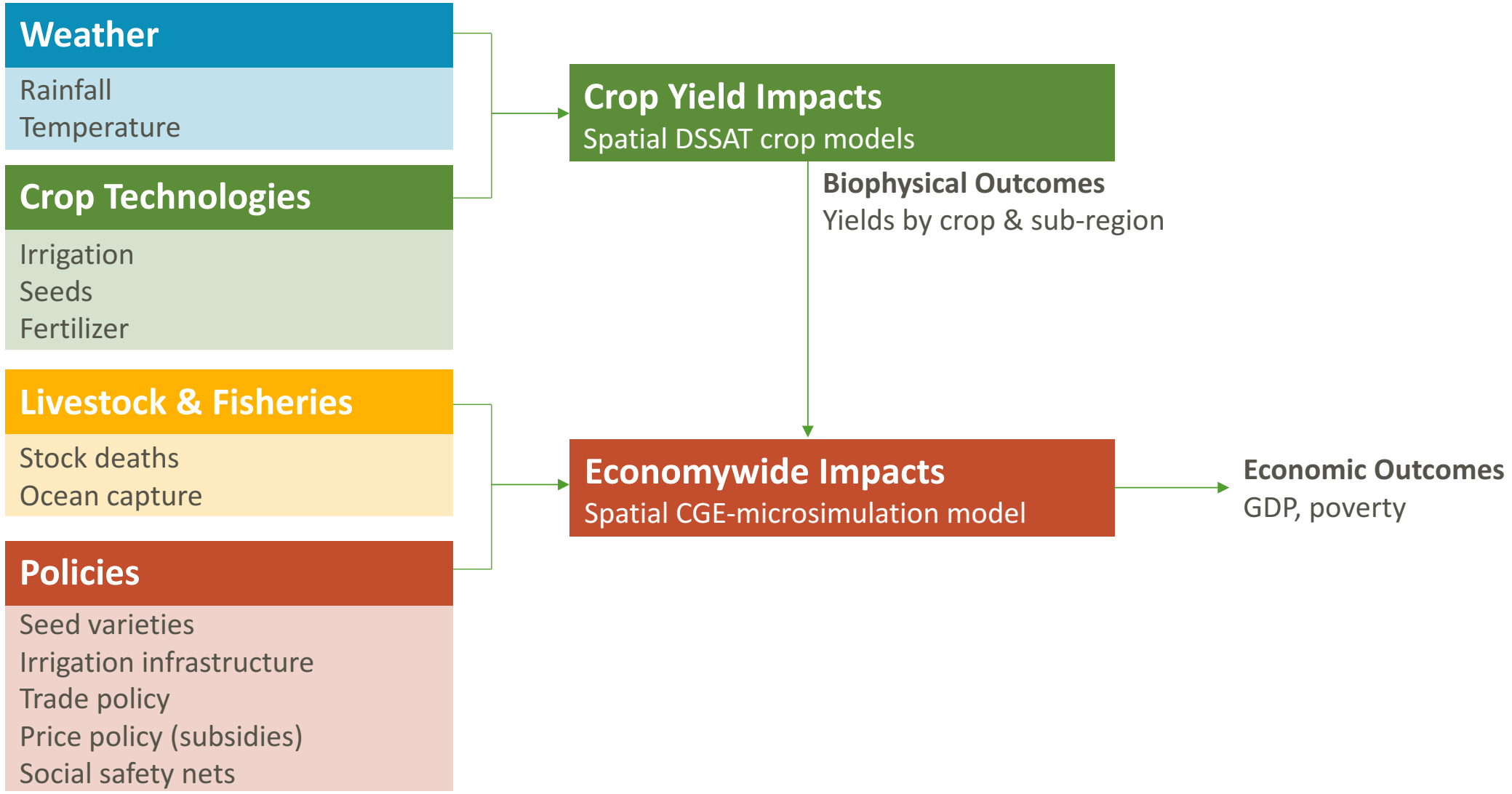
Irrigation Impacts: Agricultural and Economy-Wide Modeling System



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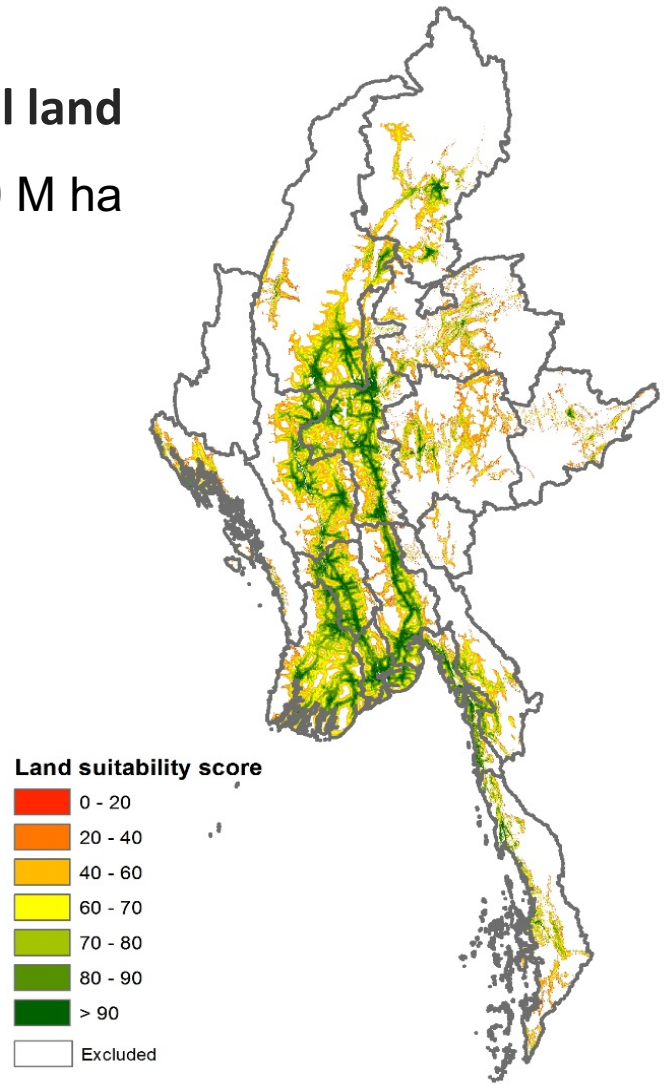
RESULTS

Land Suitability for Irrigation Development

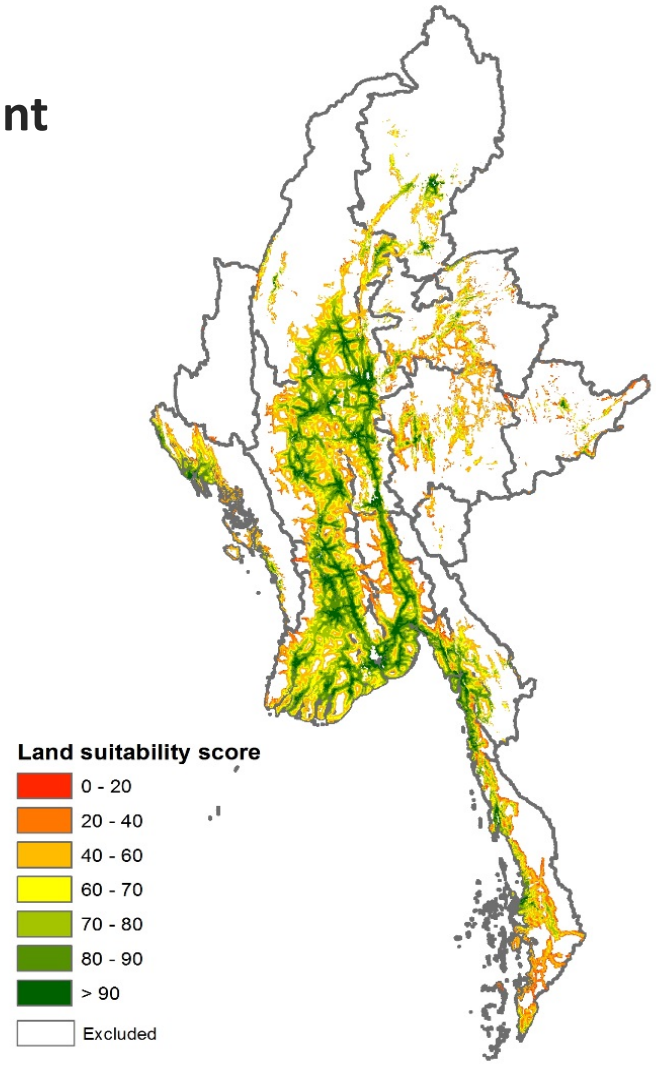
a) All land

~20 M ha



b) Within extent of existing rainfed land

~10 M ha



Note: excludes non-vegetative/urban areas

Source: IFPRI

Land Suitability by State/Division

Unit: '000 hectares

	All land	Within existing cultivated land
Rakhine	640	260
Chin	9	3
Ayeyarwaddy	2,409	1,688
Kachin	1,117	169
Kayin	779	219
Kayar	100	24
Magway	2,327	1,548
Mandalay	2,559	1,693
Mon	713	380
Sagaing	2,393	1,560
Taninthayi	1,001	164
Yangon	837	525
Bago East	1,386	874
Bago West	1,092	651
Shan (East)	365	68
Shan (North)	1,133	186
Shan (South)	1,383	208
Total	20,243	10,221

Source: IFPRI

Irrigation Potential by Suitability Class

Unit: '000 hectares

	All land	Within extent of existing rainfed land
High (>80)	4,879	3,628
Moderate (40 – 80)	12,938	6,623
Marginal (<40)	2,428	330
Total	20,243	10,221

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Source: IFPRI

Irrigation Potential Needed to Reduce Crop Yield Risk in the Monsoon Season

- Irrigation potential to improve resilience in the wet season: farmers are risk averse; managing yield variability imposes social costs
- Vulnerability score: worst annual reduction of crop yield that can be avoided by irrigation over 57 years of historical rainfall data
- Three vulnerability thresholds assessed: 30%, 50%, and 70%
- Threshold of 30% means that farmers/policymakers are willing to accept up to a 30% crop reduction due to drought before requiring irrigation

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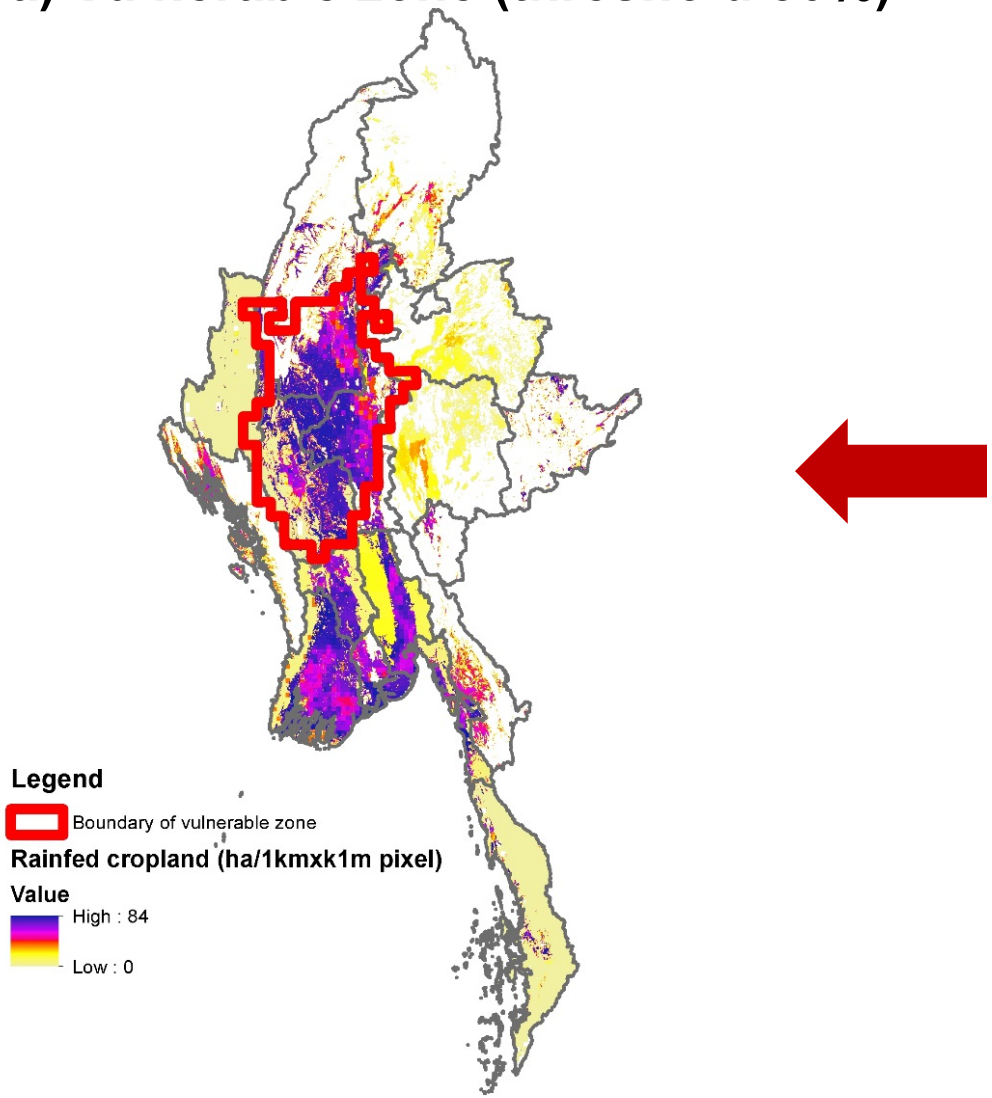
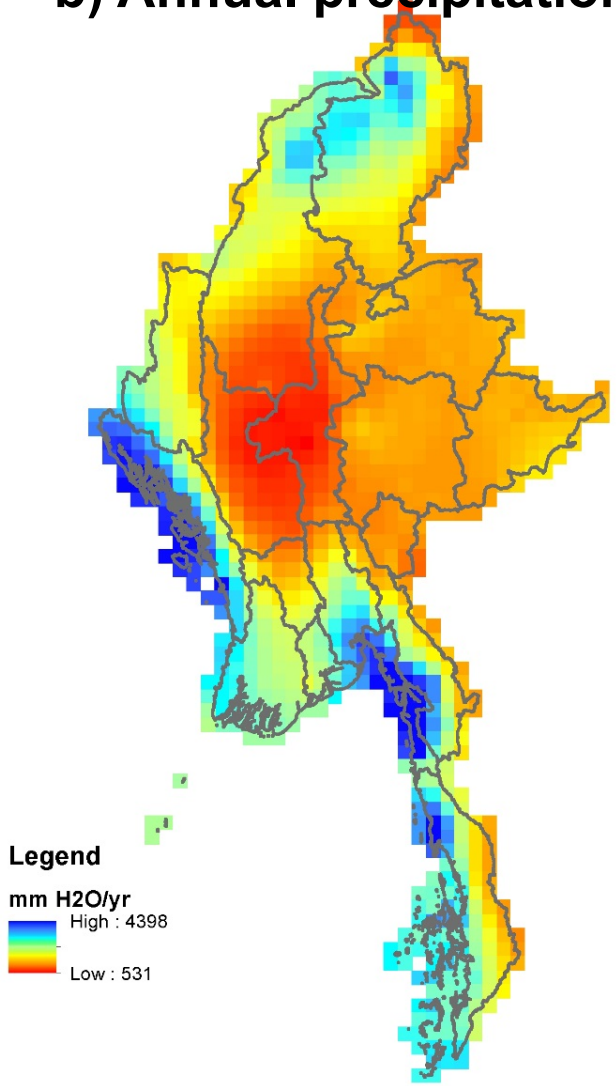
Potential for Irrigation Development in Monsoon Season—Rainfed Areas with Low Annual Precipitation

a) Vulnerable zone (threshold 30%)



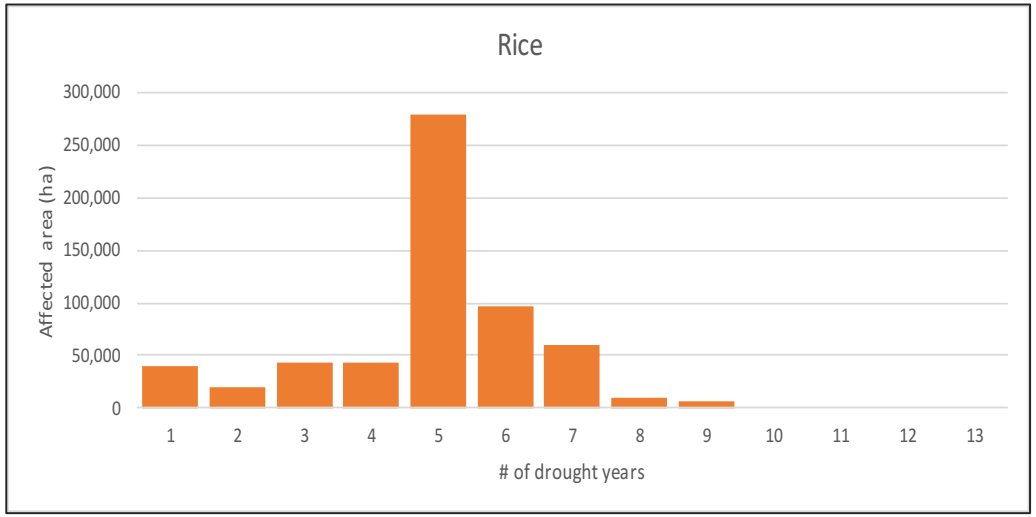
Source: IFPRI

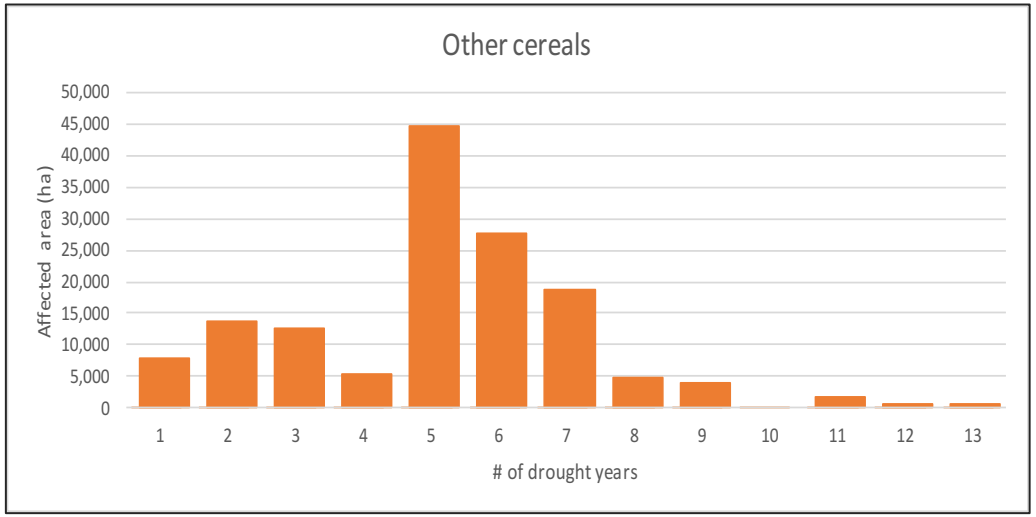
b) Annual precipitation

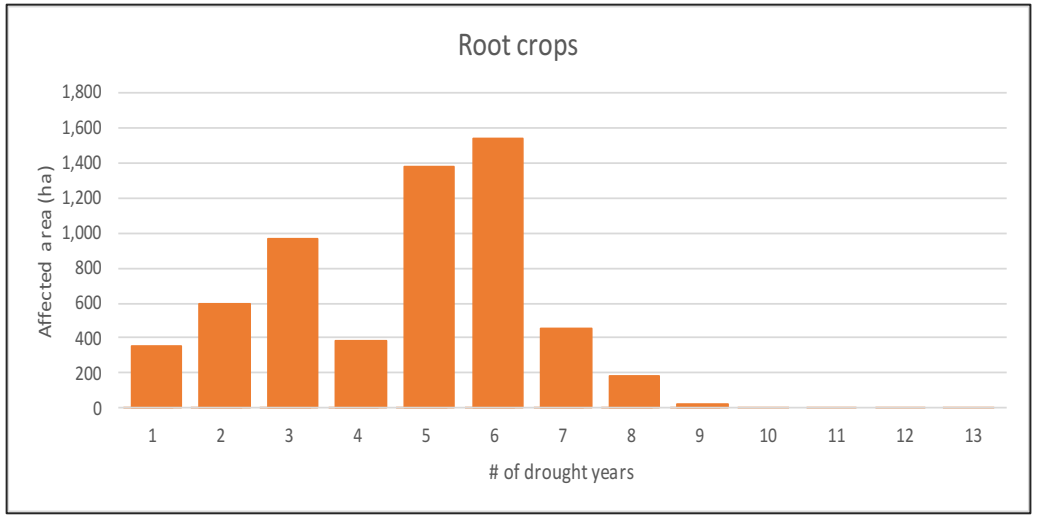


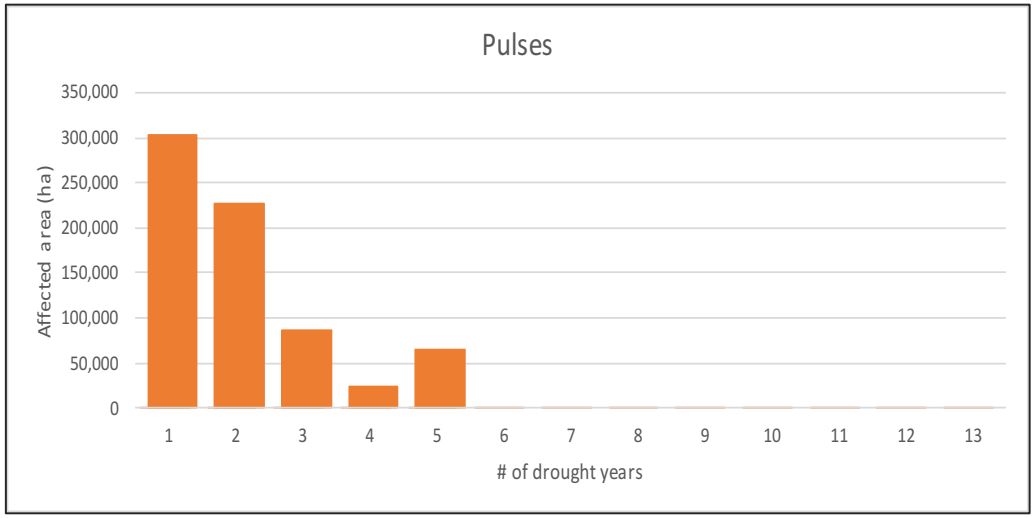
Source: APHRODITE

Irrigation Potential in Monsoon Season – Vulnerability Due to Drought Frequency—30% yield decline









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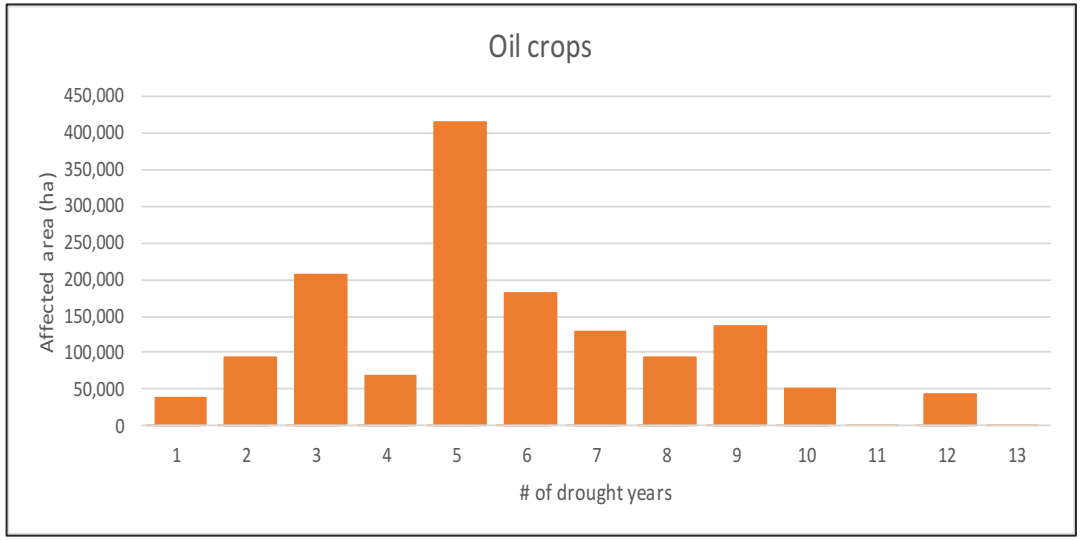
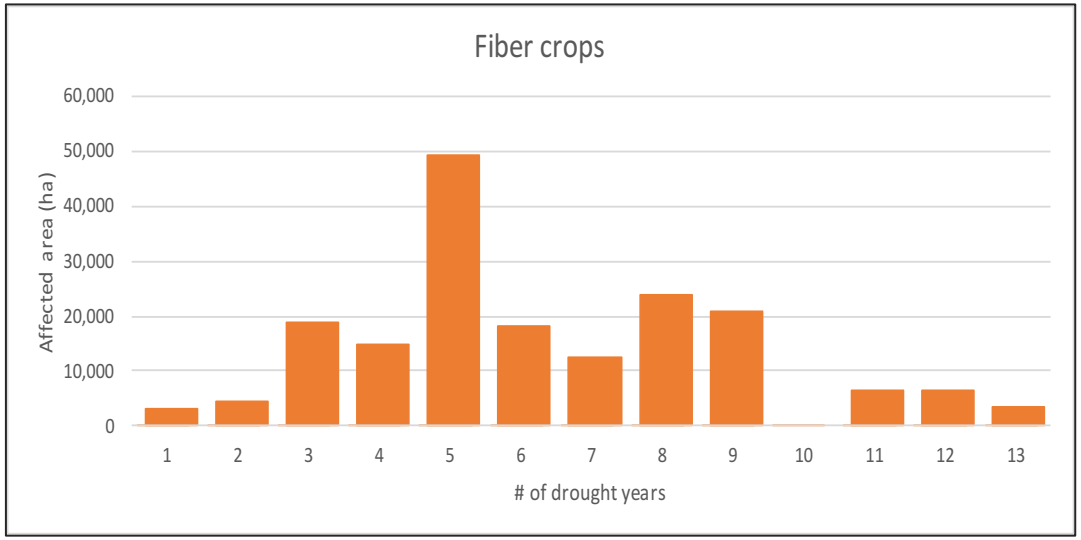
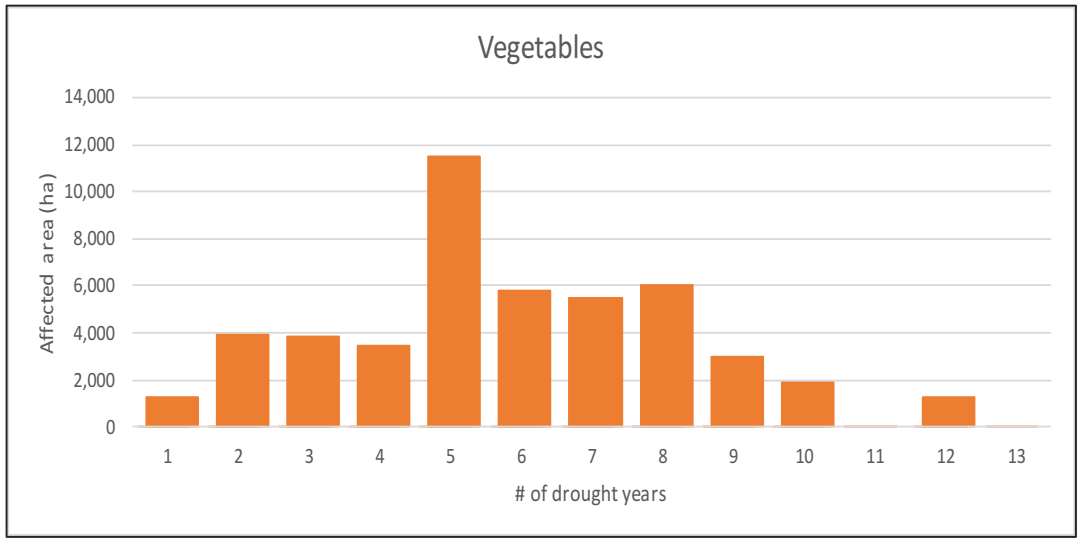
Source: IFPRI

Irrigation Potential in Monsoon Season – Vulnerability Due to Drought Frequency—30% threshold







Source: IFPRI

Irrigation Potential in Monsoon Season – Drought Frequency (30% yield decline from full potential yield) within 57 years of analyzed data

# of drought years*	Affected rainfed area ('000 hectares)	# of drought years*	Affected rainfed area ('000 hectares)
1	393	8	139
2	364	9	170
3	370	10	53
4	158	11	8
5	866	12	53
6	332	13	4
7	226	**Total**	**3,136**

*Total simulation period: 57 years

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Source: IFPRI based on Aphrodite data product

Irrigation Development Potential in Monsoon Season by State/Division: Most area in Magway and Mandalay

State/Division	Area ('000 hectares)		Increase (%)
	Potential	Existing irrigated	
Magway	1,028	138	746
Mandalay	1,209	147	820
Sagaing	859	247	347
Bago East	3	153	2
Bago West	9	97	9
Shan (North)	26	70	37
Shan (South)	2	68	3
Total	**3,136**	**921**	**341**

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Source: IFPRI

Irrigation Development Potential in Monsoon Season by Crop

Crop	Area ('000 hectares)		Conversion rate (%)
	Potential	Existing rainfed	
Rice	597	885	67
Other cereals	143	234	61
Root crops	6	9	65
Pulses	704	1,234	57
Oil crops	1,457	2,354	62
Fiber crops	182	276	66
Vegetables	48	74	65
Total	**3,136**	**5,067**	**62**

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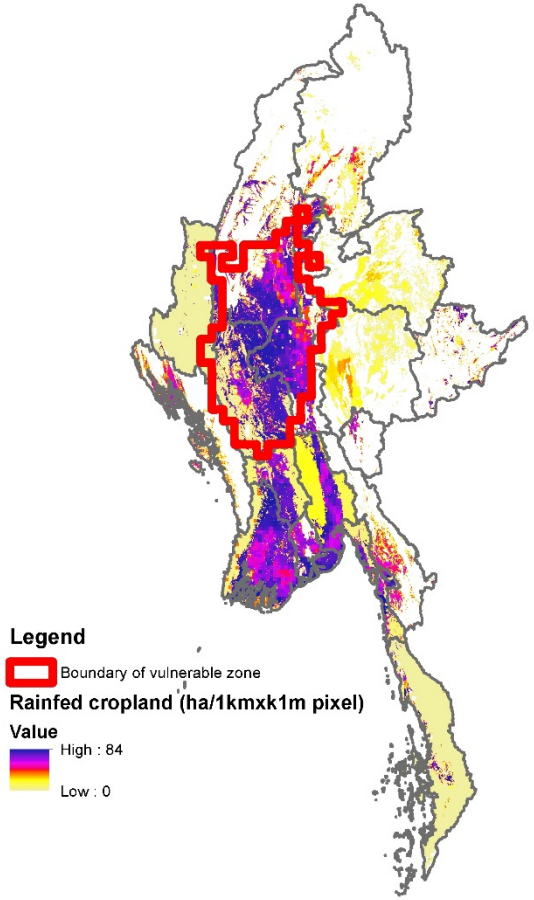
Source: IFPRI

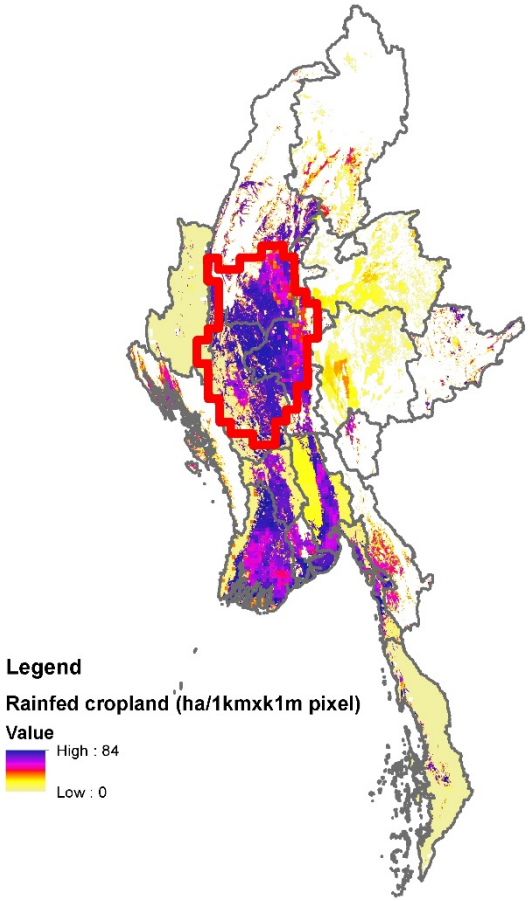
Irrigation Development Potential in Monsoon Season: Potential area is sensitive to simulated yield reduction thresholds

a) Threshold 30%



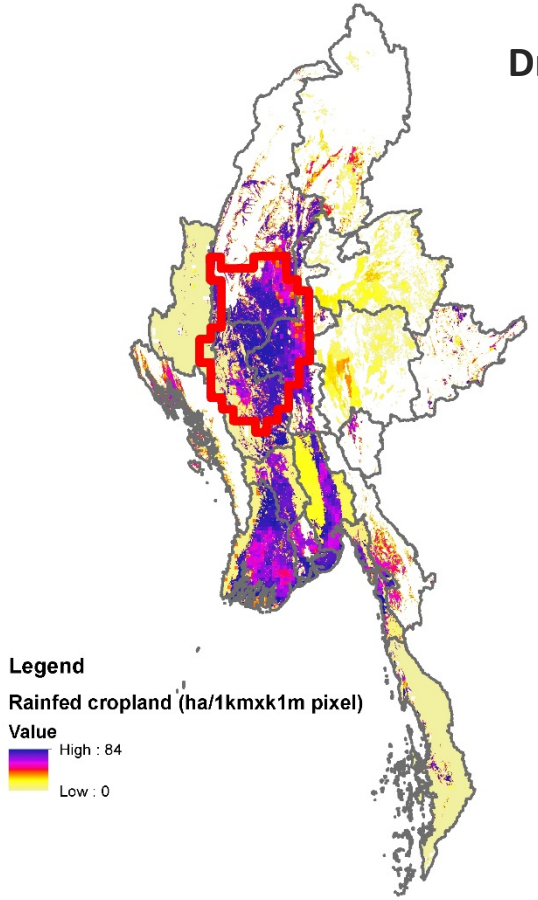
3.1 million hectares

b) Threshold 50%



2.9 million hectares

c) Threshold 70%



2.7 million hectares

Threshold definition

Drought-affected rainfed yield deviation from irrigated yield

$$\left(\frac{y_{irr,t} - y_{rf,t}}{y_{irr,t}}\right)$$

Source: IFPRI

Potential with Cost-benefit Analysis

1. Decision variables

A_{rc} — ***planting area (ha)***

2. Input variables

$P_{c,initial}$ — ***initial crop price ($/ton)***

IC_c —***irrigation costs ($/ha)***

PC_c —***other production costs ($/ha)***

$Prod_{rc,initial}$ — ***initial production (ton/yr)***

3. Variables from ex-ante analysis

$A_{r,\max}$ — ***maximum area with irrigation potentials (ha)***

4. Variables estimated by SWAT model

ΔY_{rc} — ***crop yield or increased yields as a result of AWM solutions (ton/ha-yr)***

w_{rc} — ***water use intensity (m^3H_2O/ha-yr)***

Q_r — ***amount of water available for irrigation (m^3H_2O/ yr)***

5. Variables estimated by DREAM (Dynamic Research EvaluAtion for Management)

P_c — ***crop price ($/ton)***

Model outputs for crop area, yield, net farm profits, regional net revenue under alternative scenarios

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Irrigation Development Potential Scenarios: Cost-benefit Analysis

(a) Prices (US$/ton)

	Low	Medium	High
Rice	200	300	400
Pulses	500	700	900
Vegetables	500	700	900

(b) Irrigation costs (US$/ha-yr)

	River pump	Tubewell
Low	230	45
High	430	120

(c) Demand increment of rice and pulses (million tons/yr)

	Domestic only	Domestic + Trade
Rice	1.1	3.1
Pulses	0.36	0.86

Source: IFPRI

Irrigation Development Potential in Monsoon Season: With Cost-benefit Analysis (CBA)

- Evaluate the net economic profitability for irrigation in the monsoon season
- Potential for 1.4 million ha at prevailing crop prices and irrigation costs
- Potential irrigation under mean net economic profitability cost benefit is the lower bound
  - CBA results do not take account of farmer risk aversion and social costs for managing food insecurity risk induced by drought
- May need to evaluate cost-effectiveness of irrigation investment relative to options for drought management when making irrigation investment decisions

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DRY SEASON POTENTIAL

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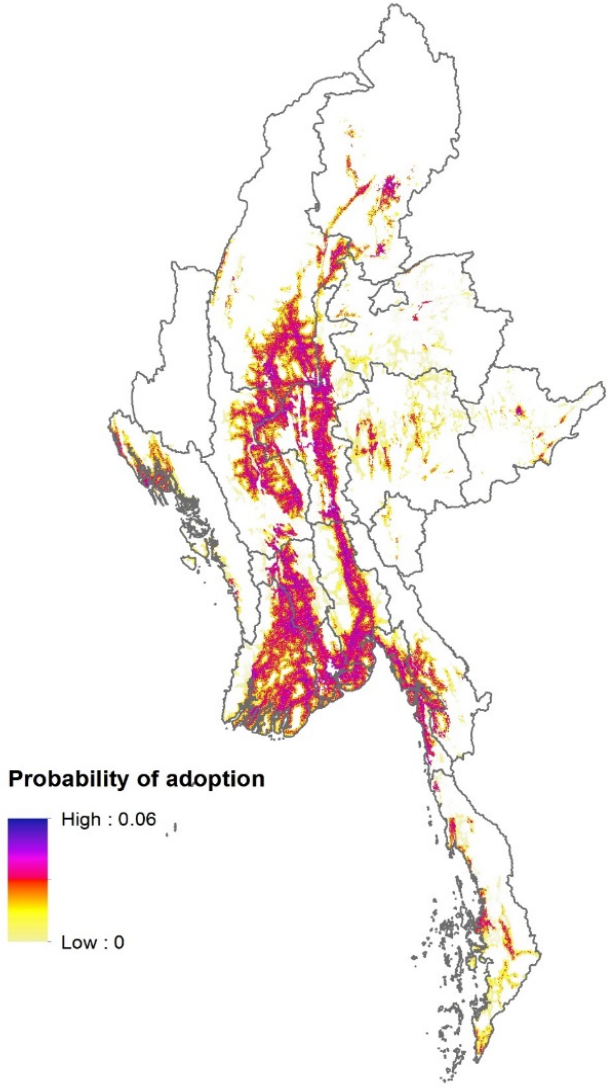
Irrigation Development Potential in Dry Season—CBA

(prevailing crop output prices and irrigation costs)



Source: IFPRI

Unit: '000 hectares

	Rice	Pulses	Vegetables	Total
Rakhine	26	33	3	62
Ayeyarwaddy	25	4	9	38
Kachin	6	5	2	13
Kayin	5	2	3	10
Kayar	1	2	0	3
Magway	45	18	5	68
Mandalay	41	19	6	66
Mon	12	3	4	20
Sagaing	70	33	7	110
Taninthayi	28	7	5	40
Yangon	13	2	4	18
Bago East	17	10	9	35
Bago West	3	2	3	8
Shan (East)	2	5	1	7
Shan (North)	2	4	3	8
Shan (South)	5	13	5	23
Total	**299**	**162**	**68**	**529**

Irrigation Development Potential in Dry Season – Key Role of Tubewells

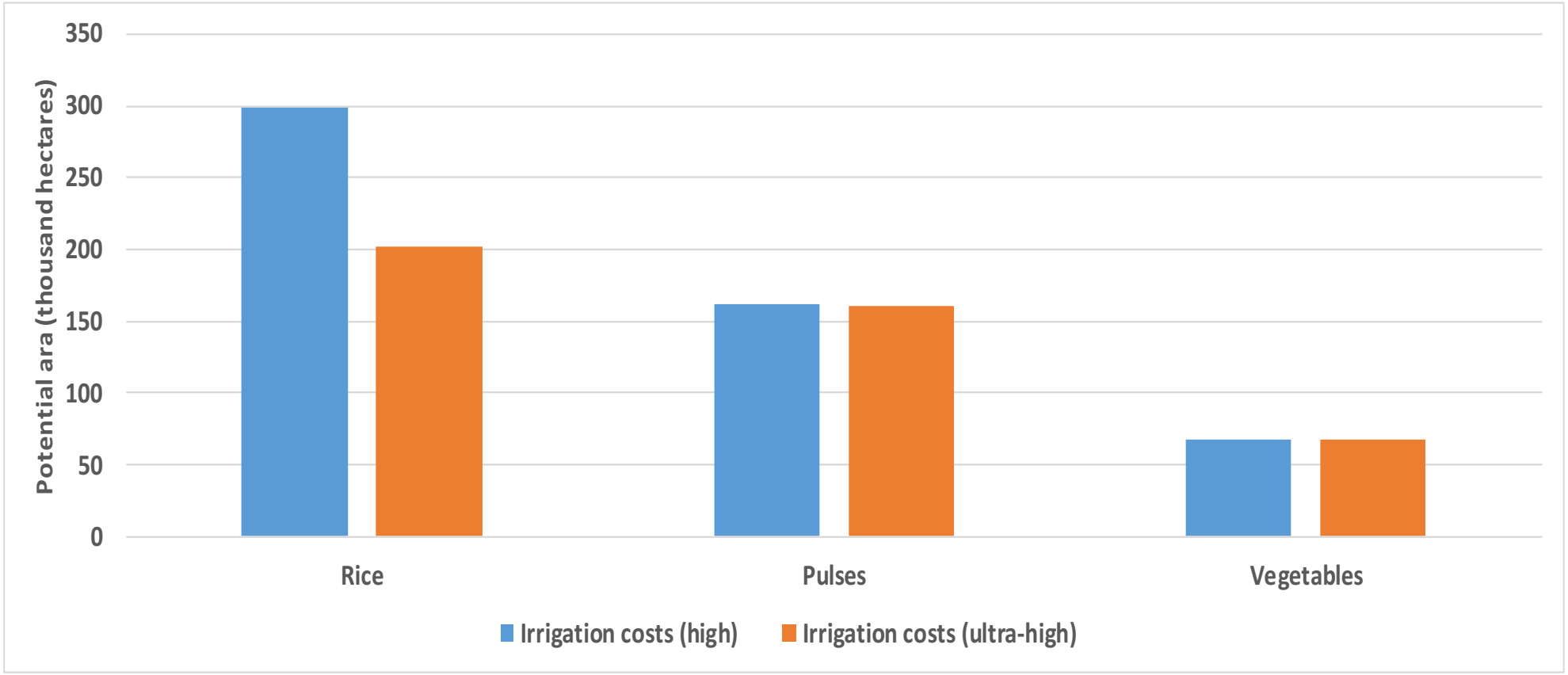
Unit: '000 hectares

	Tubewell	River pump	Total
Rakhine	15	47	62
Ayeyarwaddy	24	14	38
Kachin	4	9	13
Kayin	5	5	10
Kayar	0	3	3
Magway	63	5	68
Mandalay	59	6	66
Mon	10	10	20
Sagaing	97	13	110
Taninthayi	8	32	40
Yangon	14	4	18
Bago East	19	16	35
Bago West	4	3	8
Shan (East)	0	7	7
Shan (North)	1	7	8
Shan (South)	6	17	23
Total	**330**	**199**	**529**

Source: IFPRI

Irrigation Development Potential in Dry Season: Impacts of changes in irrigation cost

- Dry season rice production sensitive to higher irrigation costs
- Pulses and vegetables insensitive to cost fluctuations due to higher profitability



Source: IFPRI

Irrigation Development Potential in Dry Season: Impacts of Trade

Unit: '000 hectares

	Domestic demand only	Domestic + Trade
Rice	**299**	**736**
Pulses	162	461
Vegetables	68	68
Total	**529**	**1,265**

Note: No trade assumed for vegetables

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Source: IFPRI

Central Dry Zone – a focal region for irrigation development

- Land area with suitability for irrigation development = 4 million ha (40% of national total)
- Almost exclusively accounts for monsoon risk-reduction irrigation development potential of 3.1 million ha
- Irrigation development potential in Central Dry Zone in dry season = 0.2-0.4 million ha

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ECONOMY-WIDE AND POVERTY IMPACTS OF IRRIGATION INVESTMENT

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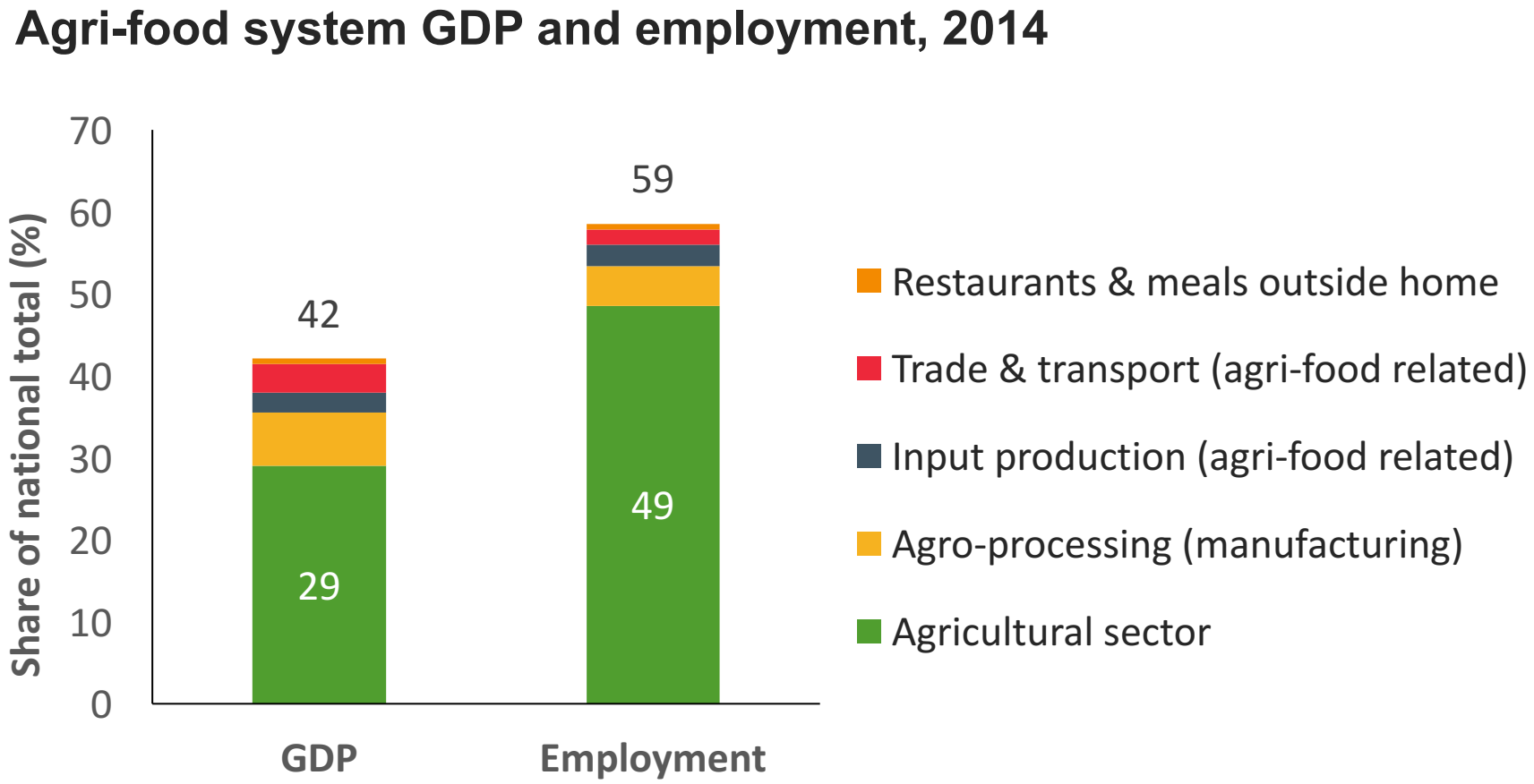
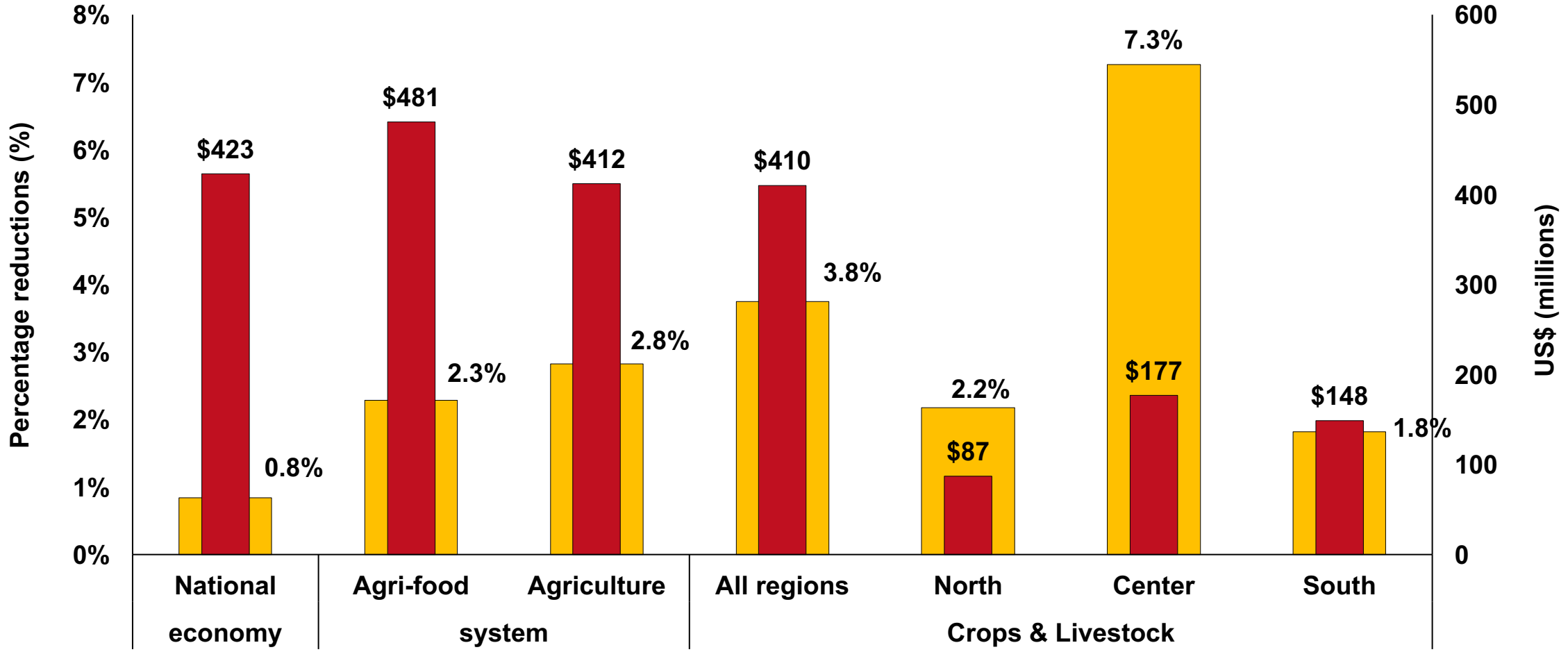
Myanmar's Agri-Food System

- Agriculture has large economywide linkages



Data source: 2014 Myanmar Social Accounting Matrix

GDP losses during El-Niño events (US$ millions lost and percentage reductions)



Source: WB-IFPRI technical report on ENSO, Agriculture and Food Security in Myanmar, forthcoming

CGE Model Policy Scenarios

CGE model - used to simulate policy changes to mitigate damages during El Niño Southern Oscillation events

- *Drought-tolerant varieties*
  - Provide farmers with more drought-resistant maize, rice and vegetable varieties
  - About 3.5% higher yields on average for rainfed farming during El Niño years
- *Additional irrigation*
  - Amount of cultivated land using irrigation infrastructure increased by 10-20% for rice, pulses, and vegetables, doubled for maize in North and Center regions (unchanged in South)
- *Food import subsidies*
  - Introduce 10% price subsidy for imported agricultural products during El Niño years
  - Subsidy costs internalized through lower government revenues and larger recurrent fiscal deficits

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CGE Model Policy Scenarios

- *Grain storage*
  - Supply 500,000 tons of rice and 100,000 tons of maize from public and private stocks
  - Depleting stocks addresses short-term supply shortfalls during ENSO events
- *Cash transfers*
  - Provide short-term US$5.20 per capita transfers to poorer households (Quintiles 1-3) during El Niño
  - This is equivalent to doubling the average 2015 household social transfer in 2015
  - Additional transfer costs internalized through higher across-the-board direct taxes (e.g., pay-as-you-earn and corporate taxes)
- *Combined*: All the above policies implemented concurrently

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GDP changes during El Niño events and intervention scenarios

Description	Without inter-ventions	With interventions					
		Drought-tolerant varieties	Additional irrigation	Food import subsidies	Grain storage	Cash transfers	All Combined
Percentage change in GDP (%)							
National	-0.84	-0.33	-0.29	-0.84	-0.84	-0.84	0.19
AFS	-2.28	-0.79	-0.77	-2.28	-2.27	-2.29	0.64
Agriculture	-2.82	-1.21	-1.09	-2.83	-2.94	-2.82	0.34
Absolute change in GDP (US$ million)							
National	-423.1	-168.2	-144.4	-423.1	-420.6	-423.6	96.7
AFS	-480.6	-167.0	-161.9	-480.9	-477.7	-482.2	134.7
Agriculture	-412.1	-176.4	-158.8	-412.2	-428.7	-411.3	49.4

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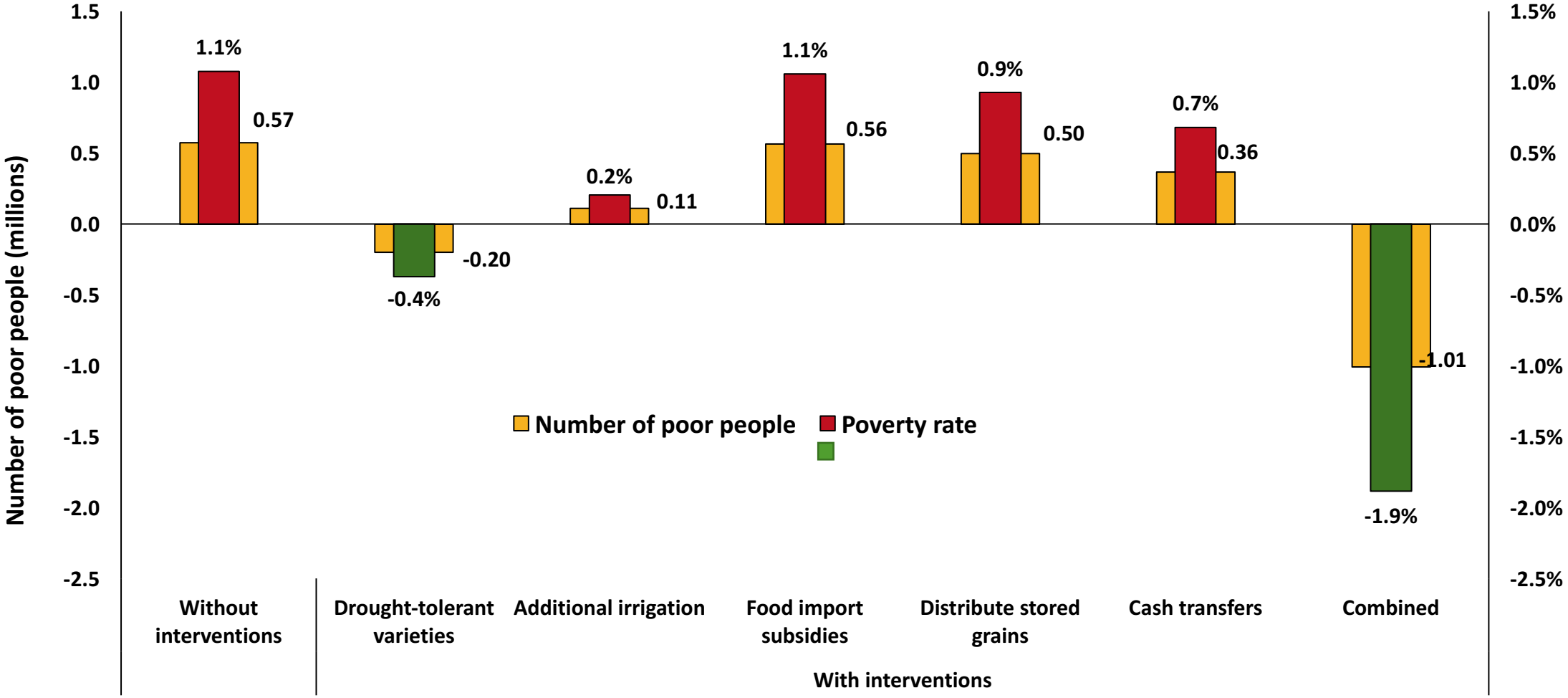
Source: WB-IFPRI technical report on ENSO, Agriculture and Food Security in Myanmar, forthcoming

Changes in national poverty headcount rate and number of poor people during El Niño events and intervention scenarios (percentage points and millions of people)



Source: WB-IFPRI technical report on ENSO, Agriculture and Food Security in Myanmar, forthcoming

CONCLUSIONS AND POLICY RECOMMENDATIONS

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Conclusions and Policy Recommendations

- Identified substantial opportunities for sustainable investment in small-scale irrigated agriculture
  - Total area suitable = 20 million ha; within existing rainfed area = 10 million ha
  - Total investment potential in monsoon season
    - = 3.1 million ha based on risk aversion to yield reduction
    - = 1.4 million ha based on mean economic profitability at prevailing prices and costs
  - Total investment potential in dry season = 0.5-1.3 million ha depending on prices and irrigation cost and export trade potential
  - Larger role for tubewells
  - Substantial potential for rice exports, but rice is the least profitable irrigated crop
  - Large potential for irrigation of pulses if export markets can be expanded

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Conclusions and Policy Recommendations

- Monsoon season: Small-scale irrigation development in the Central Dry Zone (CDZ) can reduce drought impacts
  - Agricultural production in CDZ is exposed to elevated risk of climate variability (drought)
  - Recommended irrigation schemes:
    - Tubewell (groundwater-fed)
    - Application of river/canal pumping systems
- Dry season irrigated agriculture: economically viable option to boost crop production and expand exports

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Conclusions and Policy Recommendations

- Tubewell (groundwater-fed) irrigation
  - Provides low cost option for practicing irrigation
  - Realizing estimated irrigation development potential in dry season will rely on identification and development of GW resources
  - Risk of saline GW, particularly in coastal areas
  - Requires sound GW governance and management

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Conclusions and Policy Recommendations

- Irrigation is effective in protecting against drought, as seen in the impact of irrigation investment to address El Niño events
- Irrigation investment provides significant economic benefits for the full economy, beyond agriculture
- Selective investment in irrigation combined with complementary investments is an important development strategy
- Complementary investments
  - Increased investment in agricultural research and development for traits such as drought tolerance
  - Investments in rural roads and market development to promote exports

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