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Policy options for sustainability in potato value chains in Bihar: a system dynamics approach

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Presentation for NZAE, 30 June 2016

Outline

- Motivation
- Overview of the sector
- Methodology
- Preliminary results
- Implications

Motivation

- Climate change – an important risk factor for food security in India in general, Bihar in particular (4-7 C increase by 2100)

- Potential to undo recent positive gains made in state on governance, enabling environment, etc.

Motivation

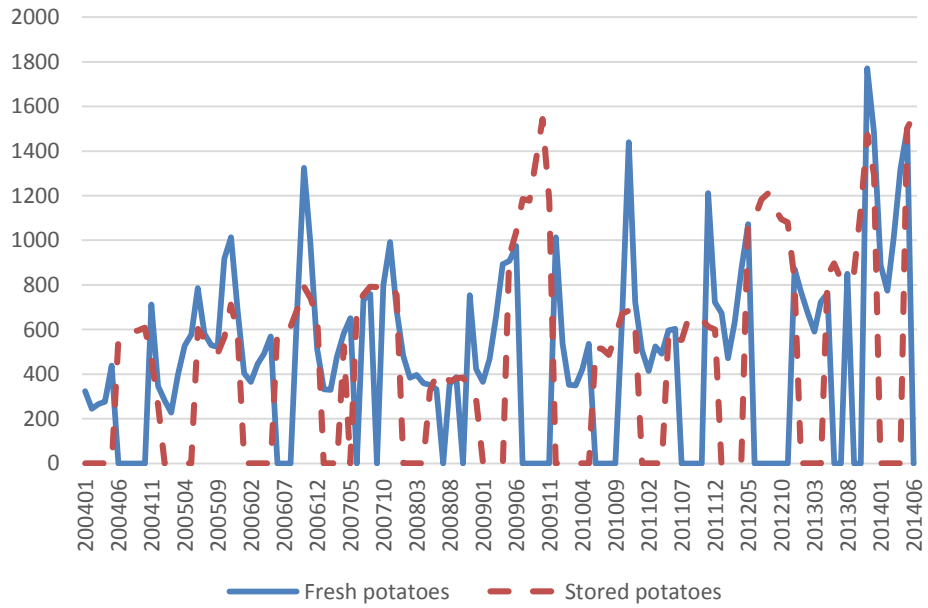
- An important mitigation strategy – linking farmers to formal markets
- But what are the “best” mechanisms and to what extent does climate change influence?
- Case study: potatoes in Bihar

Overview of the sector

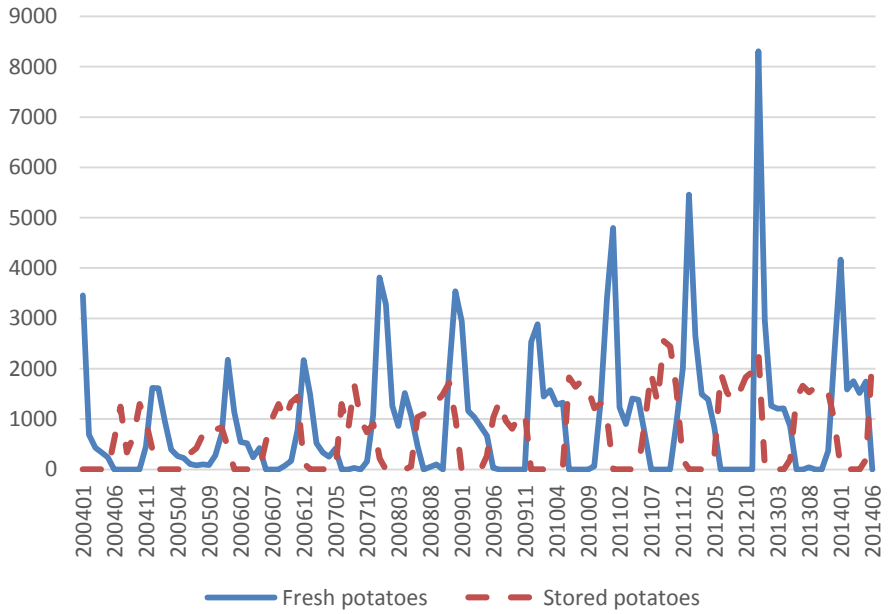
- Bihar: 15% of India's potato production (4th nationally)
- Important role in food security and livelihoods (esp. off-farm employment)
- Steady rise in production (5.7m tons in 2005/06 to 6.5m tons 2013/14), driven mostly by yield gains.
- Highly seasonal – storage plays an increasing role (just over 1m tons of potato storage capacity in the state)
- Highly vulnerable to climate change – projected state-wide yield reduction of over 20% by 2080.

Overview of the sector

Trends in market prices



Trends in market arrivals



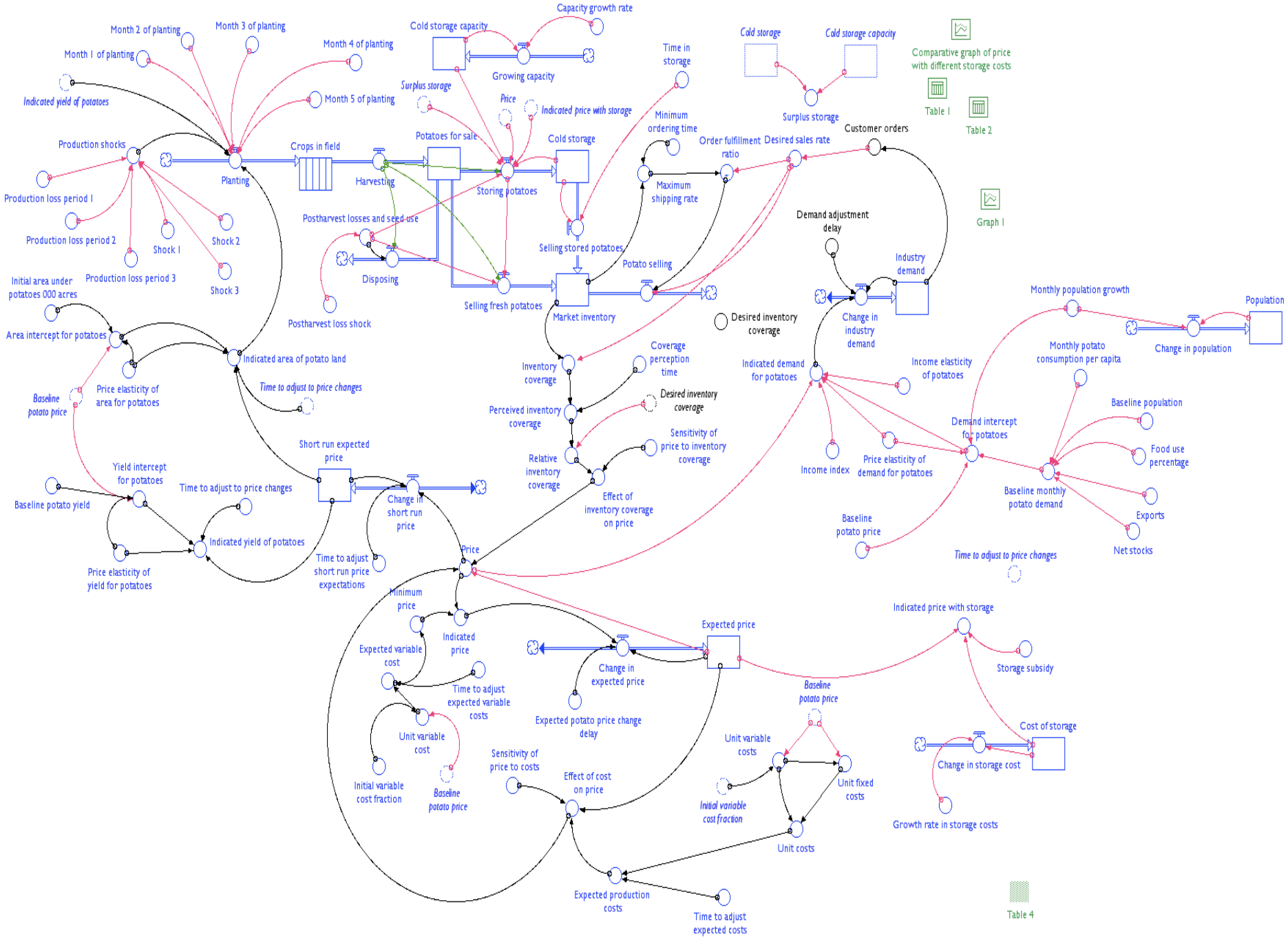
Source: Computed from Agricultural Marketing Board, Government of India

Methodology

- Use of system dynamics (SD) methodology to model key aspects of potato value chain (Sterman, 2000; McRoberts et al. 2013; Dizyee et al. 2016)

- SD models are simulation approaches that trace the evolution of system behaviour

- Adaptive vs. rational expectations (latter standard approach in storage models e.g. Wright and Williams 1991).


Month 1 of planting
Month 2 of planting
Month 3 of planting
Month 4 of planting
Month 5 of planting
Indicated yield of potatoes
Production shocks
Production loss period 1
Production loss period 2
Production loss period 3
Shock 1
Shock 2
Shock 3
Planting
Crops in field
Harvesting
Potatoes for sale
Cold storage capacity
Capacity growth rate
Growing capacity
Surplus storage
Price
Indicated price with storage
Storing potatoes
Cold storage
Time in storage
Minimum ordering time
Order fulfillment ratio
Desired sales rate
Customer orders
Maximum shipping rate
Postharvest losses and seed use
Disposing
Postharvest loss shock
Selling stored potatoes
Selling fresh potatoes
Potato selling
Market inventory
Demand adjustment delay
Industry demand
Change in industry demand
Desired inventory coverage
Initial area under potatoes 000 acres
Area intercept for potatoes
Indicated area of potato land
Time to adjust to price changes
Baseline potato price
Price elasticity of area for potatoes
Inventory coverage
Coverage perception time
Perceived inventory coverage
Desired inventory coverage
Relative inventory coverage
Sensitivity of price to inventory coverage
Effect of inventory coverage on price
Short run expected price
Change in short run price
Yield intercept for potatoes
Baseline potato yield
Time to adjust to price changes
Indicated yield of potatoes
Price elasticity of yield for potatoes
Time to adjust short run price expectations
Price
Indicated demand for potatoes
Income elasticity of potatoes
Income index
Price elasticity of demand for potatoes
Demand intercept for potatoes
Baseline potato price
Monthly population growth
Population
Change in population
Monthly potato consumption per capita
Baseline population
Food use percentage
Baseline monthly potato demand
Exports
Net stocks
Time to adjust to price changes
Minimum price
Indicated price
Expected variable cost
Time to adjust expected variable costs
Unit variable cost
Initial variable cost fraction
Baseline potato price
Change in expected price
Expected potato price change delay
Expected price
Indicated price with storage
Storage subsidy
Cost of storage
Change in storage cost
Growth rate in storage costs
Unit variable costs
Initial variable cost fraction
Unit fixed costs
Unit costs
Sensitivity of price to costs
Effect of cost on price
Expected production costs
Time to adjust expected costs
Cold storage
Surplus storage
Comparative graph of price with different storage costs
Table 1
Table 2
Graph 1
Table 4

Scenarios

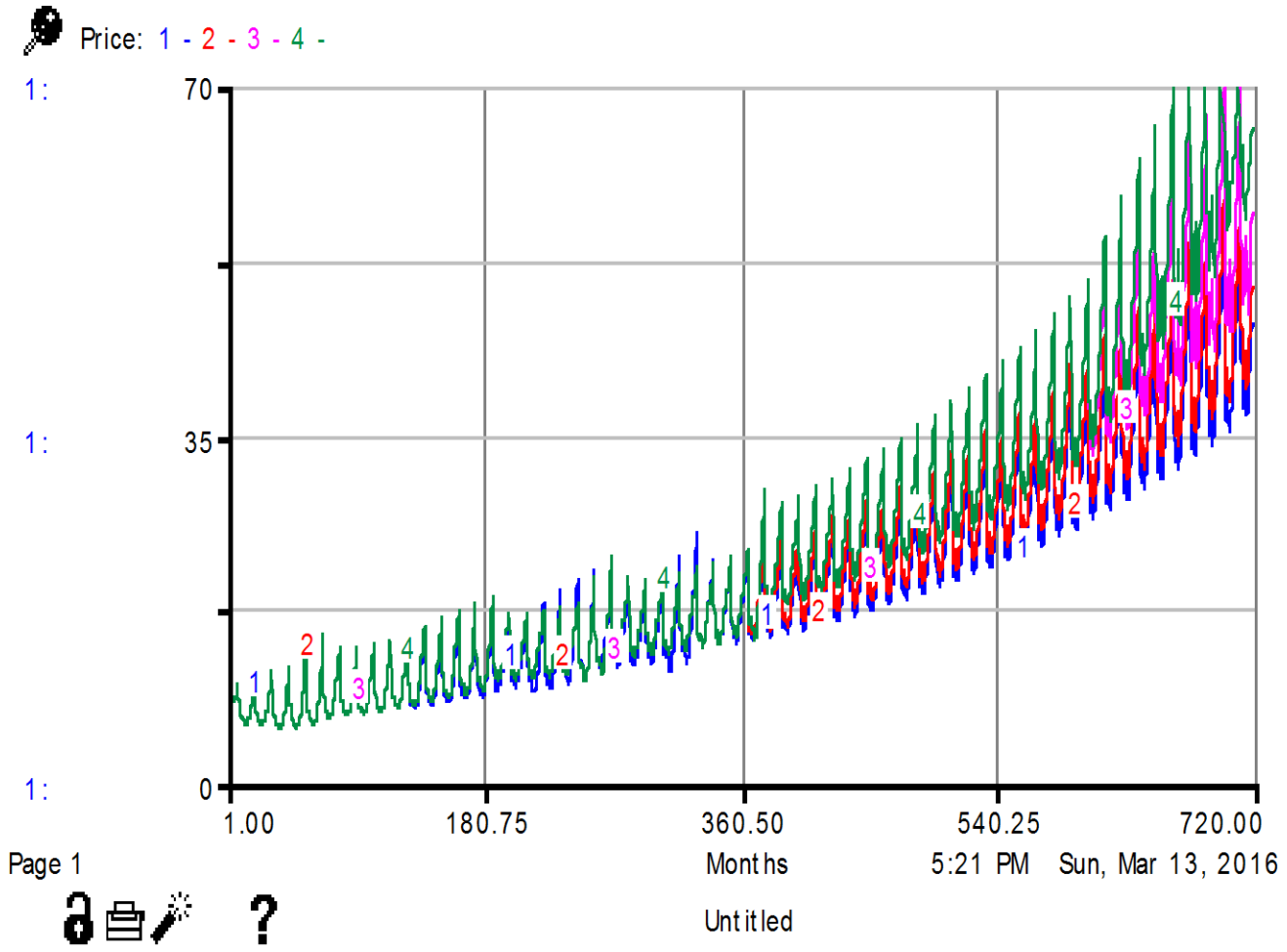
- Model run monthly over 60-year time horizon
- Scenarios assess impacts of climate change plus different mitigation strategies associated with value chain investments (storage, postharvest)

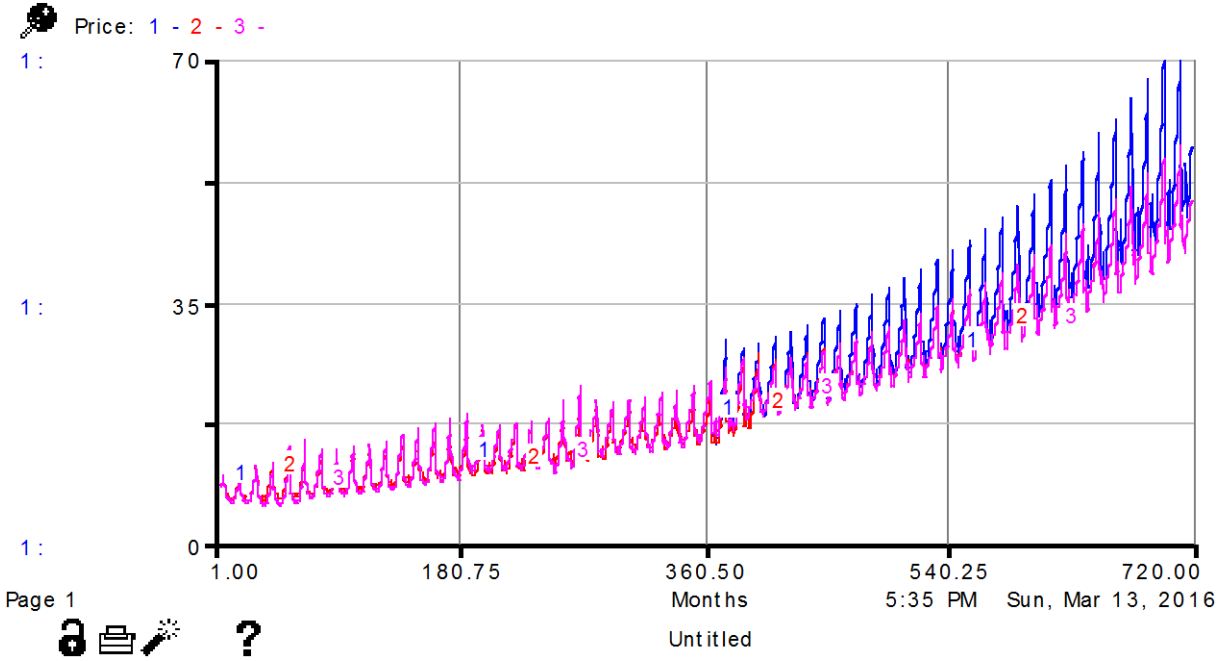
Scenario	Description
Baseline	Status quo
1	Low yield reduction (4.5%) from year 10
2	Scenario 1 + moderate yield reduction (13.8%) from year 30
3	Scenario 2 + high yield reduction (22%) from year 45
4	Scenario 2 + 50% storage cost subsidy from year 0
5	Scenario 2 + 50% storage cost subsidy from time yield shocks start
6	Scenario 2 + 50% reduction in postharvest losses from year 0
7	Scenario 2 + 50% reduction in postharvest losses from time yield shocks start
8	Scenario 2 + low investment in storage (1% p.a.)

Data sources

Parameter (units)	Value	Year	Source(s)
Area ('000 ha)	315	2011/12	Horticulture Statistics Division, Department of Agriculture and Cooperation, http://nhb.gov.in/statistics/area-production-statistics.html
Yield (tons/ha)	19.37	2011/12	Horticulture Statistics Division, Department of Agriculture and Cooperation, http://nhb.gov.in/statistics/area-production-statistics.html
Per capita consumption (kg/month/person)	3.375	2012	NSS 2012 data, averaged between rural and urban consumption
Population (million people)	104.1	2011	http://www.census2011.co.in/census/state/bihar.html
Annual population growth rate (%)	2.3		Computed from http://www.census2011.co.in/census/state/bihar.html, based on growth from 2001-2011.
Net production of potatoes (%)	60	2009	Minten et al. (2011) report 65% of potatoes marketed after losses, seed use, and home consumption; another 8-10% lost downstream
Storage capacity ('000 tons)	1030.4	2013	http://agmarknet.nic.in/binew.htm
Annual growth in storage capacity (%)	3.3		Computed from http://agmarknet.nic.in/binew.htm, annual growth 2009-2013
Price elasticity of area	0		Assumed based on limited growth in area
Price elasticity of yield	0.05		Assumed by the authors
Price elasticity of demand	-0.3		Assumed based on literature review (see text)
Income elasticity of demand	0.3		Assumed based on literature review (see text)
Baseline price (Rs/kg)	8	2012	Horticulture Statistics Division, Department of Agriculture and Cooperation

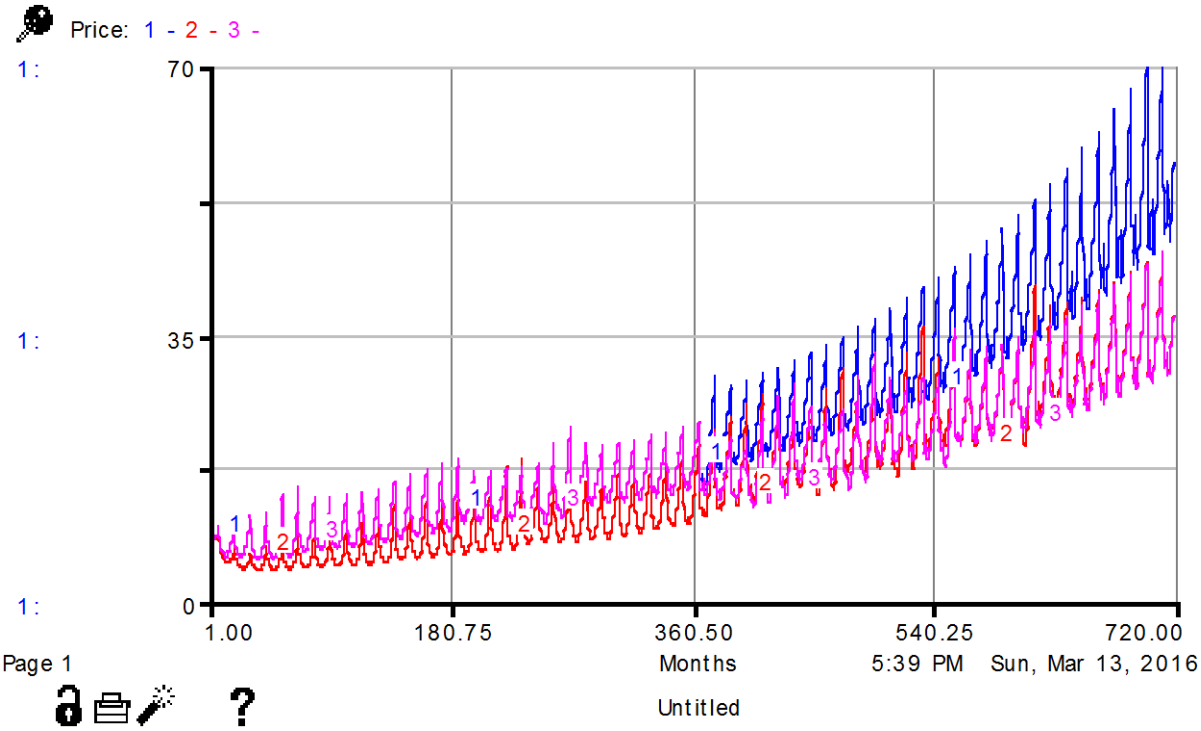
Preliminary results: climate change on prices





Effects on prices of storage subsidies

Effects on prices of reductions in postharvest losses



Preliminary results

Coefficient of variation of potato prices over different simulation periods and scenarios

Months	Baseline	Scenario number:							
		1	2	3	4	5	6	7	8
1-120	25.6%	25.6%	25.6%	25.6%	19.5%	25.6%	22.9%	25.6%	25.6%
121-240	23.0%	21.6%	21.6%	21.6%	18.0%	21.6%	31.4%	21.6%	22.8%
241-360	19.9%	18.3%	18.3%	18.3%	14.1%	18.3%	24.4%	18.3%	19.2%
361-480	16.7%	16.9%	18.3%	18.3%	15.2%	13.4%	22.3%	19.6%	18.0%
481-600	17.0%	17.0%	17.2%	17.2%	13.1%	13.1%	18.1%	18.0%	17.1%
601-720	17.2%	17.3%	17.6%	19.8%	13.8%	13.8%	16.9%	16.7%	17.6%

Implications

- Mitigation options can play a role, but trade-offs between price stability and levels

- Cost-effectiveness of options?

- Unintended consequences of cold storage (James and James 2010; Vermuelen et al. 2012).

Acknowledgements

This research was funded in part by the Norwegian Research Council FOODSEC project (#11201242). The authors acknowledge and appreciate comments from SIFO and CUTS International on an earlier draft.