Climate Change, Agricultural Adaptation, and Food Prices: A Partial Equilibrium Approach using Micro Data

Iddo Kan and Ayal Kimhi*

* Authors are affiliated with the Department of Agricultural Economics and Management, the Robert H. Smith Faculty of Agriculture, Food and Environment, The Hebrew University, and with the Center for Agricultural Economic Research.
* Kimhi is currently visiting at the Research Institute for Humanity and Nature (RIHN) in Kyoto, Japan.

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Structure of presentation

- **Methodological approach**
- Application to Israeli agriculture

Modeling farm responses to climate change

- Production approach: experimental or empirical effects of climate change on yields
- Ricardian approach: empirical effects of climate change on farm profits or land values
- Integrated approach: empirical effects of climate change on farmers' decisions feeding into market equilibrium changes that in turn affect farmers' decisions.

How will climate change affect agriculture?

- Direct effect: Farmers will alter their crop portfolios
- Indirect effect: crop prices will change as a result of the changes in supply, and this will lead to further changes in crop portfolios
- New equilibrium: these effects feed into each other until convergence

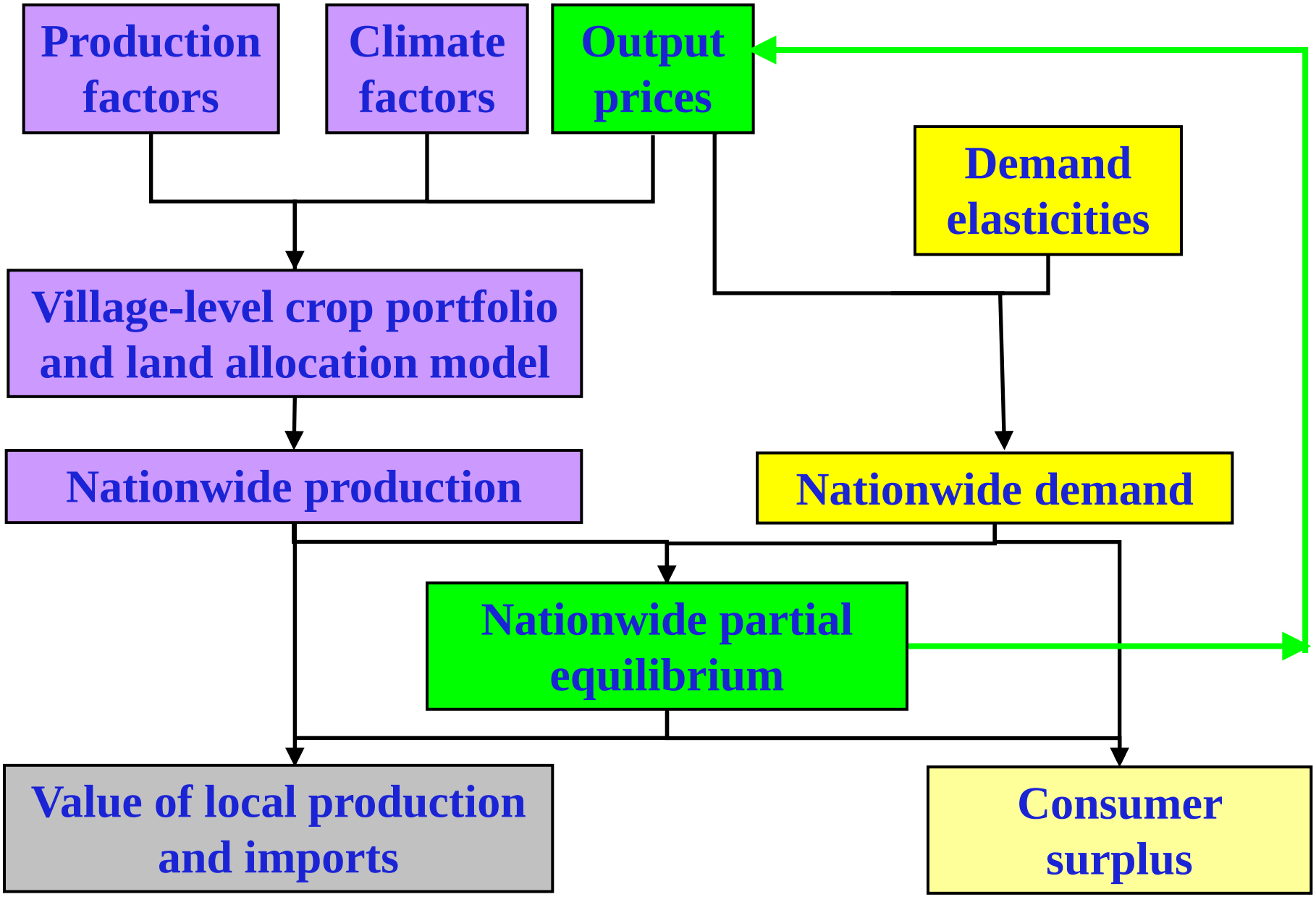
Previous research and our contribution

- Kaminski et al. (AJAE, forthcoming):

  A structural model of regional land allocation among crop-technology bundles

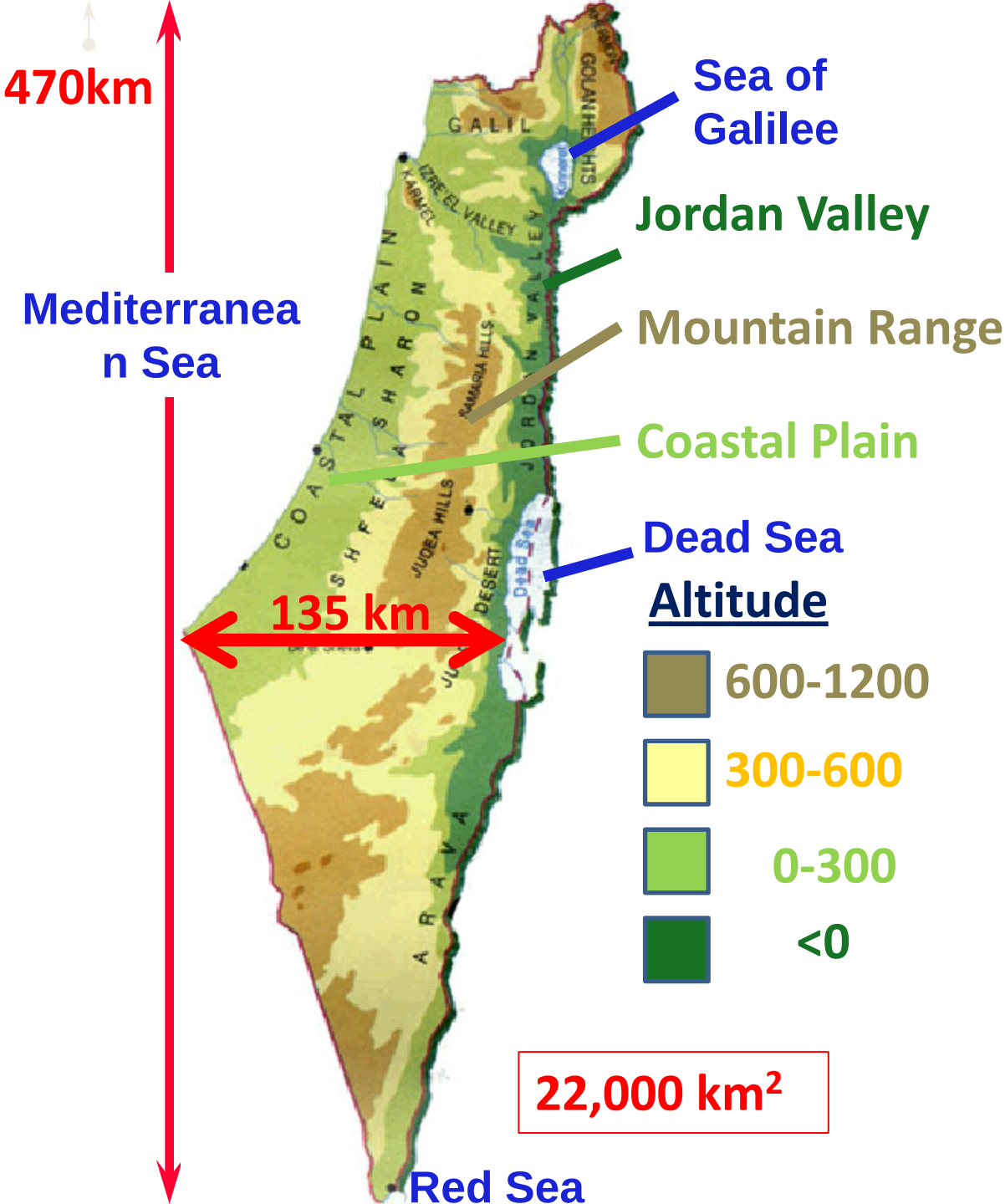
- Our contribution:
  - Adding the market equilibrium component
  - Estimating land allocations at village level
  - Allowing for corner solutions in land allocation

Analysis Flowchart



Structure of presentation

- Methodological approach
- **Application to Israeli agriculture**
  - Why is Israeli agriculture a good case study?


470km
Mediterranean Sea
135 km
Sea of Galilee
Jordan Valley
Mountain Range
Coastal Plain
Dead Sea
Altitude
600-1200
300-600
0-300
<0
22,000 km²
Red Sea
GALIL
GOLAN HEIGHTS
IZRE'EL VALLEY
KARMEL
COASTAL PLAIN
SHARON
SHFELA
SAMARIA HILLS
JUDEA HILLS
JORDAN VALLEY
DESERT
ARAVA
Dead Sea

SEASONS

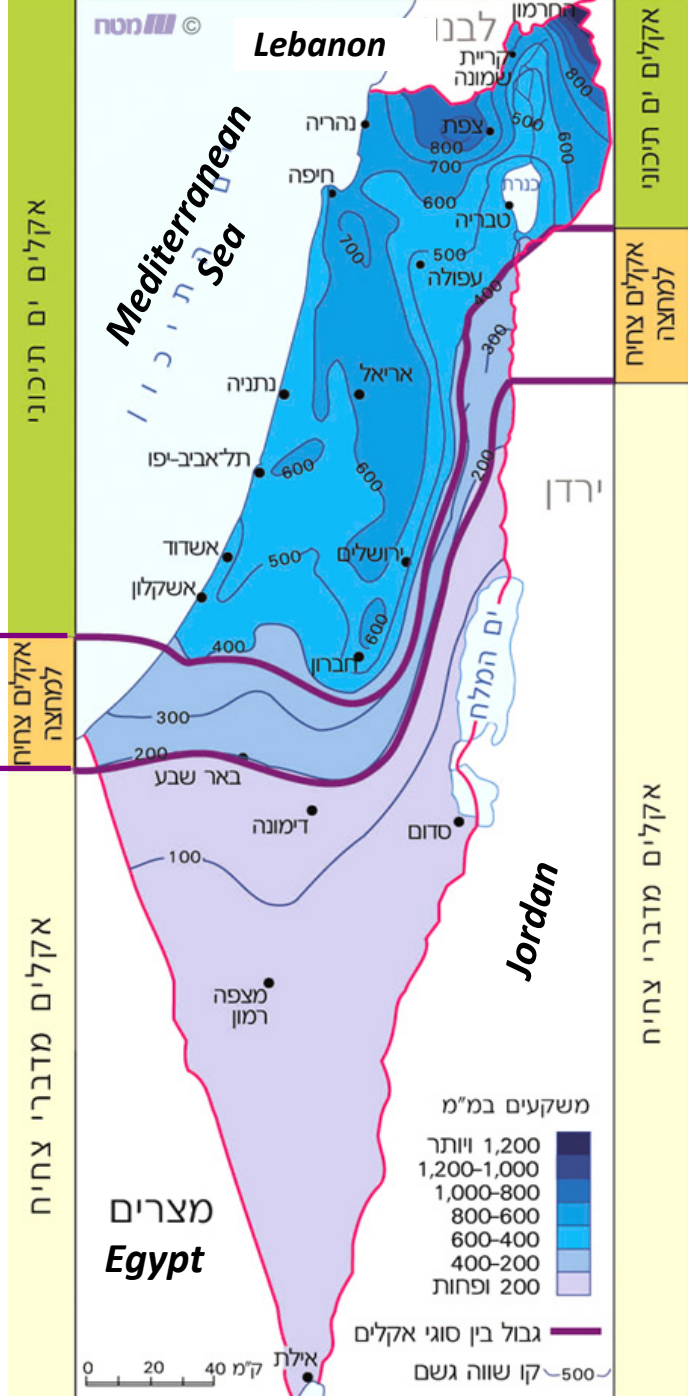
Rainy Winter November-March

Dry Summer June -August

Sub Tropic

Semi Arid

Arid



1,200 mm

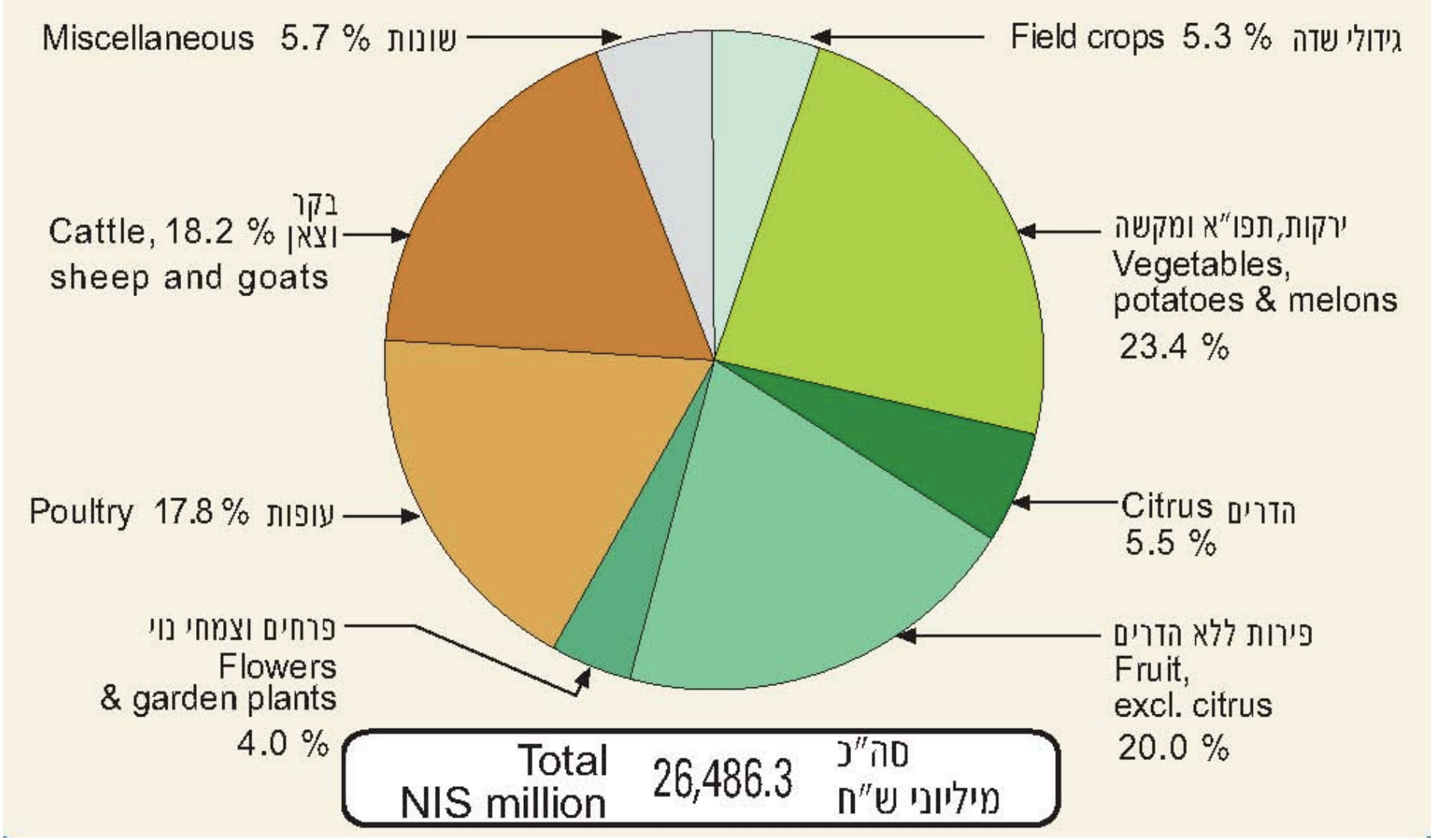
50 mm

AGRICULTURE

Varied climate conditions, topography and soil types stimulate the development of unique agricultural technologies

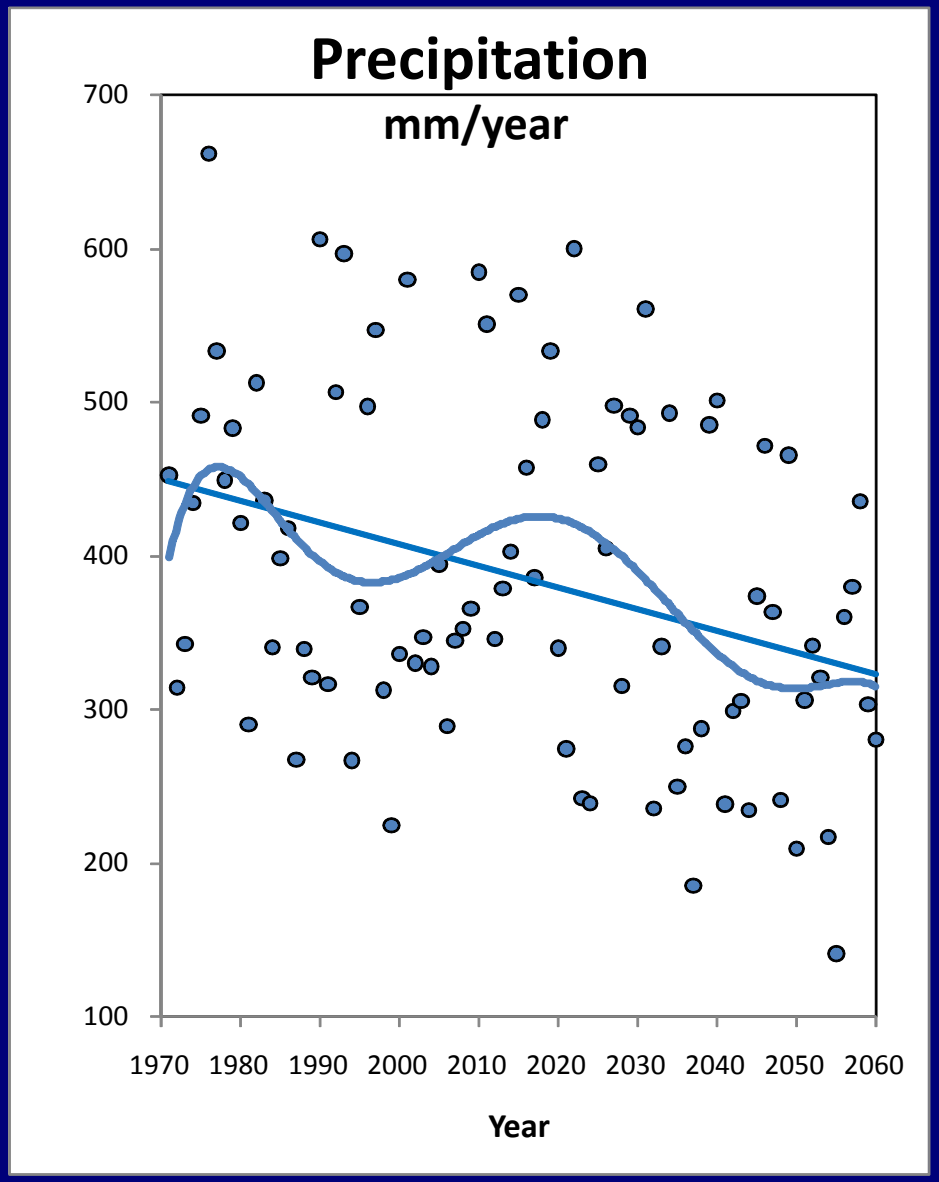
- ✓ **Climate : Subtropical to Arid**
- ✓ **Topography : - 408m to 1,208m**
- ✓ **Soil : Sand dunes to Heavy Loam**

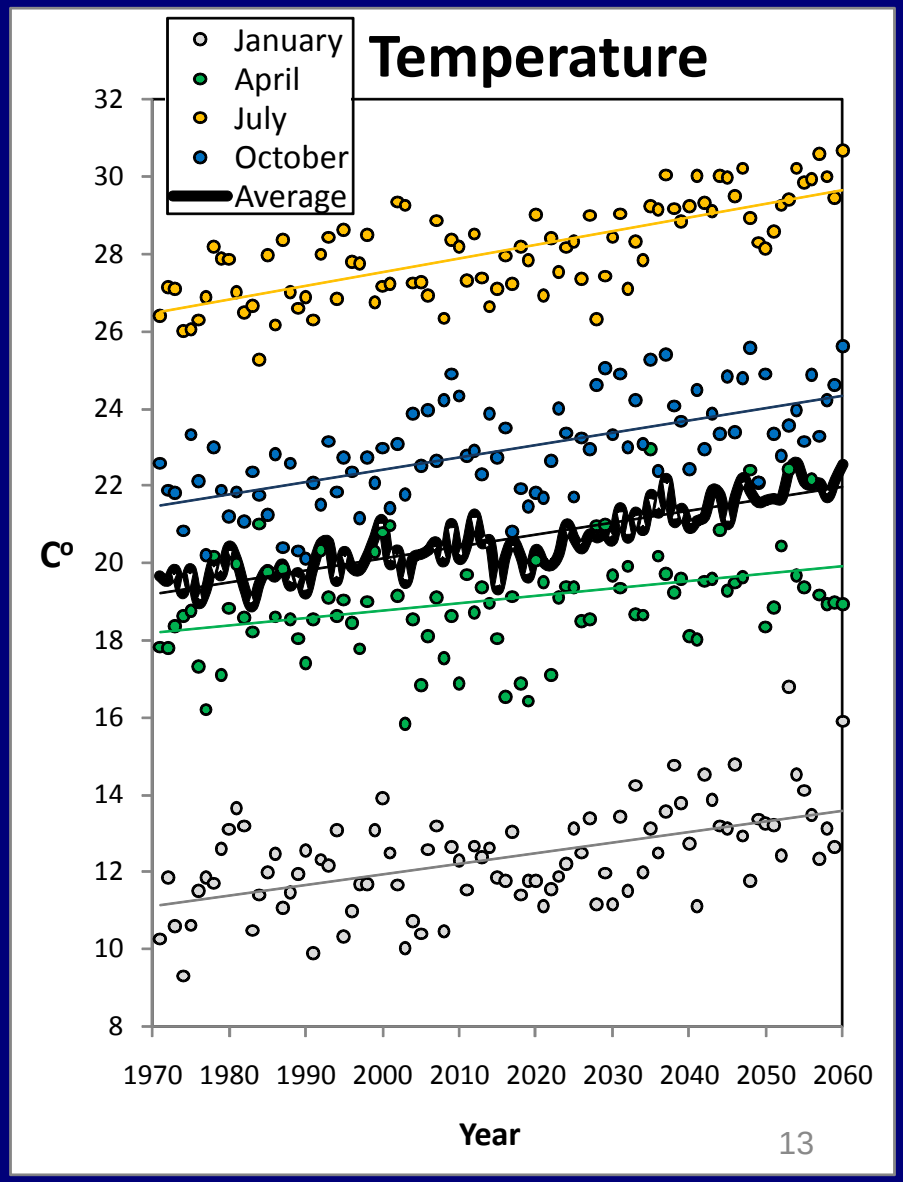
Value of agricultural production (2010)



2% of Net Domestic Product

Climate Change Forecast for Israel





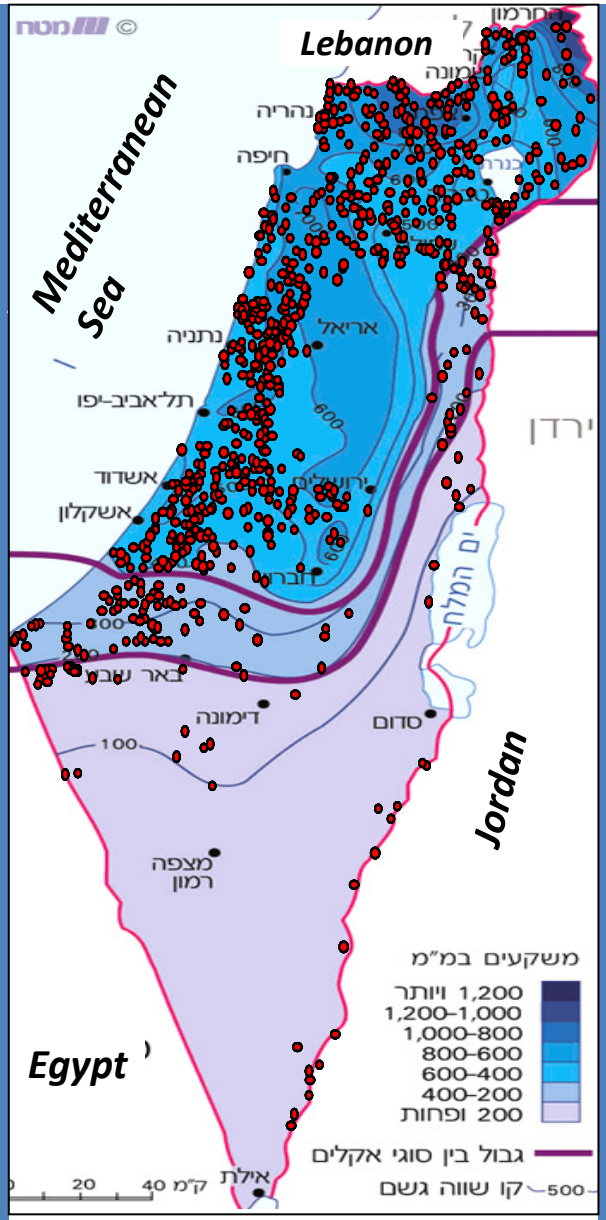
Previous research on Israel

- Kan et al. (2007)
  - Mathematical programming applied to regional data
  - 20% decrease in net farm revenues by 2100
- Fleischer et al. (2008)
  - Ricardian approach applied to farm-level data
  - Moderate climate change beneficial but extreme changes harmful
- Kaminski et al. (forthcoming)
  - structural land allocation model applied to regional data from Israel
  - Up to 10% decrease in aggregate farm profits by 2060

Data

- 1992-2002 annual data from 793 communities
- 7 crop-technology bundles:
  - Irrigated field crops
  - Rain-fed field crops
  - Open-field vegetables
  - Covered vegetables
  - Deciduous fruits
  - Subtropical fruits
  - Citrus and other fruits

Agricultural communities



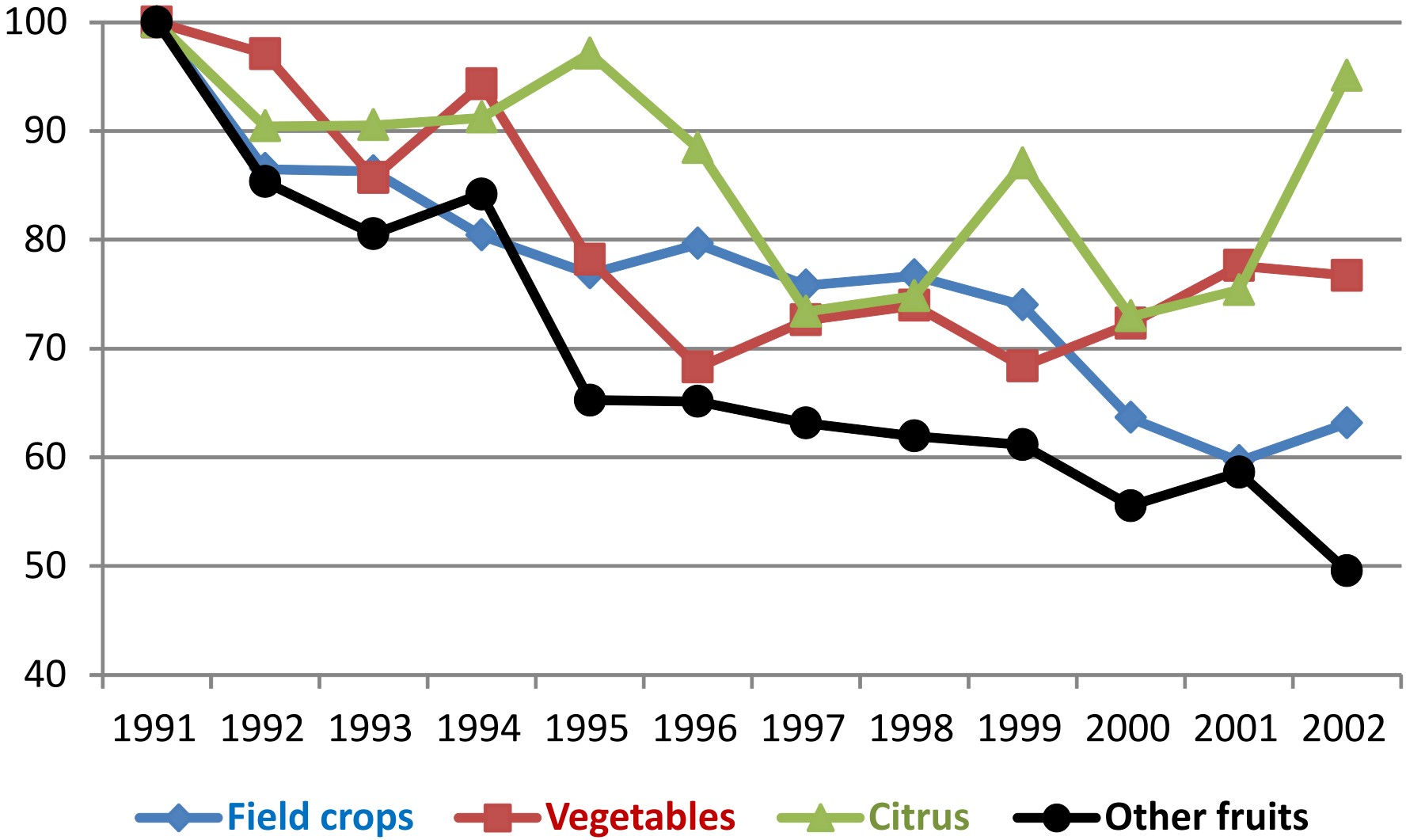
Crop portfolios

Activity	Fraction of growers	All sample (dunam)	Per-grower (dunam)
Vegetables, covered	27%	27	101
Vegetables, open field	73%	804	1,105
Field crops, irrigated	56%	879	1,573
Field crops, rain-fed	65%	1,319	2,016
Deciduous fruits	36%	123	338
Subtropical fruits	63%	174	274
Citrus & other fruits	82%	421	513

Climate data

Precipitation	mm/year	395.1
Precipitation S.D.	mm/year	121.6
Degree days - January	C°	145.1
Degree days –April	C°	328.7
Degree days – July	C°	576.9
Degree days – October	C°	441.3
Degree days – inter-annual S.D.	C°	198.9
Degree days – intra-annual S.D.	C°	5.6
Degree days above 34 C°	C°	0.46
Degree days below 8 C°	C°	6.4

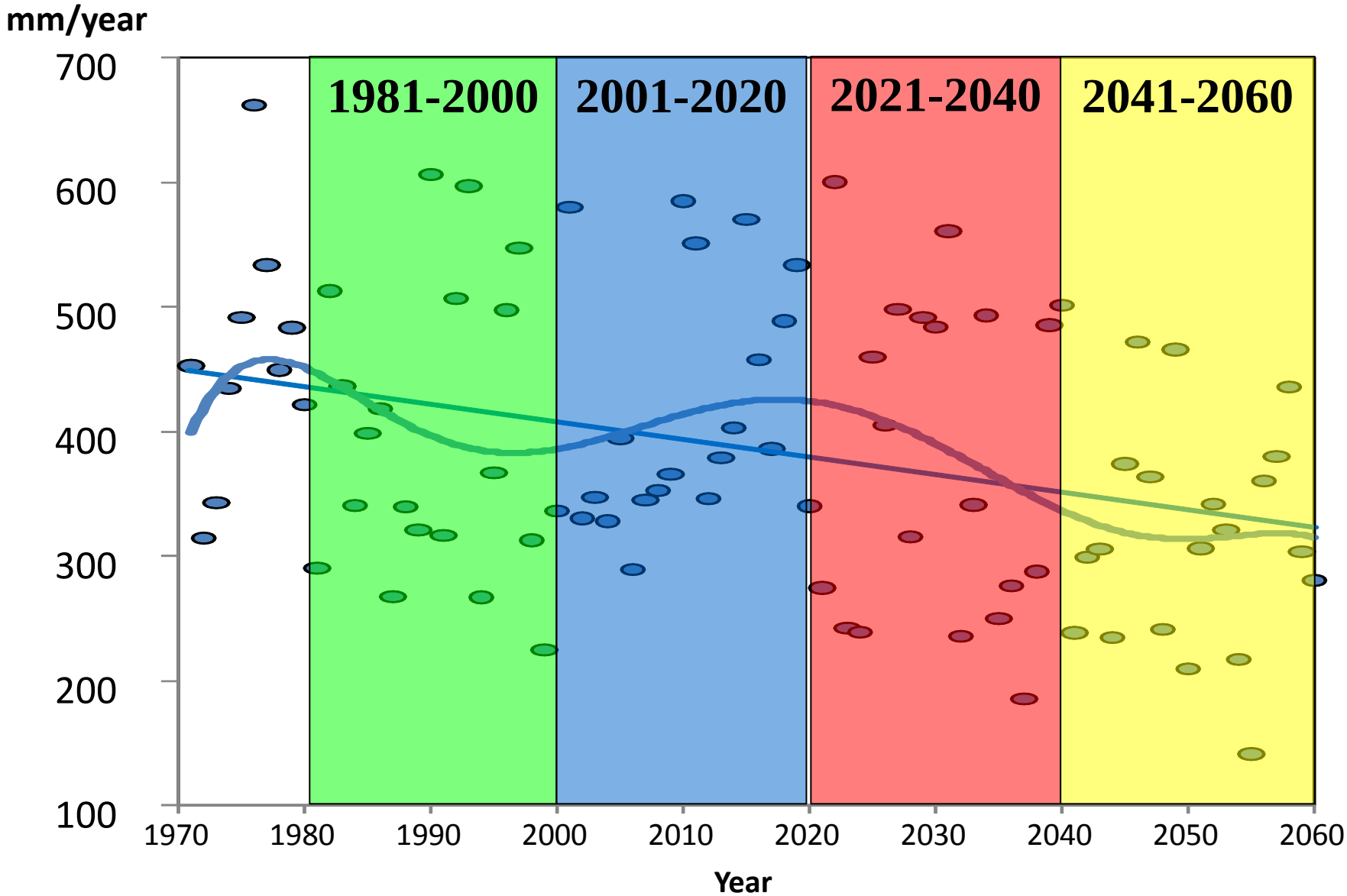
Crop price indices



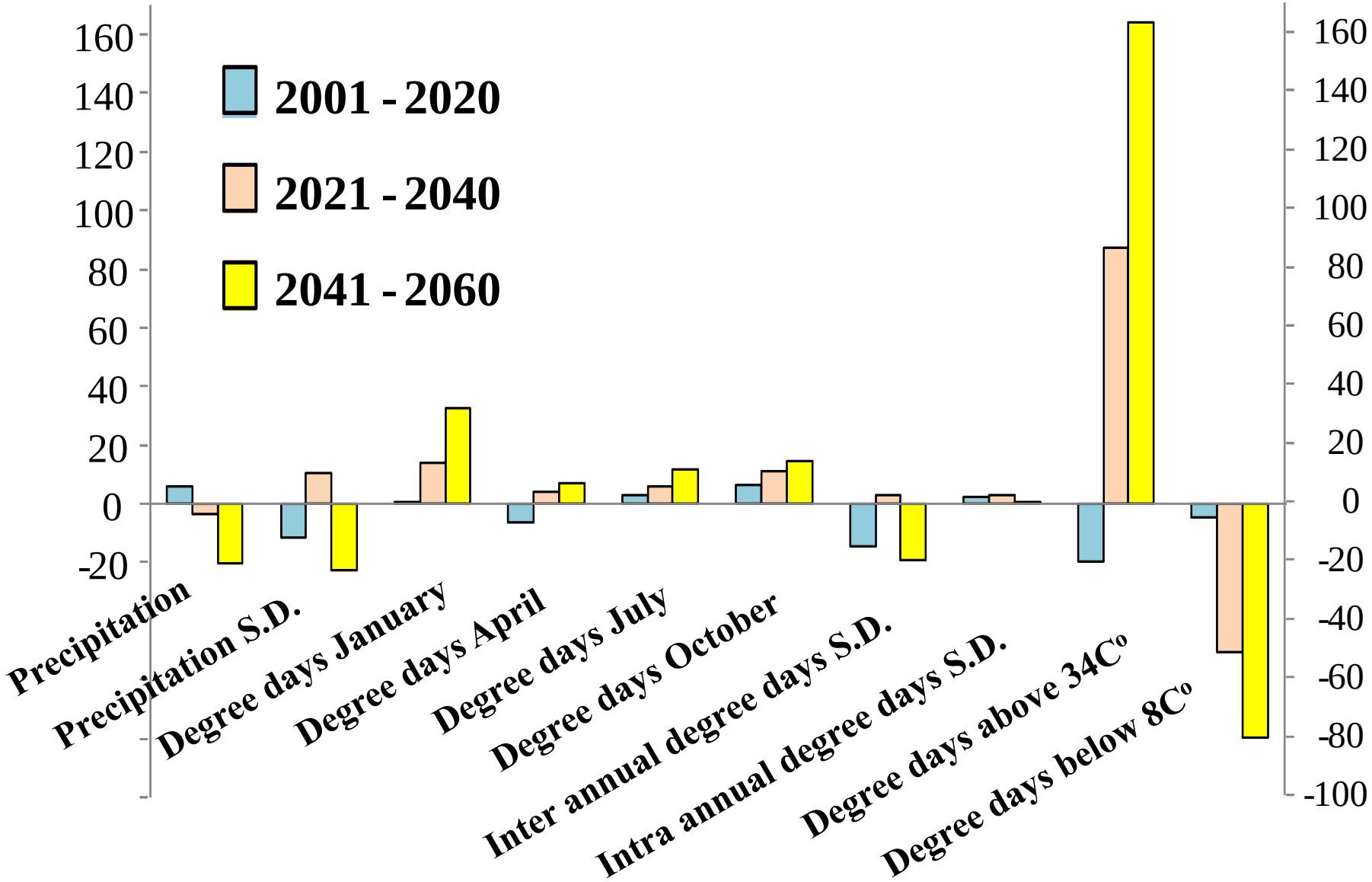
Climate variables coefficients

Variable	Vegetables Covered	Vegetables Open field	Field crops Irrigated	Field crops Rain-fed	Deciduous	Subtropic.	Citrus & Other
Precipitation	-1.543**	19.69***	9.21***	8.715**	7.759***	-0.532	-17.73***
Precipitation S.D.	6.897***	-32.65***	-14.87**	-72.07***	-18.93***	7.521***	51.98***
Deg. days - Jan.	-8.232***	15.13**	-8.701	11.73	-2.736	-9.753***	9.341**
Deg. days –April	-0.242	58.61***	34.44***	-16.03*	25.55***	-0.730	-7.721**
Deg. days – July	30.52***	49.3***	42.58***	50.58***	-18.89***	-9.886***	12.81**
Deg. days – October	-10.69***	-17.93*	-37.23***	-4.802	-43.71***	27.49***	11.36*
DD - inter ann. S.D.	2.99*	1.229	11.33**	82.05***	17.76***	-8.067***	2.681
DD - intra ann. S.D.	-1552***	-920	-2796***	-1851**	-1852***	419.4***	917.8***
DD above 34C^{o}	61.83**	-476.6***	-885.5***	-1190***	152.3***	221.2***	-472.8***
DD below 8C^{o}	-5.118**	20.54***	27.02***	-34.04***	14.61***	-1.568	5.705*

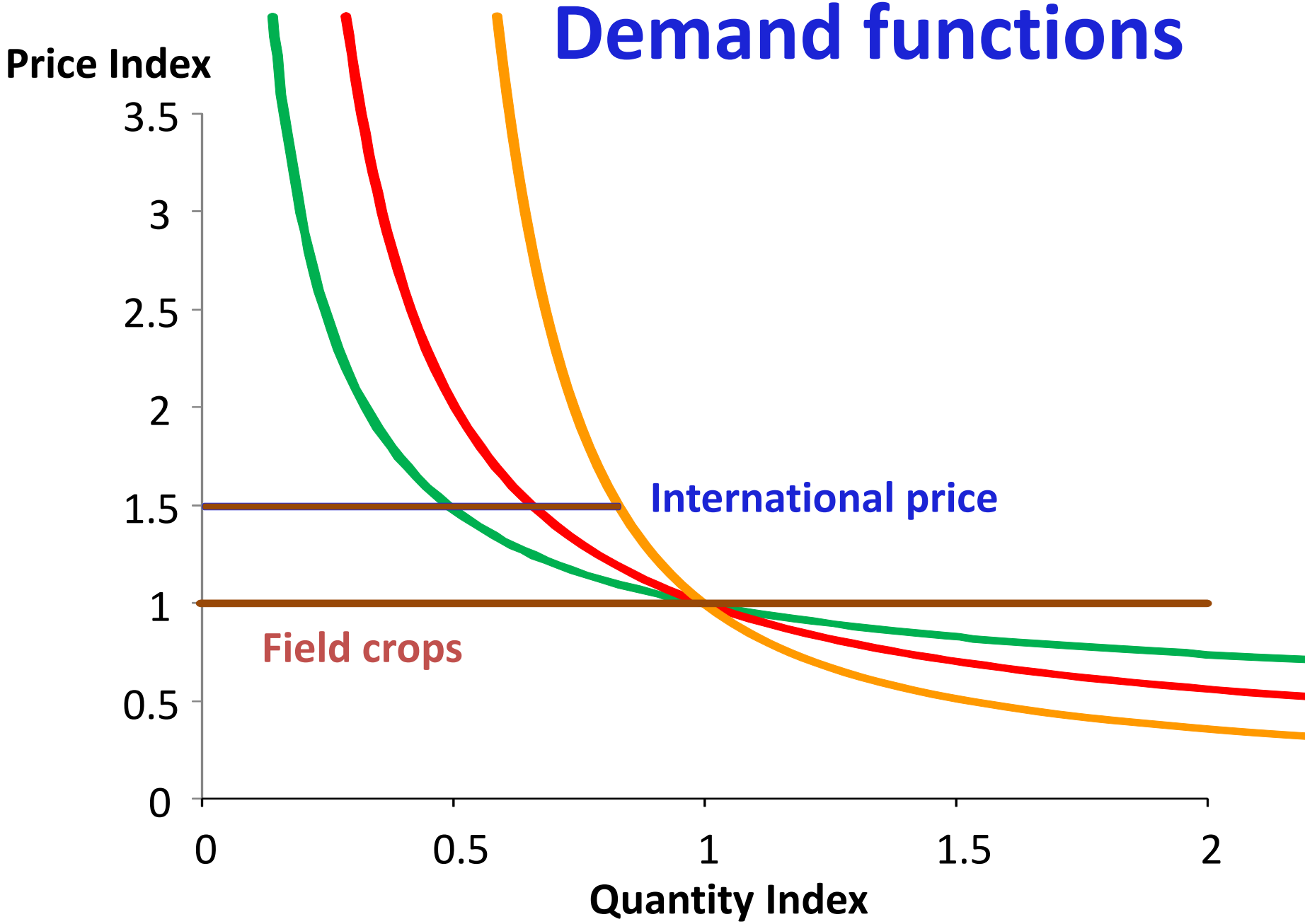
Precipitation by climate Periods



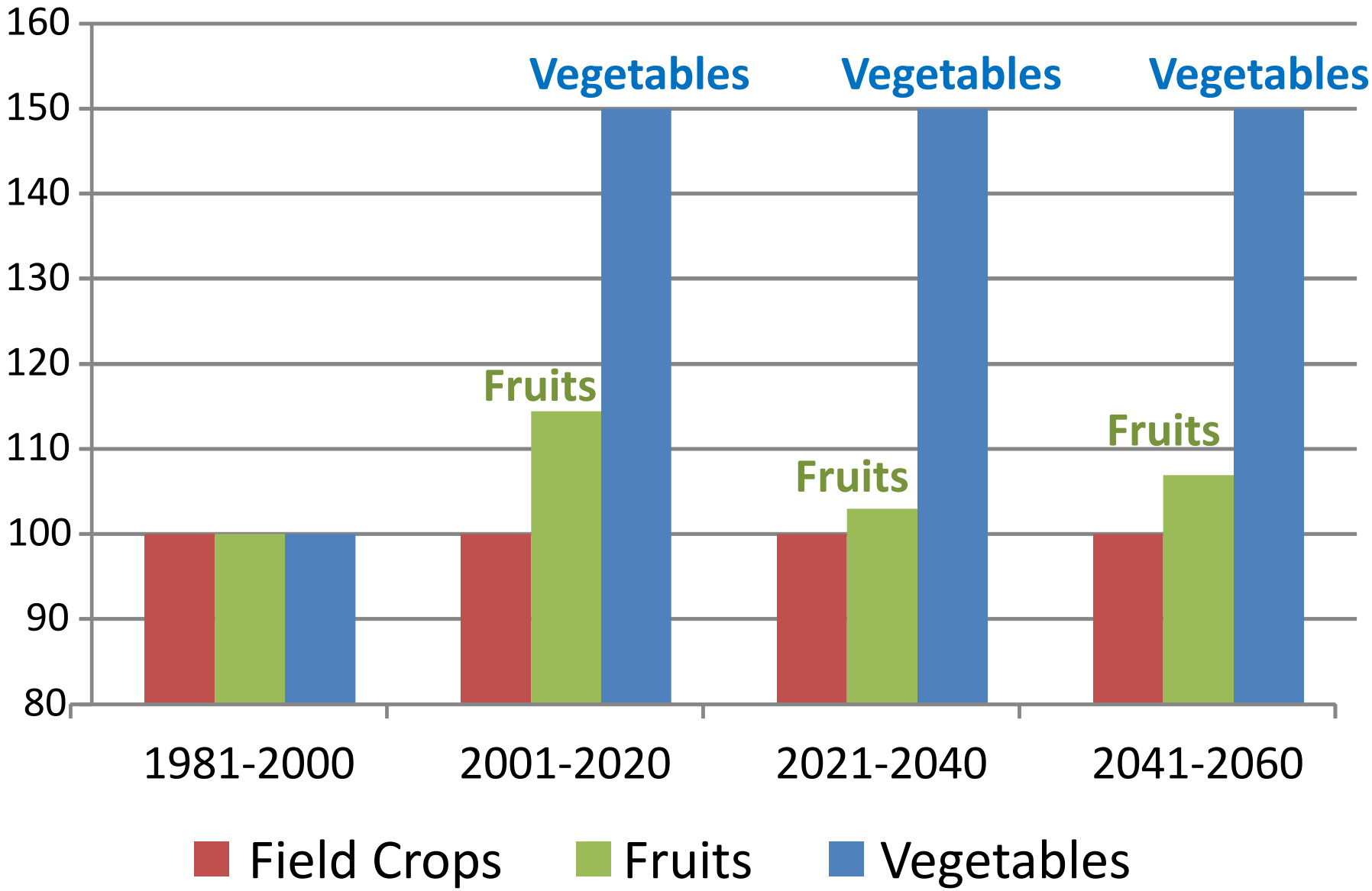
Climate Change Relative to 1981-2000 (%)



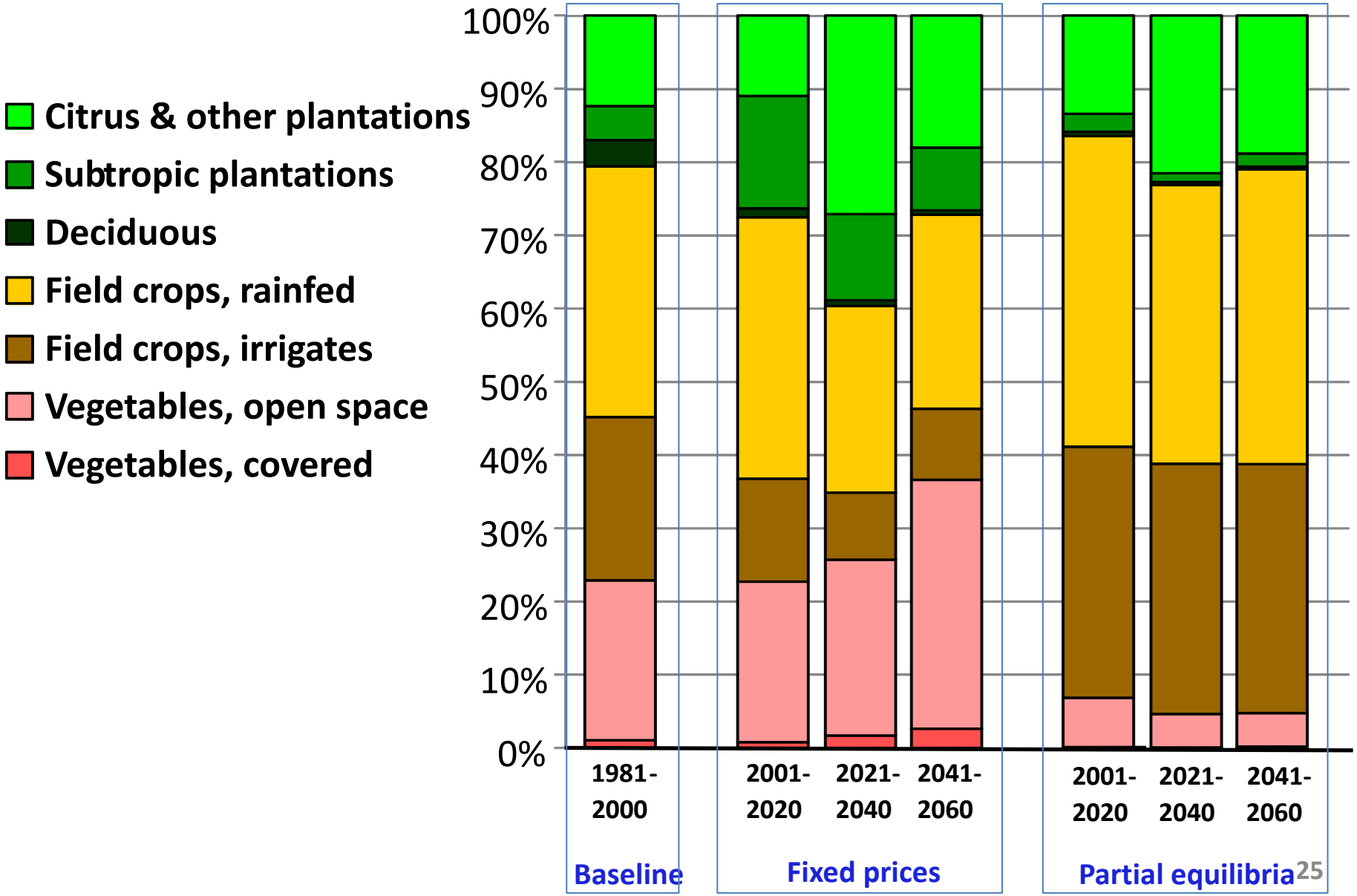
Demand functions



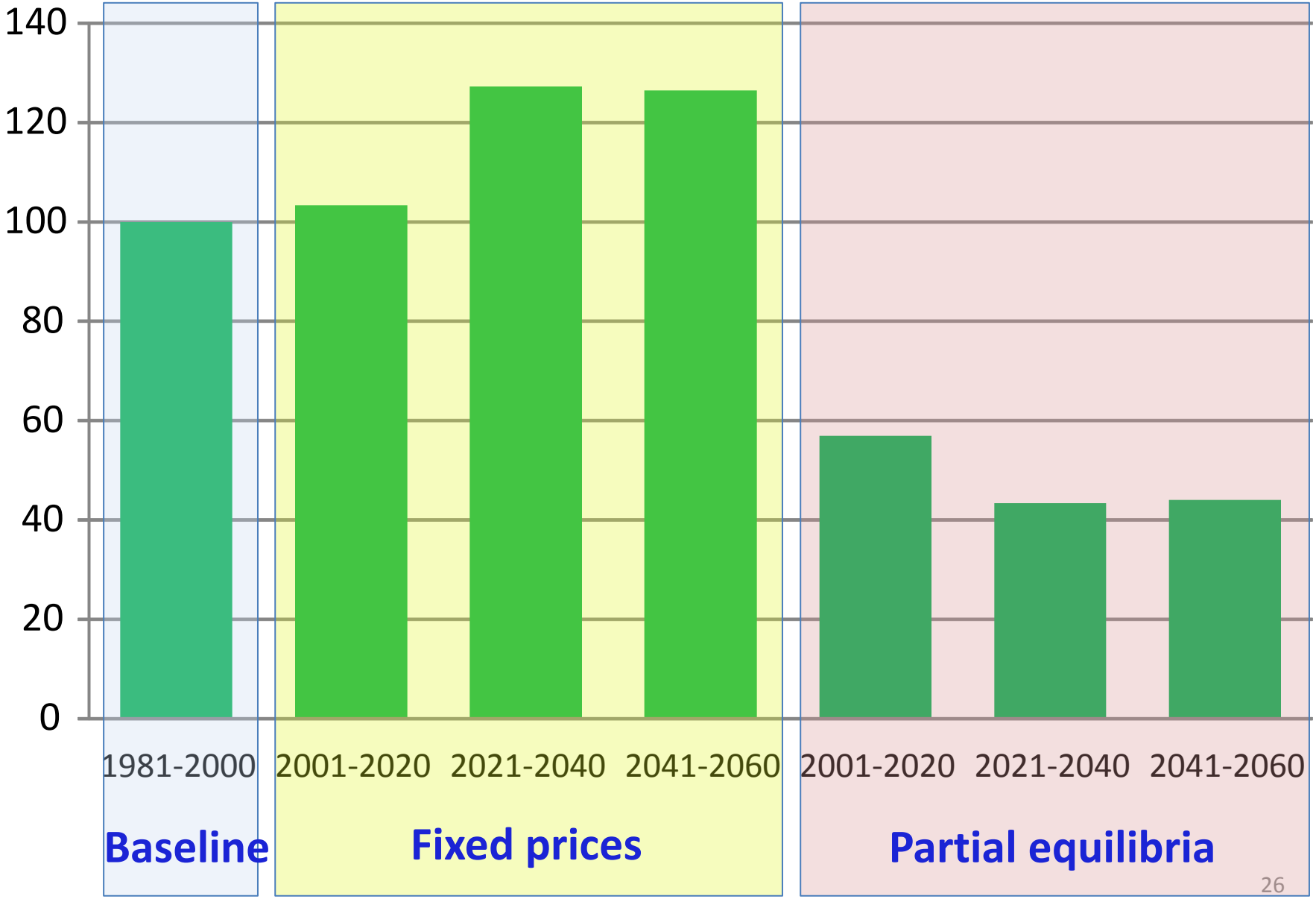
Forecasted price indices



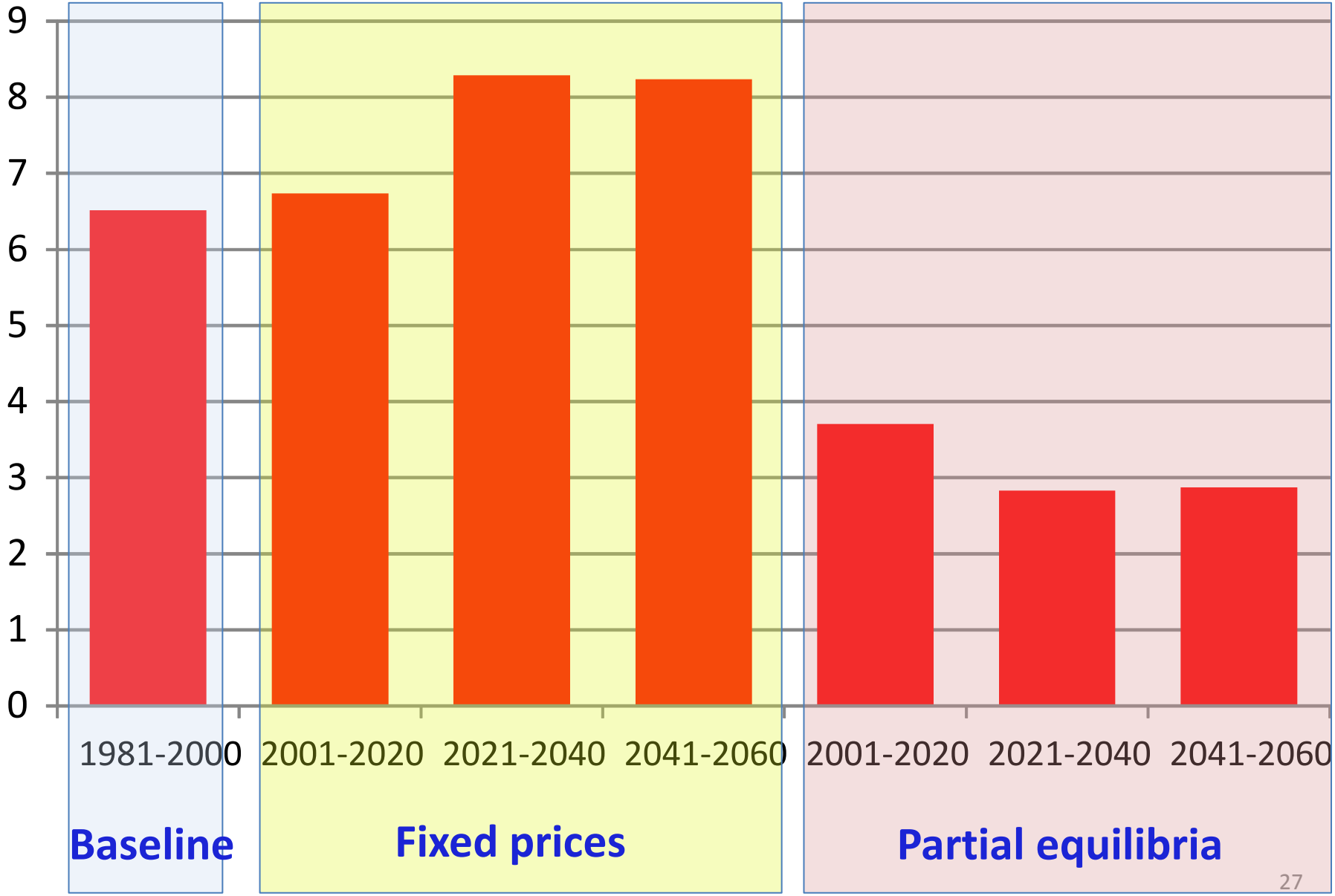
Forecasted land allocations



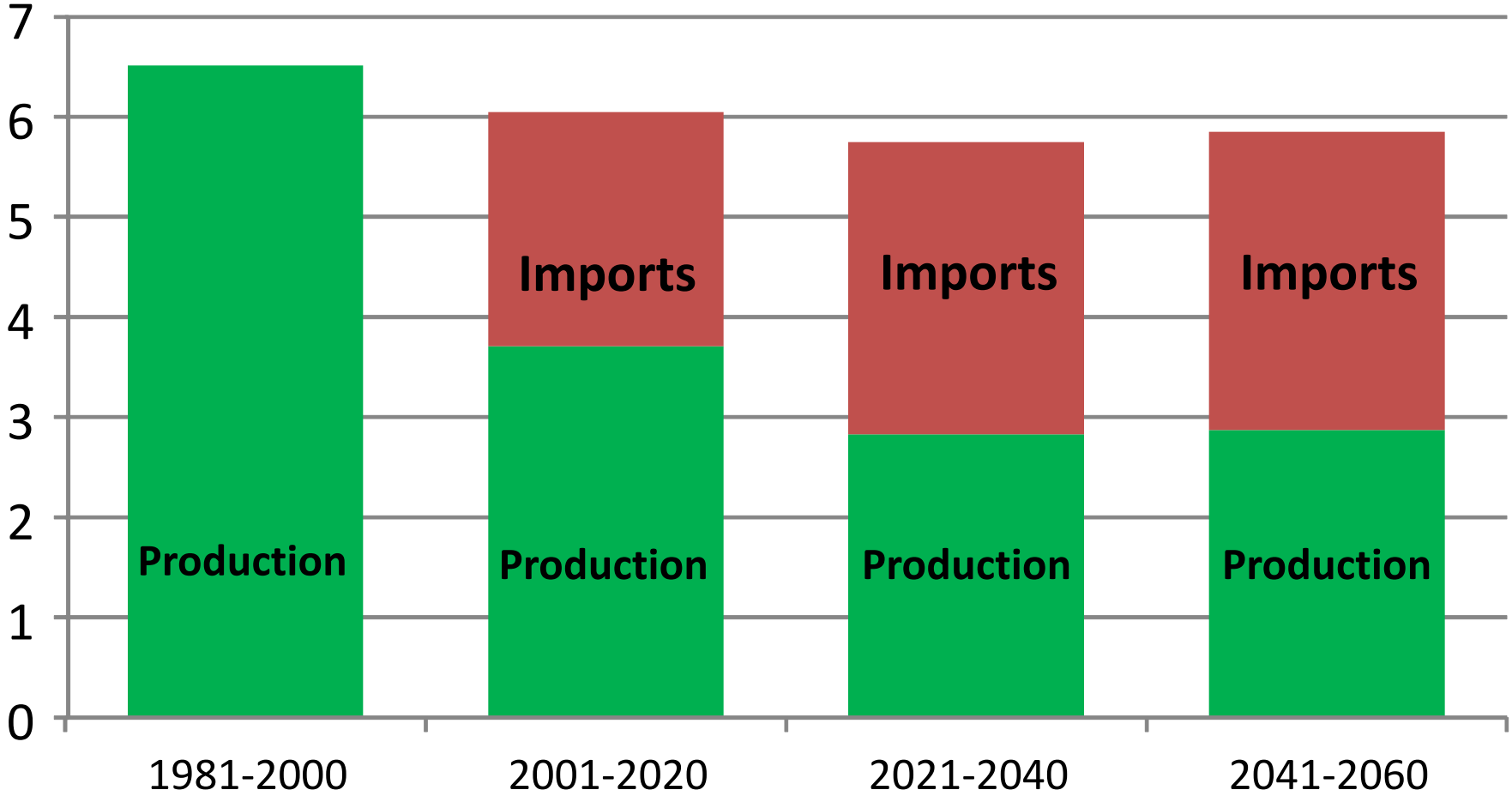
Quantity Index of Total Production



Value of Total Production (million NIS)



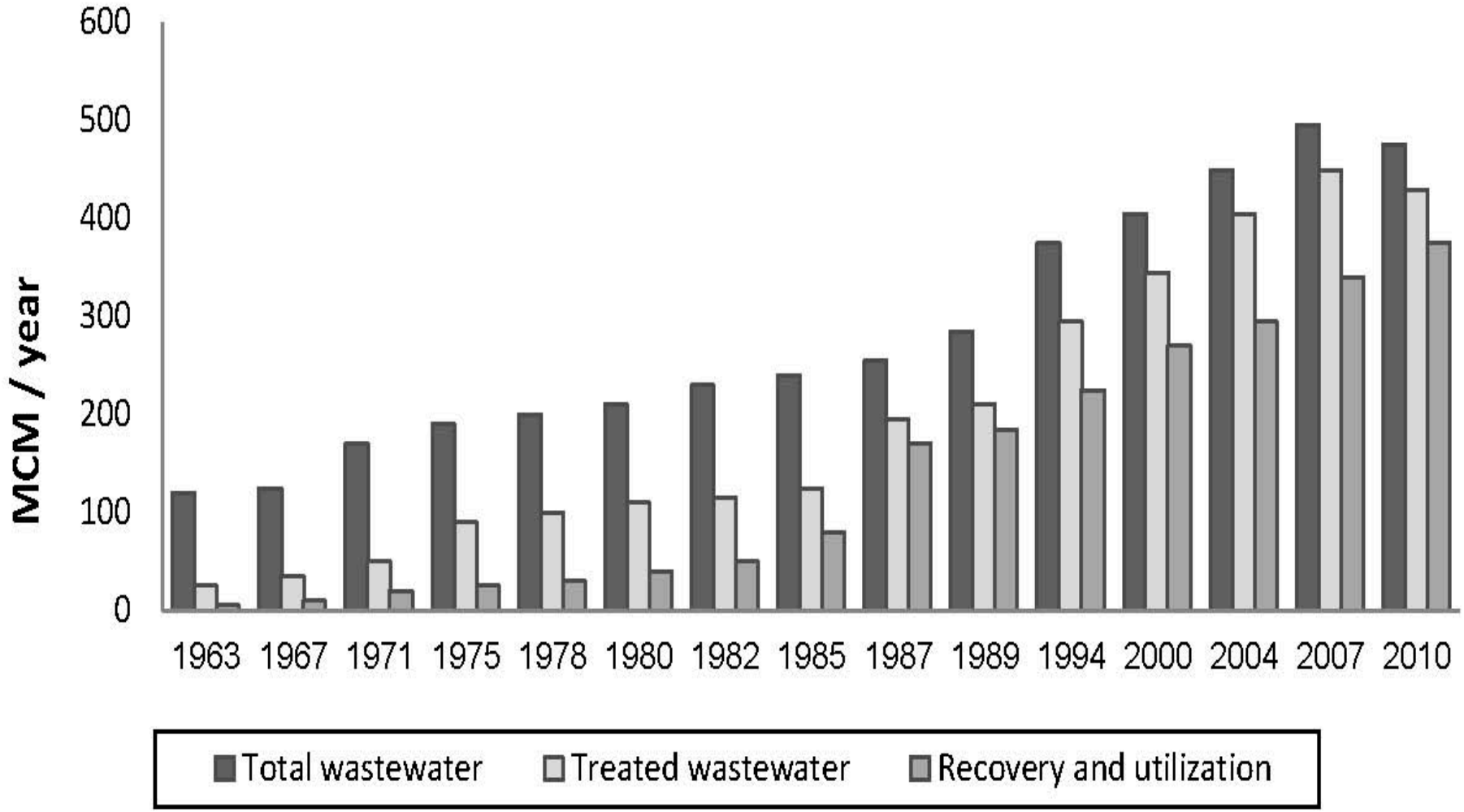
Value of Production, Imports and Consumption under partial equilibria (million NIS)



Summary

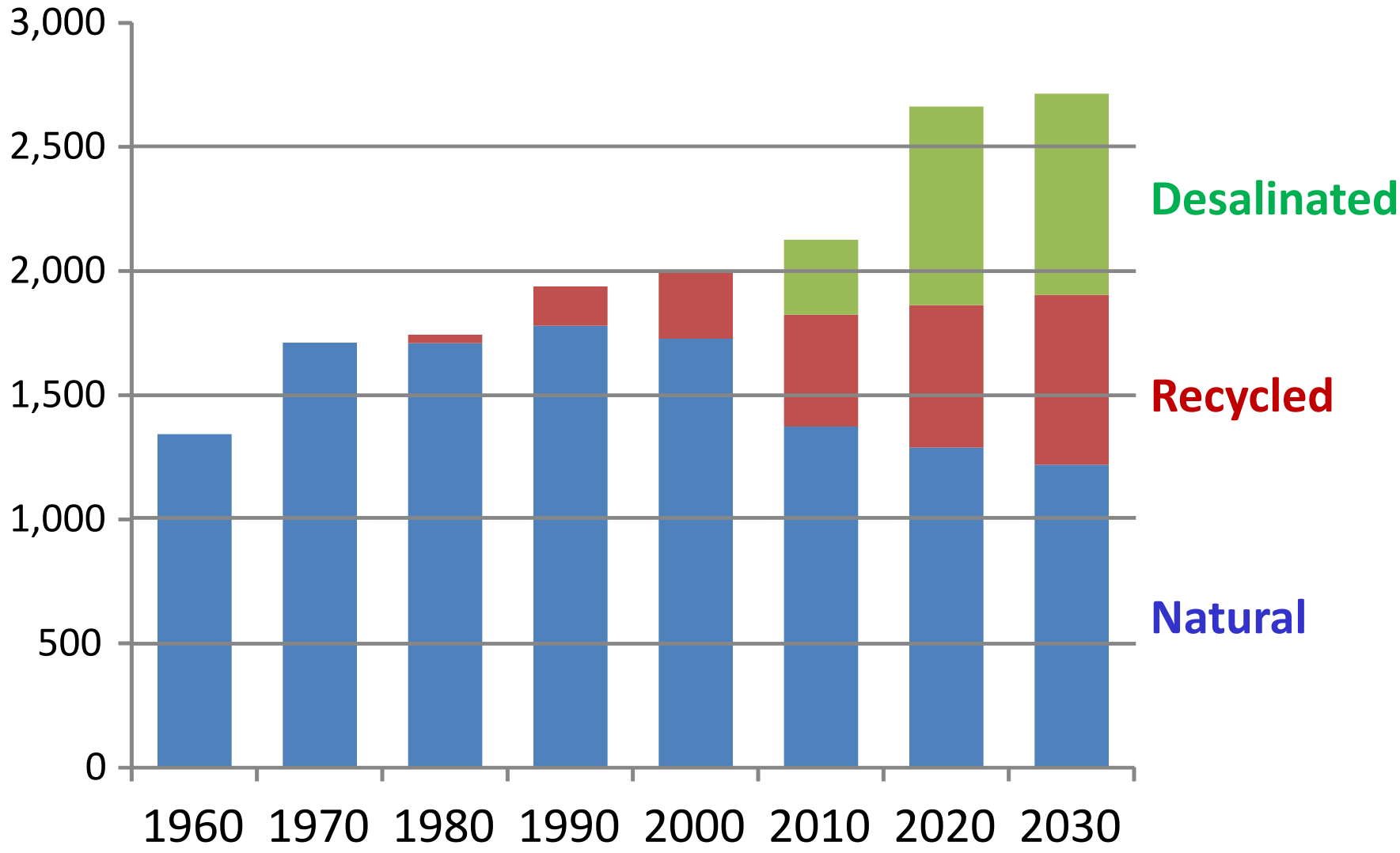
- Climate change is expected to bring about considerable changes in Israeli agriculture
- Ignoring price changes may lead to erroneous production expectations
- Our methodology takes into account:
  - Effects of price changes
  - Changes in crop portfolios at the farm level, including corner solutions

Wastewater recycling



Source: Lavee and Ash (forthcoming)

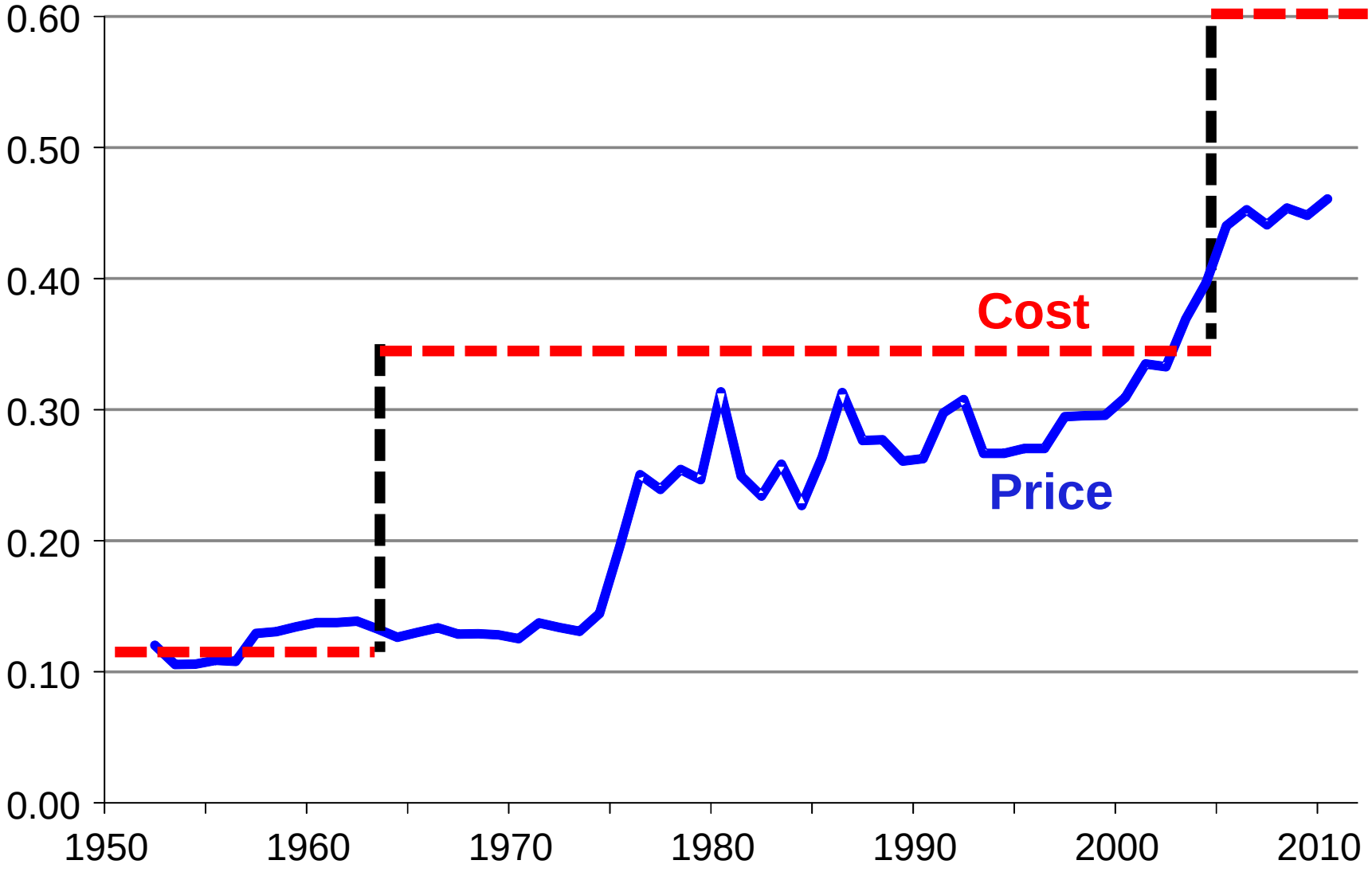
Water sources (million m^3)



Source: Yoav Kislev, Taub Center (2012)

Water prices and direct costs

water for agriculture (in $US/CM, 2010 prices)



Source: Modified from Yoav Kislev, “Water Pricing” (2010) and Taub Center (2012)