MODELING CLIMATE CHANGE AND AGRICULTURAL YIELDS: Example of Russia

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2 Methodology

3 Data

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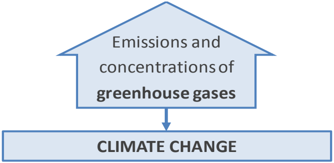
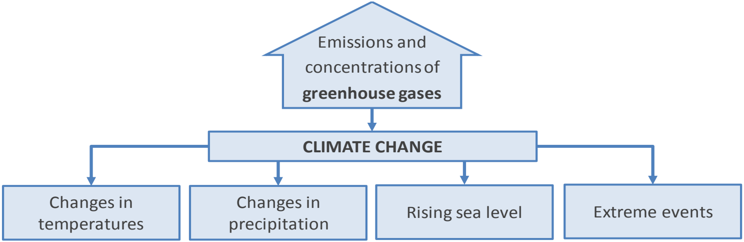
CLIMATE CHANGE



CLIMATE CHANGE



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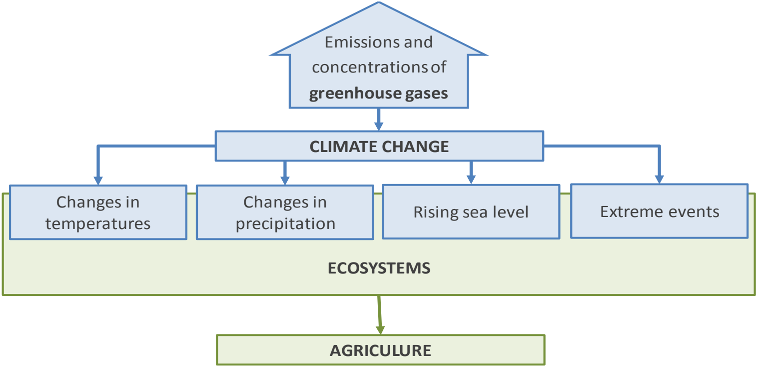
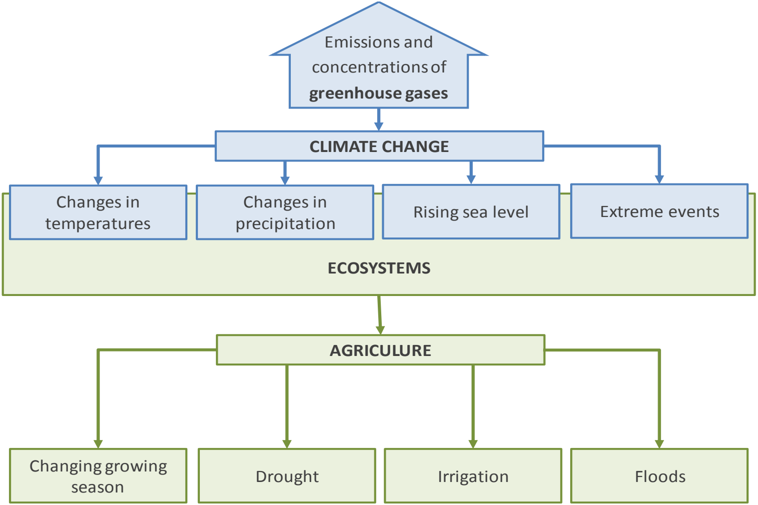
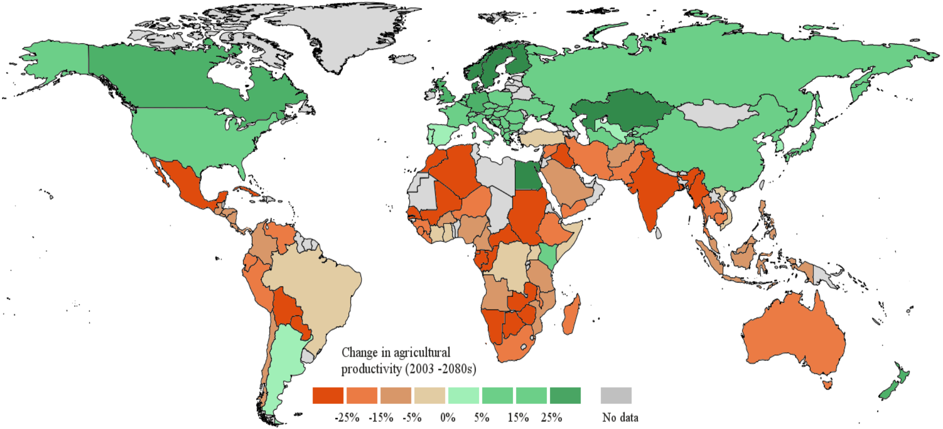


CLIMATE CHANGE



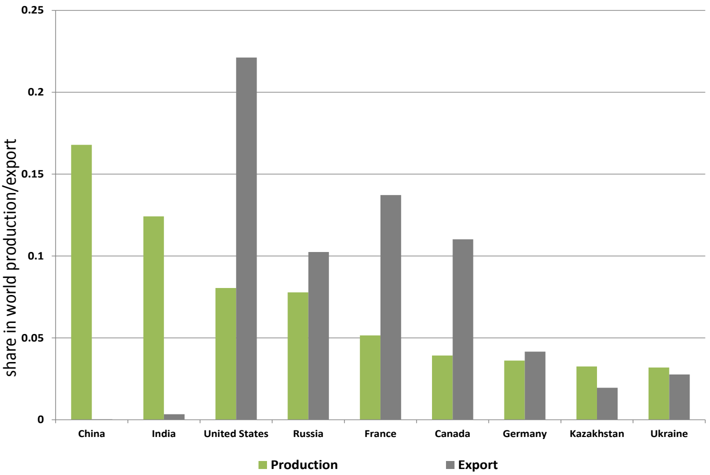
PROJECTED IMPACT OF CLIMATE CHANGE ON YIELDS



RESEARCH OBJECTIVE

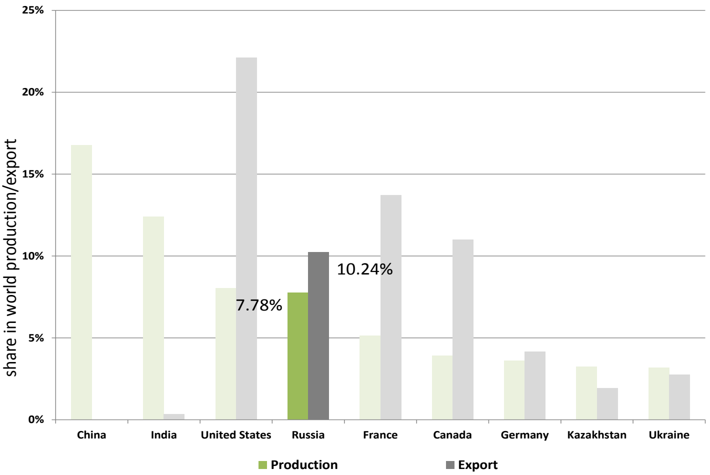
TO ESTIMATE THE EFFECT OF CLIMATE ON AGRICULTURAL PRODUCTION

WORLD GRAIN MARKET



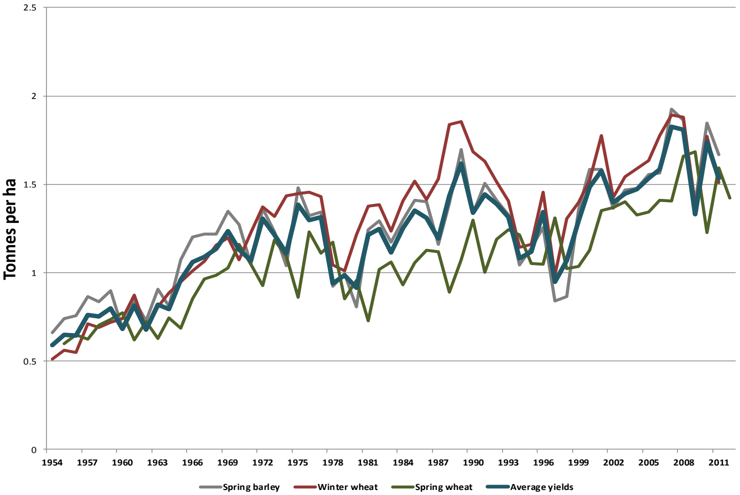
Source: FAOSTAT 2014

WORLD GRAIN MARKET



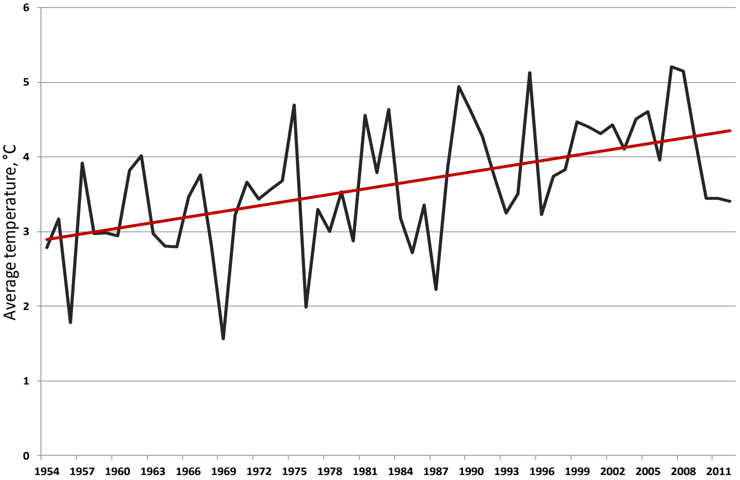
Source: FAOSTAT 2014

GRAIN YIELDS IN RUSSIA, 1955-2012



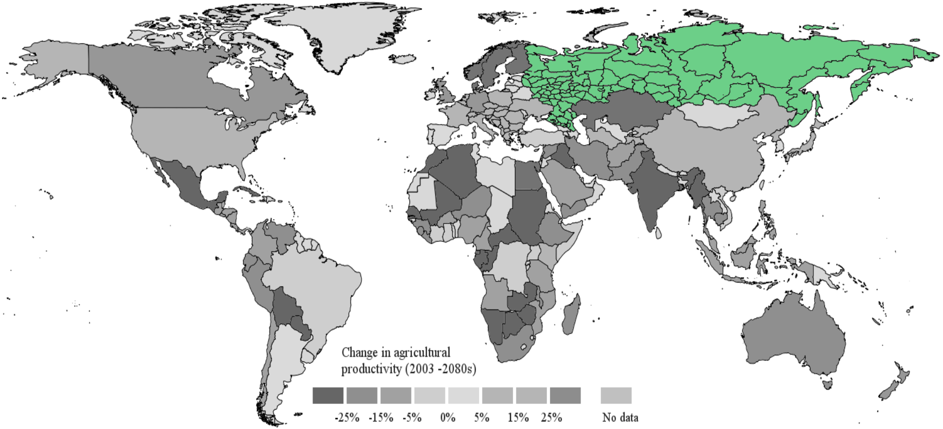
Source: TsSU (annual editions from 1956 to 1991), Rosstat (annual editions from 1992 to 2014)

AVERAGE TEMPERATURES IN RUSSIA, 1954-2012



Source: author's calculations, based on Sheffield, Goteti and Wood (2006)

PROJECTED IMPACT OF CLIMATE CHANGE ON YIELDS



PREVIOUS STUDIES

Authors	Title	Climate change impact
Sirotenko et al. (1997)	Sensitivity of the Russian agriculture to changes in climate	Reduction of 15% by 2030
Alcamo et al. (2007)	A new assessment of climate change impacts on food production shortfalls	-9% to +12% depending on oblast
Safonov and Safonova (2013)	Economic analysis of the impact of climate change on agriculture in Russia	+9% by 2030 +12% by 2050
Lobell, Schlenker, and Costa-Roberts (2011)	Climate trends and global crop production since 1980	Reduction of 15% during 1980-2008
Sirotenko and Pavlova (2012)	Methods of the estimation of climate change impact on agricultural productivity	Winter wheat productivity increased during 1975-2009

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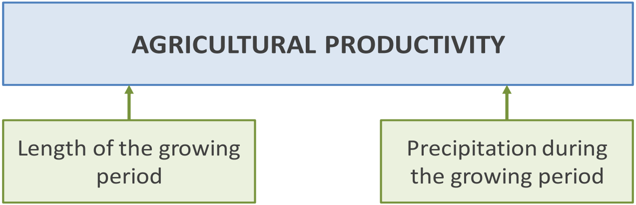
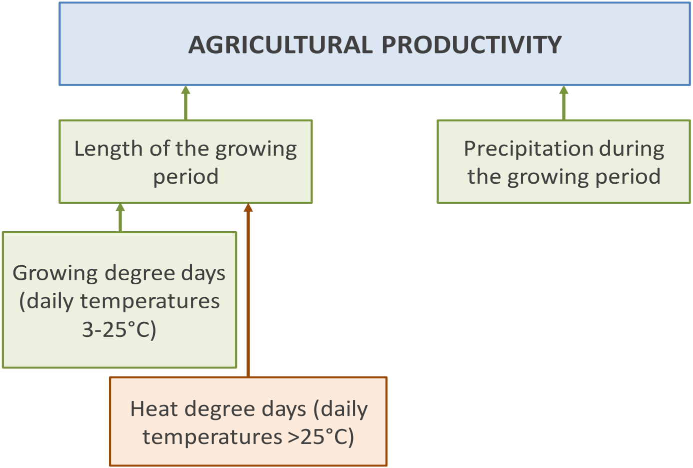
METHODOLOGY

STEP 1: TO ESTIMATE THE RELATIONSHIP BETWEEN CURRENT WEATHER CONDITIONS AND AGRICULTURAL PRODUCTION

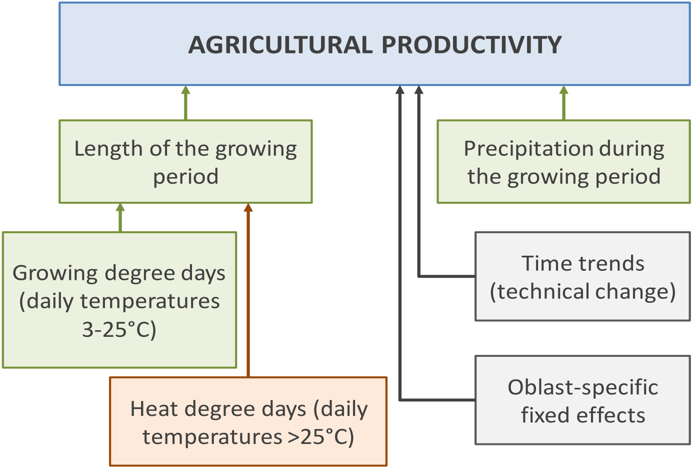
MODEL: STEP 1


AGRICULTURAL PRODUCTIVITY
Length of the growing period
Precipitation during the growing period

MODEL: STEP 1


AGRICULTURAL PRODUCTIVITY
Length of the growing period
Precipitation during the growing period
Growing degree days (daily temperatures 3-25°C)
Heat degree days (daily temperatures >25°C)

MODEL: STEP 1


AGRICULTURAL PRODUCTIVITY
Length of the growing period
Precipitation during the growing period
Growing degree days (daily temperatures 3-25°C)
Time trends (technical change)
Heat degree days (daily temperatures >25°C)
Oblast-specific fixed effects

METHODOLOGY

STEP 1: TO ESTIMATE THE RELATIONSHIP BETWEEN CURRENT WEATHER CONDITIONS AND AGRICULTURAL PRODUCTION

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STEP 2: TO ASSESS THE IMPACT OF FUTURE CLIMATE CHANGE ON AGRICULTURAL PRODUCTIVITY

MODEL: STEP 2

Option 1:

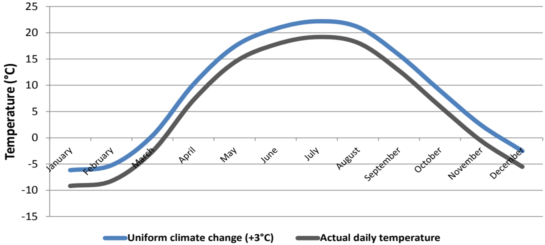
Temperatures increase gradually and uniformly in every region of the country, change reaches 5°C

Option 2:

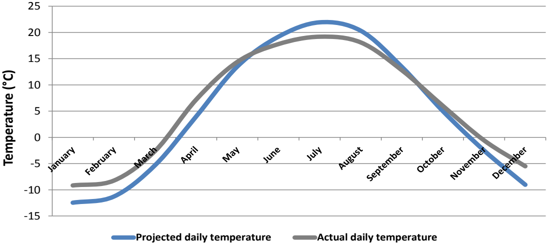
Climate change follows projections assessed by the Intergovernmental Panel on Climate Change (IPCC): unequal and non-uniform distribution of changes in climate

MODEL: STEP 2

Option 1:



Option 2:



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AGRICULTURAL DATA

- Winter wheat
- Spring wheat
- Spring barley

Time frame: 1955-2012

Sample: 62 out of 77 subjects of Russian Federation

Sources: Russian Federation Federal Statistical Service (1992-2014)
Central Statistical Directorate of the Council of Ministers of the USSR (1956-1991)

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CLIMATE DATA

Winter wheat

September – February:

- Average daily temperatures
- Total precipitation

March-June:

- Growing degree days
- Heat degree days
- Total precipitation

Spring wheat / Spring barley

May-July:

- Growing degree days
- Heat degree days
- Total precipitation

Source: 1.0° Global dataset of meteorological forces (Sheffield, Goteti, and Wood 2006)

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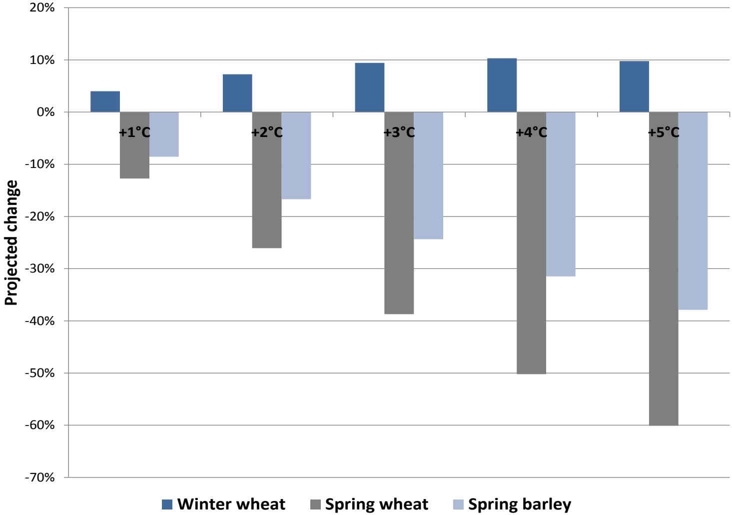
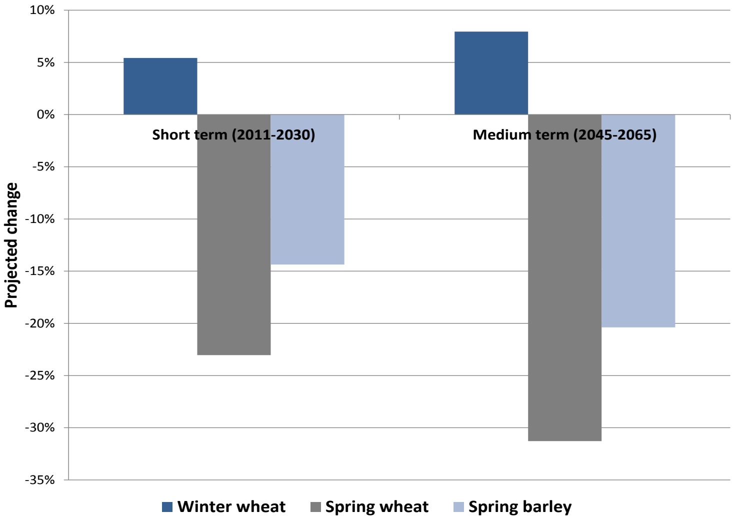
PAST YIELD OUTCOMES

Variable	Winter wheat	Spring wheat	Spring barley
Growing degree days	0.00047***	-0.000760***	-0.00080***
Heat degree days	-0.00471***	-0.010440***	-0.01950***
$Temp_{autumn}$	0.01788	-	-
$Temp^2_{autumn}$	-0.00140*	-	-
$Temp_{winter}$	0.01032*	-	-
$Temp^2_{winter}$	-0.00059**	-	-
P_{summer}	0.00377***	0.010240***	0.00396***
P^2_{summer}	-0.00001***	-0.000022***	-0.00001***
P_{autumn}	0.00077***	-	-
P^2_{autumn}	-0.00001***	-	-
P_{winter}	-0.00227***	-	-
P^2_{winter}	0.00001***	-	-
$HDD \cdot P_{summer}$	-	0.000096***	0.00018***
$HDD \cdot P^2_{summer}$	-	-0.000001***	-0.000001***
R^2	0.9953	0.9854	0.9852
N observations	3049	3689	3874

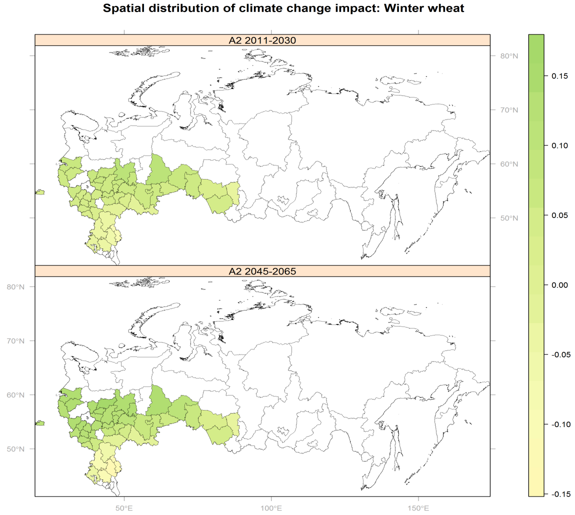
PROJECTED YIELD CHANGES (uniform CC)



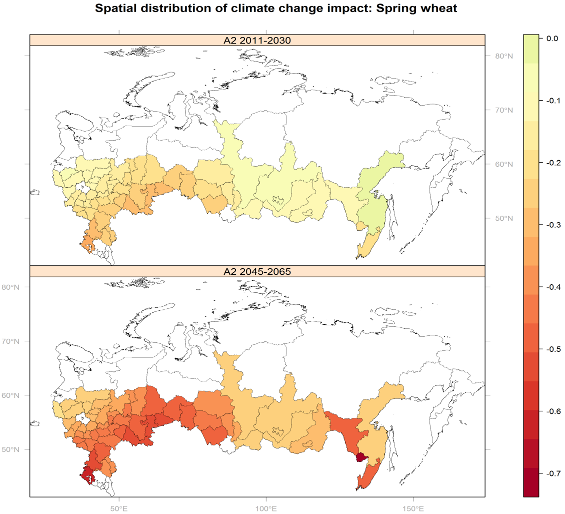
PROJECTED YIELD CHANGES (IPCC projections)



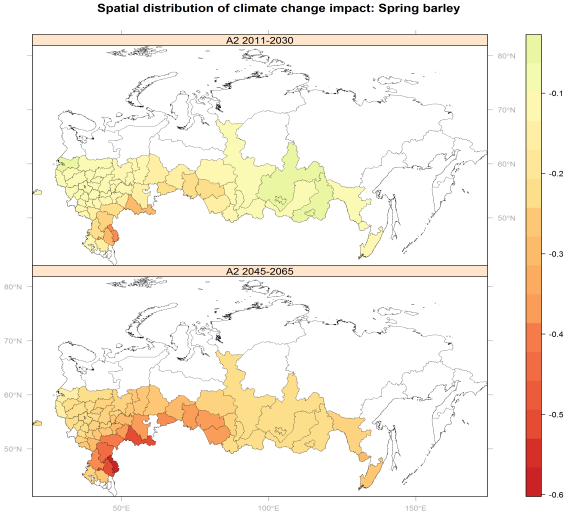
SPATIAL DISTRIBUTION: WINTER WHEAT



SPATIAL DISTRIBUTION: SPRING WHEAT



SPATIAL DISTRIBUTION:SPRING BARLEY



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CONCLUSIONS

1. Agricultural productivity is closely connected to climate conditions.
2. Winter crops will be less affected by projected climate change than spring crops.
3. Adaptation measures should include changes in production structure to avoid crops that are significantly vulnerable even to slightly changing temperatures.

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