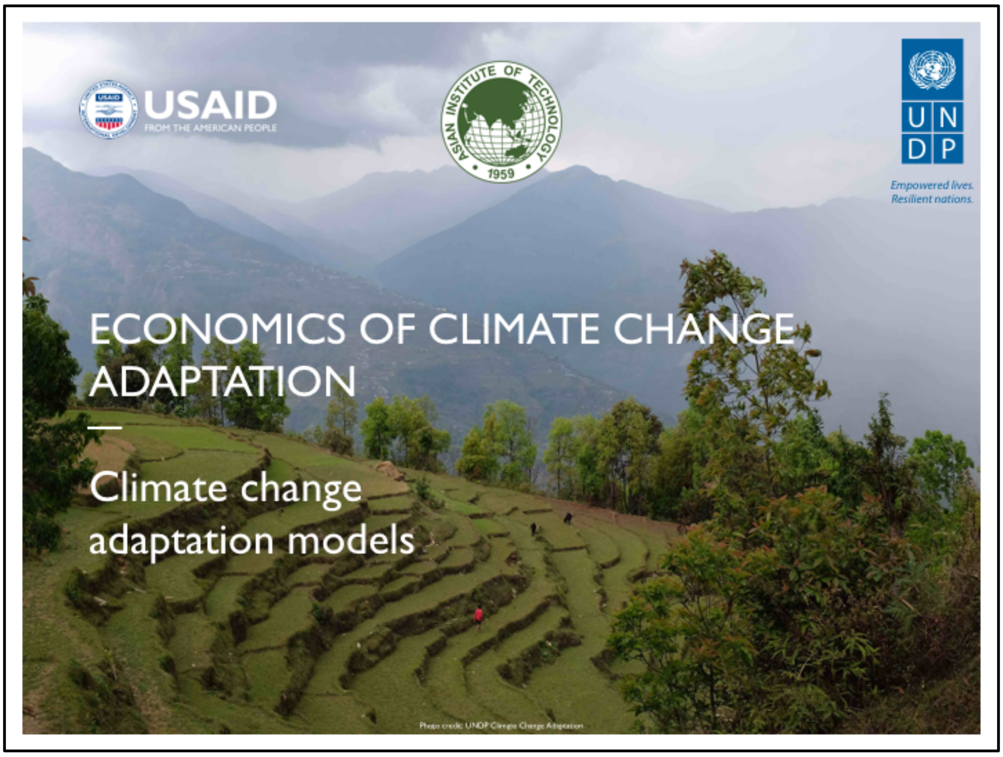

USAID
FROM THE AMERICAN PEOPLE
ASIAN INSTITUTE OF TECHNOLOGY
1959
UNDP
Empowered lives.
Resilient nations.
ECONOMICS OF CLIMATE CHANGE ADAPTATION
Climate change adaptation models
Photo credit: UNDP Climate Change Adaptation

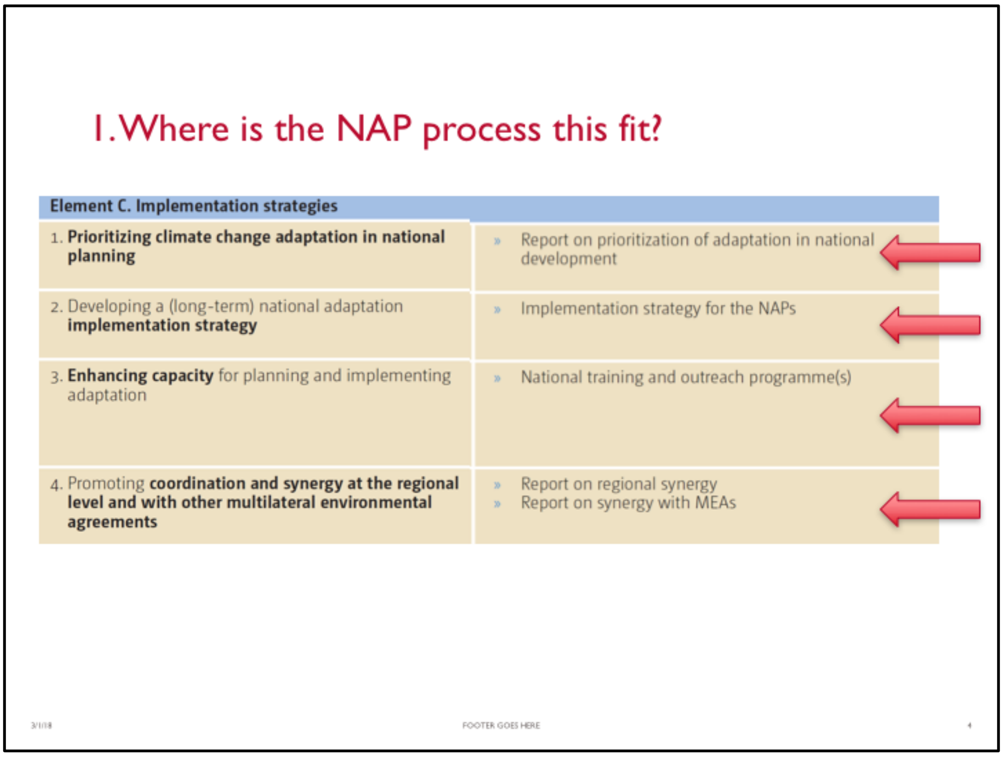
Outline of presentation

1. Where in the NAP Process…
2. Adaptation Research
3. Discrete Choice Models
4. Practical Example. Limpopo River Basin Case Study

1.Where is the NAP process this fit?

Element B. Preparatory elements	
1. **Analysing current climate and future climate change scenarios**	» Report on climate analysis » Report on climate risks/Projected climate changes » Strategy for climate information services
2. **Assessing climate vulnerabilities and identifying adaptation options** at sector, subnational, national and other appropriate levels	» Vulnerability and adaptation assessment report
3. **Reviewing and appraising adaptation options**	» Report on appraisal of adaptation options » Sectoral and subnational plans or strategies
4. **Compiling and communicating national adaptation plans**	» Draft NAPs for review » Endorsed NAPs
5. **Integrating climate change adaptation** into national and subnational development and sectoral **planning**	» Report on integration of adaptation into development

3/1/18 FOOTER GOES HERE 3


1.Where is the NAP process this fit?
Element C. Implementation strategies
1. Prioritizing climate change adaptation in national planning
Report on prioritization of adaptation in national development
2. Developing a (long-term) national adaptation implementation strategy
Implementation strategy for the NAPs
3. Enhancing capacity for planning and implementing adaptation
National training and outreach programme(s)
4. Promoting coordination and synergy at the regional level and with other multilateral environmental agreements
Report on regional synergy
Report on synergy with MEAs
FOOTER GOES HERE

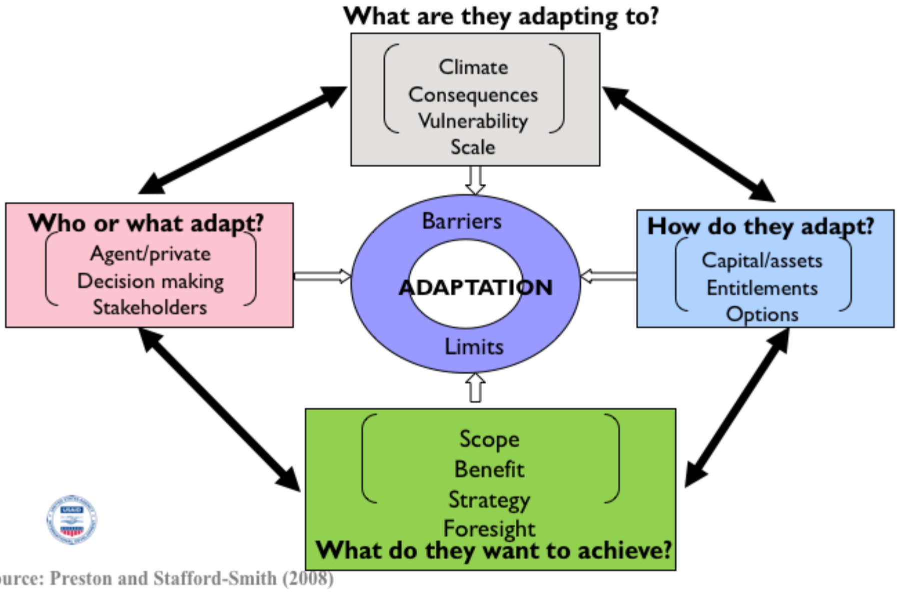
ADAPTATION RESEARCH

- There are two directions and purposes in adaptation research (Burton et al. 2002) :
  1. Mitigation policy
  2. Adaptation policy
- Since the IPCC's AR4 presented the first evidence that climate change is now occurring, interest in adaptation as a legitimate policy response has increased, led by developing country negotiators.
- Adaptation research has a critical role to help us collectively **understand and develop adaptation options** to enhance the benefits and reduce the social and economic vulnerabilities induced by climate change and variability.

ADAPTATION RESEARCH (2)

- Adaptation research, is driven by a broad range of multi-dimensional determinants characterised by four core questions (Preston and Stafford-Smith 2008):
  1. Who or what adapts?
  2. What do they adapt to?
  3. How do they adapt?
  4. What do they want to achieve?
- The adaptation cycle is iterative, dynamic, interconnected, non-linear, and likely chaotic and any specific adaptation research can start at any point in the adaptation cycle (Wheaton and Maciver 1999).

ADAPTATION CYCLE



Source: Preston and Stafford-Smith (2008)

APPROACH TO STUDY ADAPTATION

Top-down	Bottom up
• **What are we adapting to?** Scenario-based, hypothetical are invariably treated as primarily technical adjustments	• **Who or what adapt?** (agents) and their decision-making processes
• **what do they want to achieve?** aims to evaluate alternative adaptations options: assess the overall merit, suitability, utility or appropriateness	• **How do they adapt?** (determinants of adaptation, such as capital and entitlements)

TOOLS

Top-down	Bottom up
• **Scenario-based**: Agronomic-economic and Integrated assessment models (e.g. Adams et al. 1998; Rosenzweig and Parry 1994); • **Evaluation of adaptation options**: Future Agricultural Resources Model (FARM) (Darwin et al. 1995) and Ricardian models (Mendelsohn et al. 1996; Gbetibouo and Hassan 2005; Dinar et al. 2008).	• **Agents and decision making process**: Qualitative way via survey data analysis with in-depth interviews, focus group discussions (e.g. farmers and farms experts) (e.g. Belliveau et al. 2006; Smit et al. 1996) • **Determinants of adaptation**: Quantitative discrete choice (probit, logit,) models (e.g. Deressa et al. 2009; Kurukulasuriya and Mendelsohn 2008; Gbetibouo et al, 2009)

DISCRETE CHOICES MODELS

- Logit and probit are used to model a relationship between a **dependent variable** Y and one or more **independent variables** X.
- Y is a discrete variable that represents a choice or category.
- The independent variables are presumed to affect the choice or classification process.

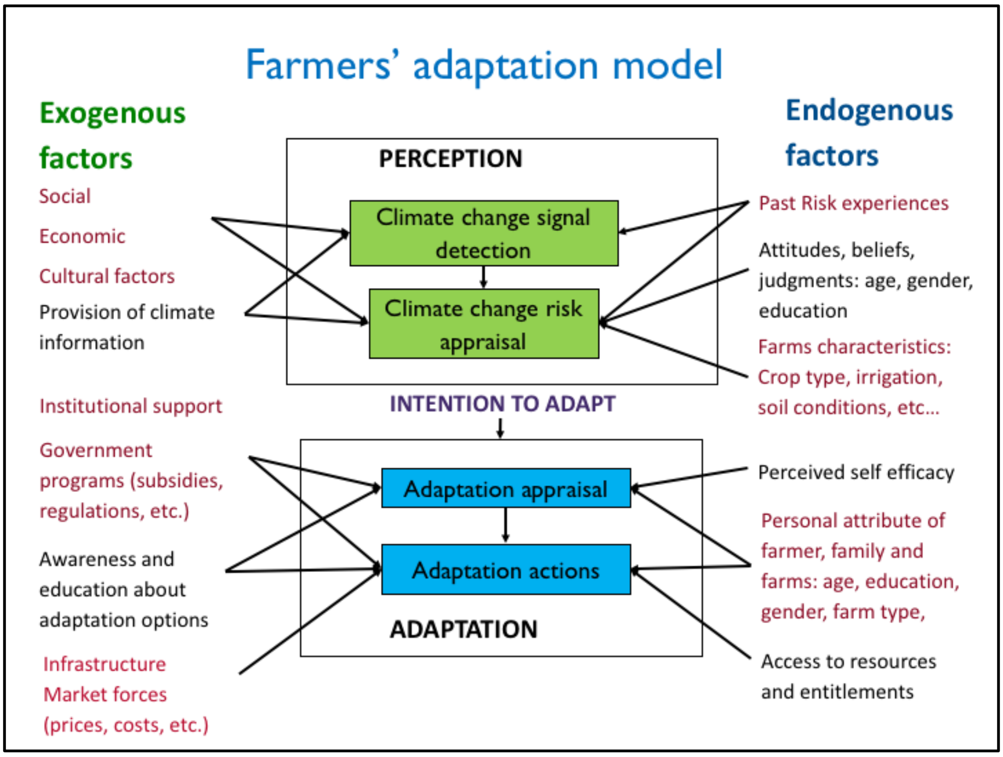
Estimate the choice models

- Set of choices or classification must be:
  - Finite.
  - Mutually exclusive. A particular outcome can only be represented by one choice or classification.
  - Collectively exhaustive. All choices or classifications must be represented by the choice set.
- Choice models are derived from the random utility theory.

Example of farmers' adaptation choice model

- Research questions:

1. Are farmers aware of the changing climate?
2. What are the different types of adaptation strategies in rural areas in the face of climate variability and change?
3. What are the factors enhancing adaptation among farmers?


Farmers' adaptation model
Exogenous factors
Social
Economic
Cultural factors
Provision of climate information
Institutional support
Government programs (subsidies, regulations, etc.)
Awareness and education about adaptation options
Infrastructure
Market forces (prices, costs, etc.)
PERCEPTION
Climate change signal detection
Climate change risk appraisal
INTENTION TO ADAPT
Adaptation appraisal
Adaptation actions
ADAPTATION
Endogenous factors
Past Risk experiences
Attitudes, beliefs, judgments: age, gender, education
Farms characteristics: Crop type, irrigation, soil conditions, etc…
Perceived self efficacy
Personal attribute of farmer, family and farms: age, education, gender, farm type,
Access to resources and entitlements

Analytical model

- The decision of whether or not to use any adaptation option could fall under the general framework of utility and profit maximization.
- Consider a farmer who seeks to maximize the present value of expected benefits of production over a specified time horizon, and must choose among a set of *J* adaptation options.
- The farmer *i* decides to use *j* adaptation option if the perceived benefit from option *j* is greater than the utility from other options → Benefit Option A > Benefit Option B
- Farmer practices an adaptation option that generates net benefits.

Analytical model

Multinomial logit model (MNL)

- The probability that household *i* with characteristics X chooses adaptation option j is specified as follows:

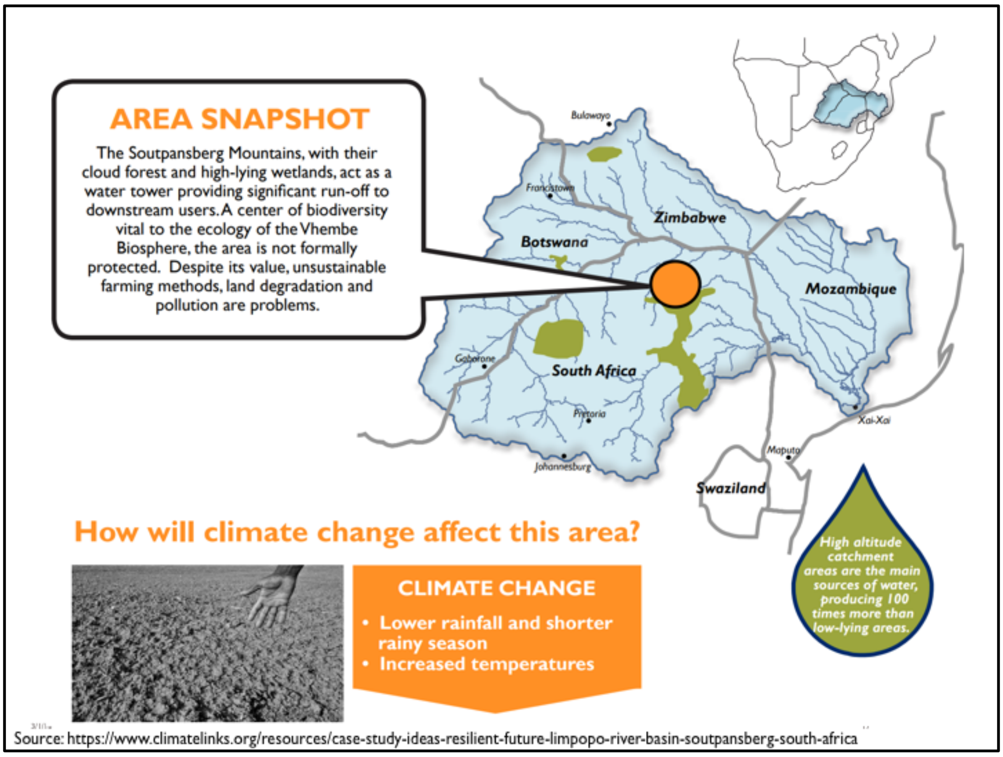
$$P_{ij} = prob(Y = 1) \quad = \frac{e^{x'\beta}}{1 + \sum_{j=1}^{j} e^{x'\beta}}$$

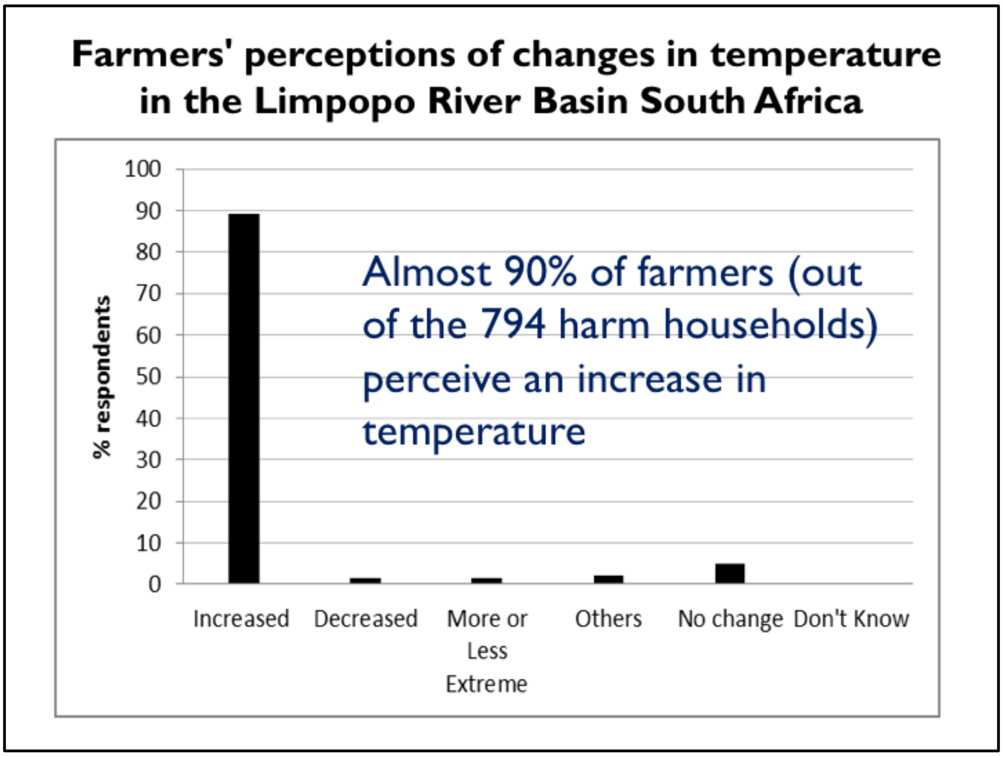
- Marginal effects : $\frac{\partial P_j}{\partial x_k} = P_j\left(\beta_{jk} - \sum_{j=1}^{j-1} P_j \beta_{jk}\right)$

PRACTICAL TRAINING: LIMPOPO CASE STUDY (SOUTH AFRICA)

- Data:
  - 794 farm households
  - Agricultural season April/May 2004 to April/May 2005
  - Four provinces of the Limpopo River Basin in South Africa.
  - Large dataset but this study used principally the section of the survey on perceptions of climate change, adaptations made by farmers, and barriers to adaptation.
  - Monthly precipitation and temperature data from the South African Weather Service (SAWS). The data covers the period from January 1960 to October 2003.

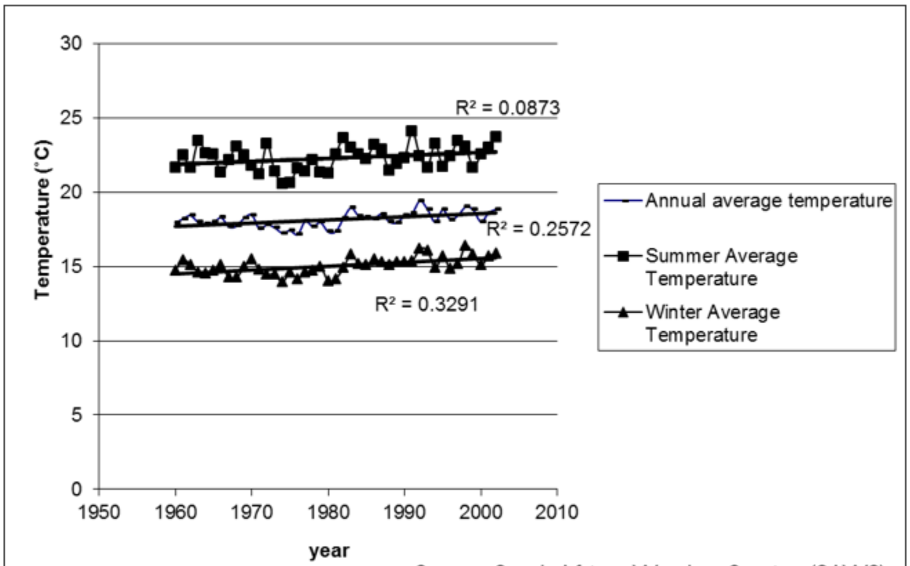
This paper examines climate adaptation strategies of farmers in the Limpopo Basin of South Africa. Survey results show that while many farmers noticed long-term changes in temperature and precipitation, **most could not take remedial action**. **Lack of access to credit and water were cited as the main factors inhibiting adaptation**. Common adaptation responses reported included **diversifying crops, changing varieties and planting dates, using irrigation, and supplementing livestock feed**.
A multinomial logit analysis of climate adaptation responses suggests that access to water, credit, extension services and off-farm income and employment opportunities, tenure security, farmers' asset base and farming experience are key to enhancing farmers' adaptive capacity. This implies that appropriate government interventions to improve farmers' access to and the status of these factors are needed for reducing vulnerability of farmers to climate adversities in such arid areas.
(http://www.tandfonline.com/doi/abs/10.1080/03031853.2010.491294)


AREA SNAPSHOT
The Soutpansberg Mountains, with their cloud forest and high-lying wetlands, act as a water tower providing significant run-off to downstream users. A center of biodiversity vital to the ecology of the Vhembe Biosphere, the area is not formally protected. Despite its value, unsustainable farming methods, land degradation and pollution are problems.
Bulawayo
Francistown
Zimbabwe
Botswana
Mozambique
Gaborone
South Africa
Pretoria
Johannesburg
Xai-Xai
Maputo
Swaziland
High altitude catchment areas are the main sources of water, producing 100 times more than low-lying areas.
How will climate change affect this area?
CLIMATE CHANGE
• Lower rainfall and shorter rainy season
• Increased temperatures
Source: https://www.climatelinks.org/resources/case-study-ideas-resilient-future-limpopo-river-basin-soutpansberg-south-africa



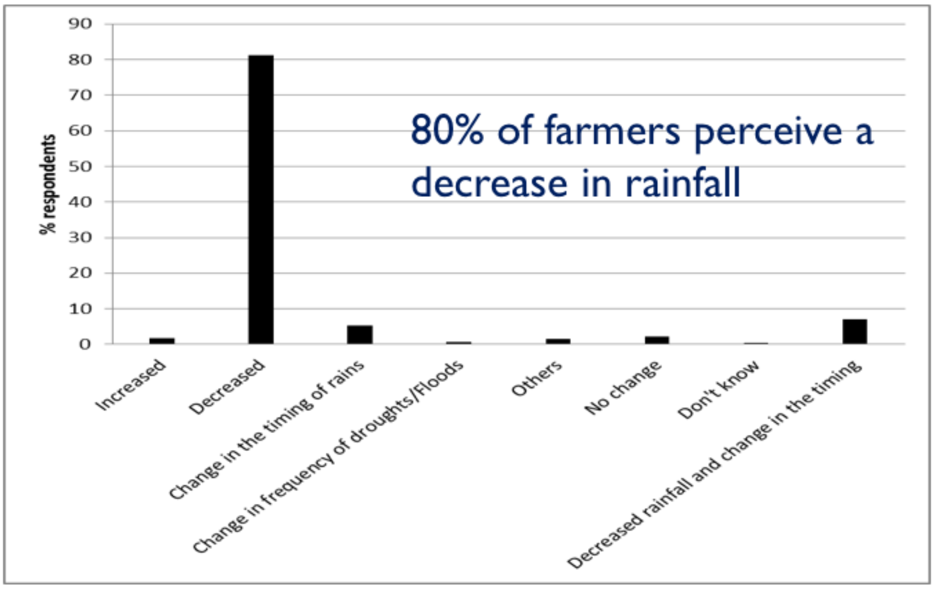
Farmers' perceptions of changes in temperature in the Limpopo River Basin South Africa
% respondents
100
90
80
70
60
50
40
30
20
10
0
Increased
Decreased
More or Less Extreme
Others
No change
Don't Know
Almost 90% of farmers (out of the 794 harm households) perceive an increase in temperature

Farmers' perceptions of changes in temperature in the Limpopo River Basin

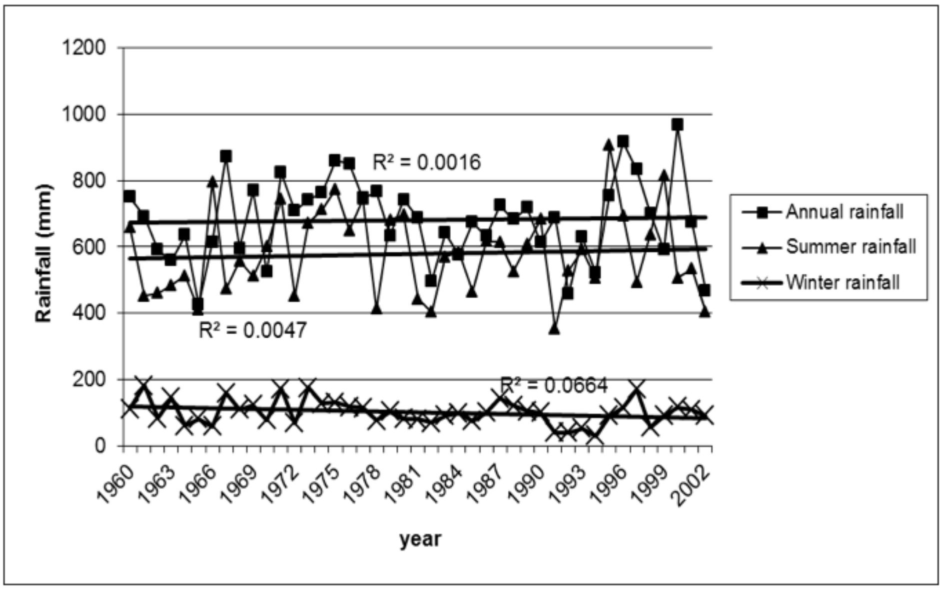


Source: South African Weather Service (SAWS)

Farmers' perceptions of changes in rainfall in the Limpopo River Basin



Farmers' perceptions of changes in rainfall in the Limpopo River Basin



Spatial clustering of climate change perceptions

Moran's I test for spatial correlation of climate change perception

Perception of temperature	Moran I statistics	Perception of rainfall	Moran I statistics
Increased temperature	0.044**	Increased rainfall	-0.013
Decreased temperature	0.002	Decreased rainfall	0.125**
More or less extreme	0.001	Change in the timing	0.051**
No change	-0.003	Change in frequency of droughts/floods	-0.007
		No change	0.003

** Significant at 1% level * significant at 5% level

Factors influencing farmers' perceptions

Results of the seemingly unrelated biprobit of farmers' perception of change in the climate, Limpopo River Basin

Variable	Perceived change in temperature	Perceived change in rainfall
Education	-0.0049	-0.0371***
Farming experience	0.0136*	0.0048
Farm size	0.2900	-0.3474
Crop farm	0.0822	-0.0219
Infertile soil	-0.3838	0.0994
Highly fertile soil	-0.3231**	0.6542**
Access to water for irrigation	-0.5917**	-0.7279**
Access to extension services	0.3361**	0.2271
Access to climate information	-0.0101	0.2044
Gauteng dummy	-0.6374***	0.2454
Intercept	1.91923 ***	2.4828***
*** significant at 1% level; ** significant at 5% level; * significant at 10% level		

Adaptation to long-term changes in TEMPERATURE (% respondents)

Variable	Total Basin	Limpopo	North West	Gauteng	Mpumalanga
Change crop variety	3.03	1.21	3.92	2.27	6.57
Increasing irrigation	3.96	3.38	1.96	6.82	5.56
Plant different crops	6.86	9.66	3.62		4.04
Change planting date	3.69	3.62	0.98	6.82	4.55
Change amount of land	3.43	4.11	1.96	2.27	3.03
Livestock feed supplements	3.69	3.62	5.88	4.55	2.53
Crop diversification/mixing	0.53	0.97			
Other	5.01	4.83	2.94	6.82	6.06
No adaptation	69.39	67.87	78.43	70.45	67.68

Adaptation to long-term changes in RAINFALL (% respondents)

Variable	Total Basin	Limpopo	North West	Gauteng	Mpumalanga
Change crop variety	0.66	0.72			1.01
Increasing irrigation	7.75	4.82	13.99	4.55	11.56
Plant different crops	4.99	6.75	2.91	2.27	3.02
Change planting date	4.73	3.13	3.88	9.09	7.54
Change amount of land	2.76	4.43			1.51
Livestock feed supplements	2.23	2.41	3.88	2.27	1.01
Water-harvesting scheme	3.81	3.61	1.94	4.55	5.03
Other[3]	5.12	4.34	4.85	4.55	7.04
No adaptation	67.94	69.88	68.06	72.73	62.31

Barriers to adaptation in the Limpopo River Basin (%)

Variable	Total Basin	Limpopo	North West	Gauteng	Mpumalanga
Lack of information about long-term climate change	6	4.3	10.5	0	8.6
Lack of knowledge concerning appropriate adaptations	2	2.7	0	0	2
Lack of credit or savings / poverty	53.9	24.2	54.7	32	48
No access to water	20.8	32.6	3.5	12	8.6
Insecure property rights	9.6	14.3	3.5	0	5.9
Lack of market access poor transport links	6.2	10.3	1.2	4	1.3
Other	11	8	9.3	20	13.1
No barriers to adaptation	0.8	8.3	22.1	10	23

Empirical specification of the variables

- The choice sets considered in the adaptation model include 7 variables:
  1. Portfolio diversification;
  2. Irrigation;
  3. Change planting date;
  4. Change amount of land;
  5. Livestock feed supplements;
  6. Other and
  7. No adaptation.

Specification of the variables

- Explanatory variables is based on data availability and the literature:

1. **Households characteristics**: age, education level and gender of the head of the household, family size, years of faming experience, and wealth
2. **Farm characteristics**: farm size (large-scale or small-scale) and soil fertility
3. **Institutional factors**: Extension, access to credit, off-farm employment, and land tenure
4. **Other factors** that describe local conditions are hypothesised **to influence farmers' decisions**: climate variables (temperature and rainfall), latitude and longitude references for each household, location characteristics (province)

Results of the Heckman probit model of adaptation behaviour, Limpopo River Basin

Variables	Estimated coefficients outcome equation Adaptation model	Estimated coefficients selection equation Perception model
Access to water for irrigation		-0.621***
Gender	0.134	-0.088
Education	-0.011	-0.012
Farming experience	0.01***	0.006
Wealth	0.114	0.051
Farm size	0.649***	-0.036
Soil fertility	-0.142*	-0.005
Extension	0.179*	0.364***
Climate information	-0.1	-0.115
Credit	0.232*	-0.0650
Off-farm employment	0.127	0.0472
Land tenure	0.268***	0.0359
Mpumalanga	-0.006	-0.031
Gauteng	-0.603***	-0.527**
North West	-0.445***	-0.029
Intercept	-0.6615***	1.83***

Total observations: 577 Censored observations:43

Estimate of the marginal effects of the MNL adaptation model, Limpopo River Basin

	Portfolio diversification	Irrigation	Changed planting dates	Changed the amount of land	Livestock supplement feeds	Other	No Adaptation
Education	-0.0023 (0.39)	0.0019 (0.50)	-0.0003 (0.82)	0.0003 (0.56)	-0.0003 (0.62)	0.0009 (0.49)	-0.0003 (0.94)
Gender	-0.0084 (0.75)	0.0388 (0.22)	0.0115 (0.38)	-0.0034 (0.54)	0.0046 (0.41)	-0.0044 (0.8)	-0.0387 (0.37)
Household size	-0.0021 (0.60)	0.0058 (0.25)	-0.0002 (0.94)	0.0003 (0.79)	-0.0010 (0.25)	**-0.0041 (0.09)***	0.0013 (0.85)
Farming experience	**0.0020 (0.01)*****	0.0007 (0.59)	**0.0011 (0.03)****	**0.0005 (0.09)***	-0.0002 (0.47)	-0.0001 (0.8)	**-0.0039 (0.03)****
Wealth	-0.0083 (0.29)	0.0128 (0.23)	**0.0231 (0.00)*****	0.0030 (0.22)	0.0010 (0.49)	0.0026 (0.62)	**-0.0343 (0.01)*****
Farm size	0.0536 (0.32)	**0.1176 (0.09)***	0.0034 (0.91)	0.0077 (0.58)	-0.0007 (0.94)	0.0030 (0.9)	**-0.1846 (0.05)****
Highly fertile soil	0.0342 (0.21)	0.0314 (0.39)	-0.0066 (0.64)	**0.0125 (0.10)***	0.0080 (0.32)	-0.0148 (0.33)	-0.0648 (0.17)
Infertile soil	-0.0375 (0.29)	-0.0168 (0.73)	0.0091 (0.70)	0.0176 (0.30)	-0.0032 (0.64)	0.0471 (0.20)	-0.0162 (0.81)
Extension	**0.0434 (0.09)***	-0.0075 (0.80)	0.0138 (0.30)	0.0052 (0.35)	0.0016 (0.73)	-0.0027 (0.84)	**-0.0537 (0.08)***
Climate information	-0.0257 (0.32)	0.0018 (0.95)	-0.0112 (0.43)	0.0031 (0.60)	-0.0011 (0.82)	0.0172 (0.26)	0.0161 (0.69)
Credit	**0.0355 (0.06)***	0.0289 (0.42)	-0.0014 (0.93)	-0.0093 (0.19)	**0.0149 (0.09)***	0.0172 (0.37)	**-0.0858 (0.08)***
Off farm	0.0302 (0.27)	-0.0046 (0.88)	0.0006 (0.96)	**-0.0077 (0.09)***	**0.0339 (0.00)*****	0.0074 (0.63)	-0.0597 (0.18)

OPPORTUNITIES FOR ACTION

31

3/1/18

Source: https://www.climatelinks.org/resources/case-study-ideas-resilient-future-limpopo-river-basin-soutpansberg-south-africa

Conclusions

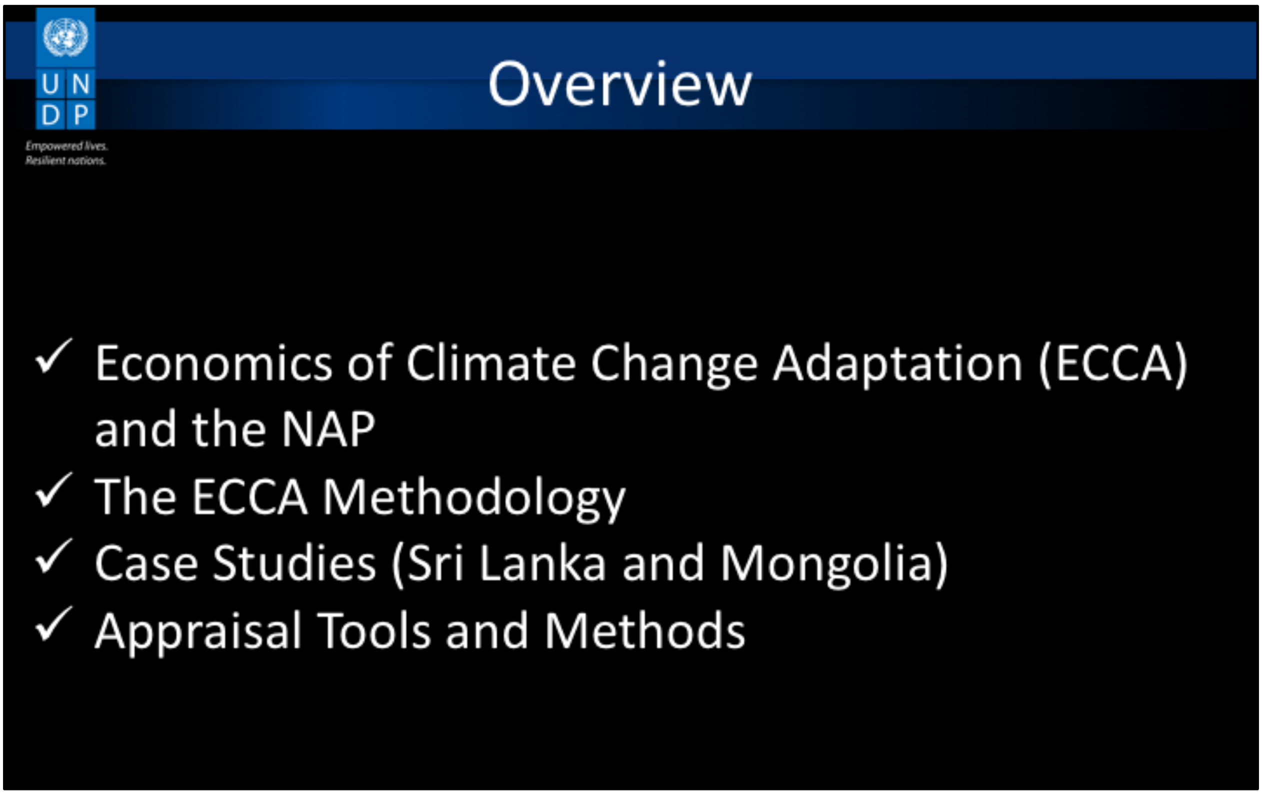
- Perceptions are not only based on observed changes in climate conditions but are also influenced by other factors: **improved farmer education and awareness about climate change**
- Factors that enhance adaptive capacity: Access to water, credit, extension services, off-farm income and employment opportunities, tenure security , farmers' asset base and farming experience
- Appropriate government interventions to improve farmers' access and status of these factors are needed.

Thank you

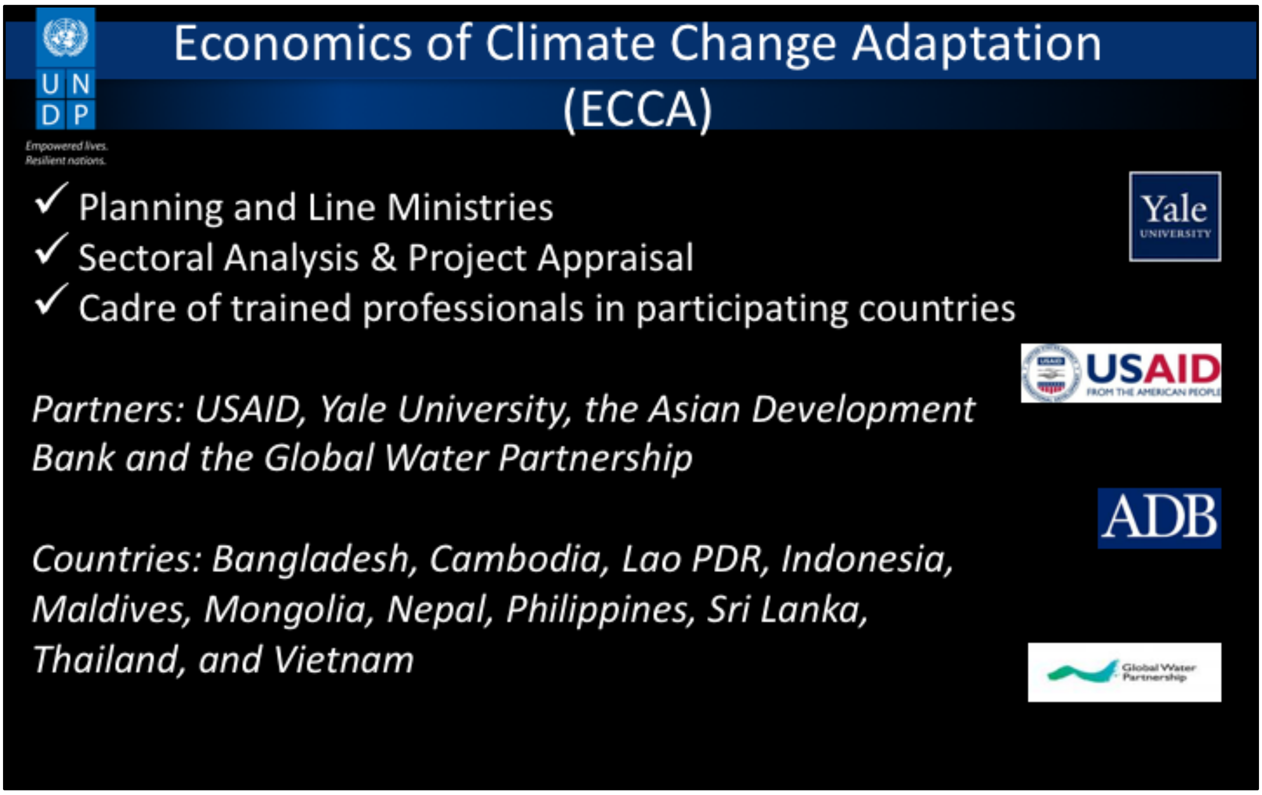
Empowered lives.
Resilient nations.

Capacity Building on Economics of Adaptation: case studies of Sri Lanka and Mongolia

Mari Tomova mari.tomova@undp.org, UNDP



Outline
UNDP's work to support adaptation to climate change
UNDP's role in the ECCA programme
Overview of appraisal tools and methods
Case studies of CBAs



The three-year capacity building programme (ECCA) was first launched in October 2012 by UNDP, in a partnership with USAID, Yale University, the Asian Development Bank and the Global Water Partnership. Aiming to enhance the technical capacities of governments in 11 countries in the Asia-Pacific (Bangladesh, Cambodia, Indonesia, Lao PDR, Maldives, Mongolia, Nepal, Philippines, Sri Lanka, Thailand and Viet Nam).

The training activities as part of the ECCA programme are key area of technical assistance required by countries, as per the United Nations Framework on the Convention of Climate Change's (UNFCCC) guidelines for countries on the National Adaptation Plan (NAP) process – a process established under the Cancun Adaptation Framework (CAF) to help countries identify their medium- and long-term adaptation needs.

Case Studies from ECCA 1:

Bangladesh – the ECCA Programme was instructive in reviewing and revising the country's agriculture and water policies. "The study found warming and changing rainfall patterns will become increasingly harmful for farmers. An increase in temperature of one degree Celsius would result in a loss of US$273 per acre for irrigated farms (69% of their income given an average earning of US$394).The study supported that adaptation options for farmers in Bangladesh are strengthened national extension services, irrigation infrastructure in the dry zone of the country and the introduction of new cultivation techniques.

Maldives:

The ECCA programme has benefited government officials in the Maldives by expanding their knowledge of **economic tools, including conducting cost-benefit analyses**. They have been able to apply that knowledge to successfully access international funds, such as the **Green Climate Fund.**

The ECCA Methodology

Sri Lanka

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Resilient nations.

- ✓ 321 households were interviewed spanning the agro-ecological zones of the country, resulting in 321 households detailed data;
- ✓ A whole farm approach based on the Ricardian method was used;
- ✓ The marginal impacts of climate (temperature and precipitation) is estimated to give an indication of changes in net revenue when there is a unit change in climate.
- ✓ By changing the values of the climate variables to levels predicted by climate change projections and by comparing the projected net revenue to the current net revenue scenario, the impact of climate change on the agriculture sector is estimated.

The ECCA Questionnaire

Please access the full survey here: http://adaptation-undp.org/sites/default/files/datasets/tools/undp_adapt_asia_agriculture_survey_v4.pdf

Information on extension services. Detailed information was provided by private extension groups, non-governmental organizations (NGOs), central government agencies, cooperatives and local government to be able to elicit potential policy tools available to support adaptation.

The ECCA Questionnaire

- Survey **translated into the local language** and tested twice with local farmers.
- Interviewees asked about their **perception about climate change** and current sources of weather information.
- Information on **farm planting area, fallow land area, and the division of the plots by crops and other livelihood by the household**.
- Detailed information on **household members, gend**er and basic **infrastructure** availability.

Please access the full survey here: http://adaptation-undp.org/sites/default/files/datasets/tools/undp_adapt_asia_agriculture_survey_v4.pdf

Information on extension services. Detailed information was provided by private extension groups, non-governmental organizations (NGOs), central government agencies, cooperatives and local government to be able to elicit potential policy tools available to support adaptation.

The ECCA Questionnaire

1. GENERAL HOUSEHOLD INFORMATION (To be completed for ALL RESPONDENTS)

1.0. BASIC INFORMATION

1.0.1.	Please state the relationship of the respondent to the head of household		1. Head of household; 2. Husband; 3. Wife; 4: Child; 5. Grandchild; 6. Parents; 7. Siblings; 8. Other family members (includes household helpers); 9: Manager/other proxy for owner
1.0.2.	Who makes decisions on the farm/for the herd?		1. Head of household; 2. Husband; 3. Wife; 4: Child; 5. Grandchild; 6. Parents; 7. Siblings; 8. Other family members (includes household helpers); 9: Manager/other proxy for owner

1.1. CLIMATE CHANGE, AGRICULTURE AND FARMER PERCEPTIONS

Surveyor: The word "Long-term" in the following questions means the last 1 or 2 decades (or if the farmer has farmed for less than a decade, since whenever she or he began farming).

1.1.1.	How long have you been a herder/farmer/both (or herd/farm manager)?		Years
1.1.2.1.1.	Have you noticed any long-term shifts in temperature on your pastureland/where you farm?		1. No; 2. Yes
→ If respondent answered "No" to 1.1.2.1.1., go to 1.1.2.2.1.			
1.1.2.1.2.	Has it become cooler or warmer?		1. Cooler; 2. Warmer
1.1.2.1.3.	What kinds of adaptations have you made for temperature shifts?		
1.1.2.1.3.1.	**Crops**		
1.1.2.1.3.1.1.	Changed planting dates		1. No; 2. Yes
1.1.2.1.3.1.2.	Change crop types		1. No; 2. Yes
1.1.2.1.3.1.3.	Use different crop varieties (hybrid or genetically modified)		1. No; 2. Yes
1.1.2.1.3.1.4.	Made irrigation investment (such as sprinkler or groundwater pump)		1. No; 2. Yes
1.1.2.1.3.2.	**Livestock**		

Please access the full survey here: http://adaptation-undp.org/sites/default/files/datasets/tools/undp_adapt_asia_agriculture_survey_v4.pdf

The ECCA Questionnaire

1.1.2.2.2.	Has it become drier or wetter?		1. Drier; 2. Wetter
1.1.2.2.3.	What kinds of adaptations have you made for precipitation shifts?		
1.1.2.2.3.1.	**Crops**		
1.1.2.2.3.1.1.	Changed planting dates		1. No; 2. Yes
1.1.2.2.3.1.2.	Change crop types		1. No; 2. Yes
1.1.2.2.3.1.3.	Use different crop varieties (hybrid or genetically modified)		1. No; 2. Yes
1.1.2.2.3.1.4.	Made irrigation investment (such as sprinkler or groundwater pump)		1. No; 2. Yes
1.1.2.2.3.2.	**Livestock**		
1.1.2.2.3.2.1.	Alter livestock mix		1. No; 2. Yes
1.1.2.2.3.2.2.	Invest in new breeds		1. No; 2. Yes
1.1.2.2.3.2.3.	Build winter, spring, autumn shelter for animal		1. No; 2. Yes
1.1.2.2.3.2.4.	Made investment for water (such as, digging well)		1. No; 2. Yes
1.1.2.2.3.2.5.	Build storage for hay and fodder		1. No; 2. Yes
1.1.2.2.3.2.6.	Migrate to new pasture		1. No; 2. Yes
1.1.2.2.3.2.7.	Purchase livestock insurance		1. No; 2. Yes
1.1.2.2.3.2.8.	Other		1. No; 2. Yes
1.1.2.3.1.	Have you noticed any long term changes in frequency of droughts where you farm/on your pastureland?		1. No; 2. Yes

Please access the full survey here: http://adaptation-undp.org/sites/default/files/datasets/tools/undp_adapt_asia_agriculture_survey_v4.pdf

The ECCA Questionnaire

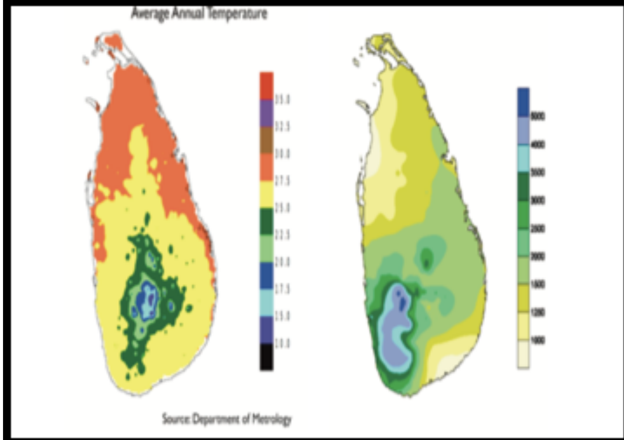
Household

1.2. HOUSEHOLD ROSTER

1.2.1.	Household size (of owner/manager of the farm)		Number
1.2.2.	Household characteristics:		
1.2.2.1.	Age of the head of the household		Years
1.2.2.2.	Gender of the head of the household		1: Female; 2: Male
1.2.2.3.	Education of the head of the household (total years)		Years
1.2.2.4.1.	Number of adult males (16 plus)		Number
1.2.2.4.2.	How many of these adult males work on farm(s) that you manage?		Number
1.2.2.5.1.	Number of adult females (16 plus)		Number
1.2.2.5.2.	How many of these adult females work on farm(s) that you manage?		Number
1.2.2.6.1.	Number of male children (under 16)		Number
1.2.2.6.2.	How many of these male children work on farm(s) that you manage?		Number
1.2.2.7.1.	Number of female children (under 16)		Number
1.2.2.7.2.	How many of these female children work on farm(s) that you manage?		Number
1.2.3.	Does the household have electricity?		1. No; 2. Yes
1.2.3.1	What is the source of electricity for your household?		1. Solar panel; 2. Electricity grid; 3. Other (please specify)
1.2.3.2	How many hours of electricity do you have in a day?		hours

Please access the full survey here: http://adaptation-undp.org/sites/default/files/datasets/tools/undp_adapt_asia_agriculture_survey_v4.pdf

(ECCA) Sri Lanka



1.First Inter-monsoon (FIM) Season (March - April).
2.Southwest-monsoon (SWM) Season (May - September).
3.Second Inter-monsoon (SIM) Season (October - November).
4. Northeast-monsoon (NEM) Season (December - February).

- 28.5% of labor force employed in agriculture
- Mean annual rainfall ranges from under 900 mm in the driest parts (southeastern and northwestern) to over 5,000 mm in the wettest areas.
- Mean annual temperature ranges from 26.5 degrees Celsius (°C) to 28.5 °C, whereas in the highlands, the temperature falls rapidly with the elevation

(ECCA) Sri Lanka

92% of households have observed long-term shift in temperature, and 95% observed a long-term shift in rainfall

How are farmers adapting to climate change?

Predominant Risk Management Practices	Households (%)
Irrigation Investment	52.34
Crops dates, crop types, crop varieties	31.15
Status Quo	16.51

(ECCA) Sri Lanka

A simple representation of the Ricardian model can be represented as follows:

$$NR = \beta_0 + \beta_1 C + \beta_2 C^2 + \beta_3 Soil + \beta_4 Z + \varepsilon$$

Where net revenue (NR) is the net revenue per acre of the farmers, C are climate attributes such as temperature and rainfall; Soil includes soil characteristics; Z includes all other factors that may be an important determinant of NR of the farm. The quadratic term is included to capture non-linear relationships.

If a positive number for the quadratic term is obtained, the function assumes a U-shaped form, whereas if the value is negative, the function assumes a hill shape form. Finally, ε is the error term.

(ECCA) Sri Lanka

The impact of non-climatic variables on net revenue in Sri Lanka

Q: Are larger farms more profitable than smaller farms?

A: The data suggest that the larger the planted area for a farmer, the lower the net revenue **– smaller farms appear to be performing better per acre than larger farms**. However, the apparent advantage of small farms most likely reflects measurement error because there **is no observed cost for household labour**. This inflates farm net revenues. Household labour is likely a higher fraction of the labour at small farms.

(ECCA) Sri Lanka

Seasons	Temperature	Precipitation
First Inter-monsoon	An increase of 1°C above the mean (26.5°C) would increase net revenue.	A 1 mm increase beyond 200 mm increases net revenue.
Southwest-monsoon	An increase of 1°C above the mean (26°C) would increase net revenue.	A 1 mm increase above the mean (150 mm) increases net revenue.
Second Inter-monsoon	An increase of 1°C above the mean (25°C) would increase net revenue.	A 1 mm increase above the mean (300 mm) decreases net revenue.
Northeast-monsoon	An increase of 1°C above the mean (24°C) would decrease net revenue.	A 1 mm increase above the mean (160 mm) increases net revenue, but any rainfall beyond 250 mm decreases it.

(ECCA) Sri Lanka

^ temperature by 1°C → a decrease of **US$85.95** or (18% of the total average NR) in NR per acre.

A decrease of 1mm in precipitation during the NEM season → a **US$1.69** decrease in NR per acre.

Impact on farm size:
An average farmer would lose as much as **US$94.37** of revenue per acre due to climate change, whereas a medium-scale farm would lose **US$148.75** of NR per acre

Impact on districts:
Largest impacts in Kurunegala and Anuradhapura → a loss of approximately LKR6,026.98 (or US$40.8) which would bring 26.4% of the farmers into chronic poverty.

(ECCA) Sri Lanka

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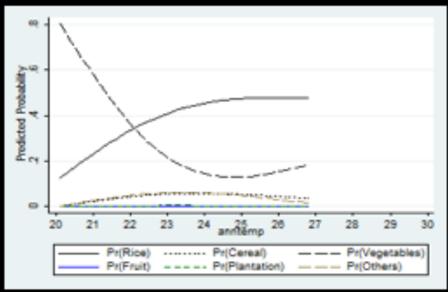
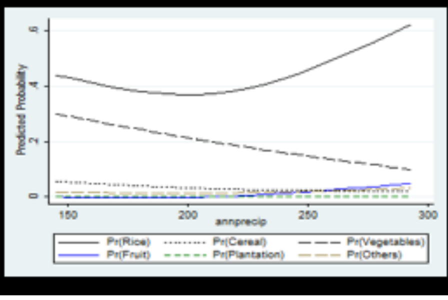


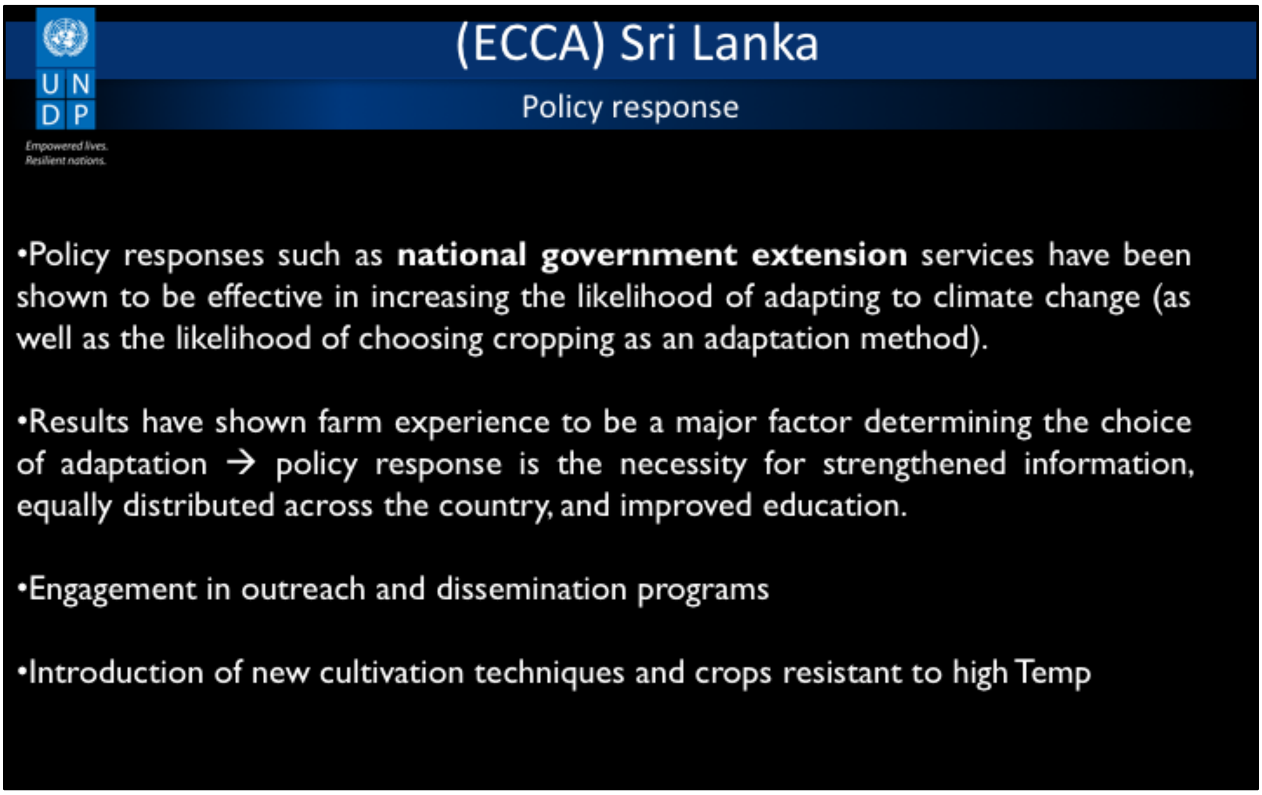


- Using climate projections, it is possible to predict the type of crops that farmers will choose to invest **by 2030, 2050 and 2070**, based on changes in precipitation and temperature.
- As T rises, farmers would focus on annual crops such as **rice, cereals and vegetables and would not invest in fruits, plantation and others**.
- As P increases, farmers would invest in **fruit, cereal and plantation and would move away from rice, vegetables and other crops.**
- By **2030, farmers will choose cereal and other crops**, whereas by **2050 and 2070,** farmers will invest in **rice and cereal.**

(ECCA) Sri Lanka

Variable	Rice	Cereal	Vegetables	Fruit	Plantation	Others
Annual Temperature	✓	✓	✓	X	X	X
Annual Precipitation	X	✓	X	✓	✓	X

- Strengthening research capacity is an important step in the development of new techniques and cultivation methods, in accordance with changes in climate;
- Introduction of new crop varieties that will be better suited for the weather conditions;
- Continuous support for farmers in reducing climate variability induced hazards, particularly in the season of NEM;
- Modernized agricultural technologies;
- Ensuring year-round access to water sources, particularly for farmers;


(ECCA) Sri Lanka
Policy response
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•Policy responses such as **national government extension** services have been shown to be effective in increasing the likelihood of adapting to climate change (as well as the likelihood of choosing cropping as an adaptation method).
•Results have shown farm experience to be a major factor determining the choice of adaptation → policy response is the necessity for strengthened information, equally distributed across the country, and improved education.
•Engagement in outreach and dissemination programs
•Introduction of new cultivation techniques and crops resistant to high Temp

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(ECCA) Mongolia

- CC impacts – dzhud, droughts, average T increase by 1.9C over the last 60 years
- Focus on agricultural sector, in particular herders of livestock, as the primary source of income and agricultural growth, especially for the rural poor

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(ECCA) Mongolia

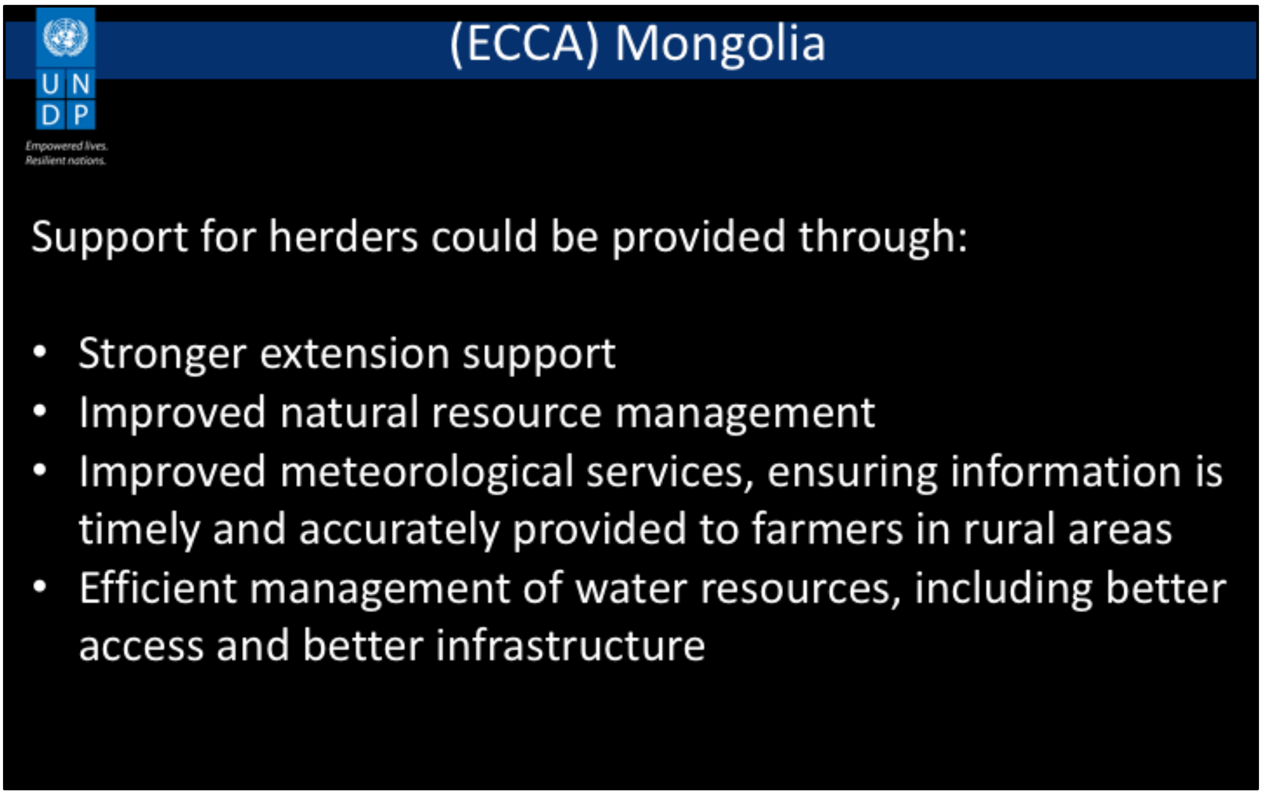
Climatic Variables

As P^ by 10mm in winter, livestock density will ^ by 2.8%

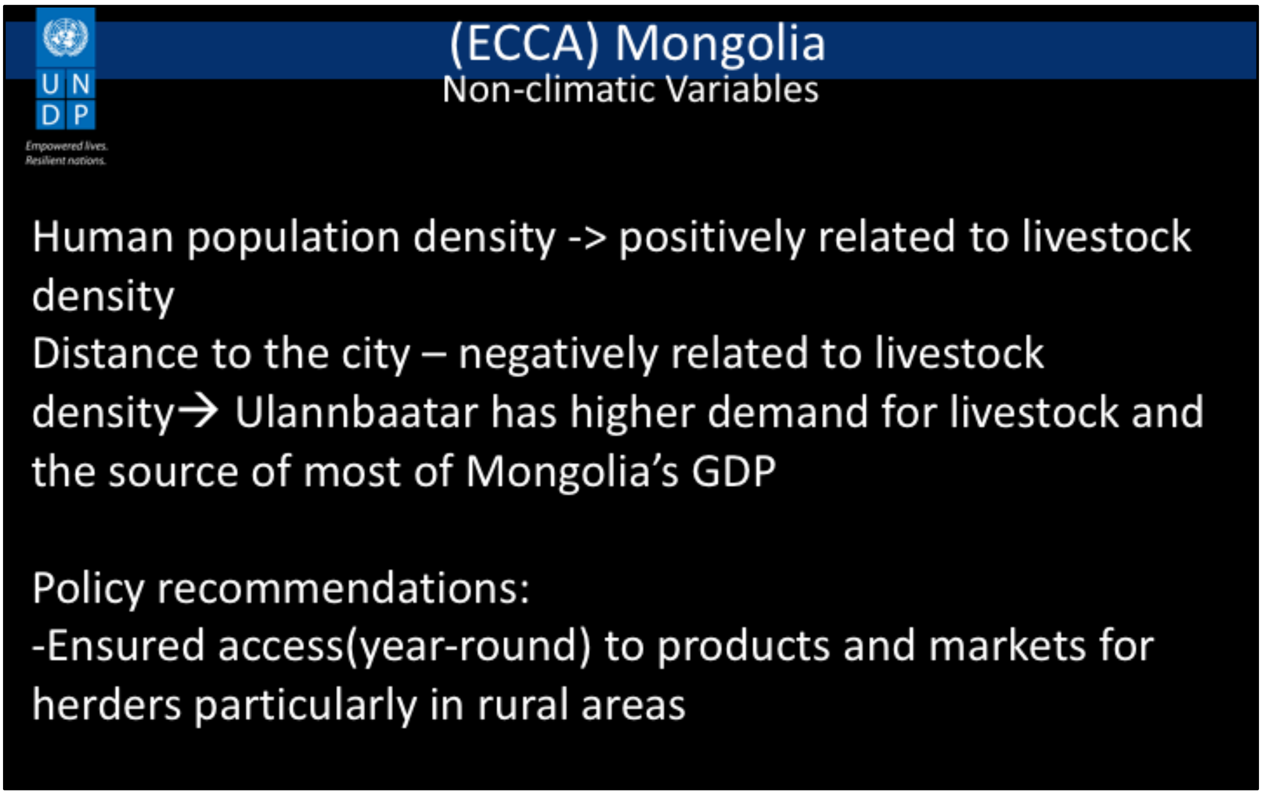
Further 1C^of T→ net income per livestock decrease by 1.47$

^of P by 1mm → reduction in NR by 1.06$

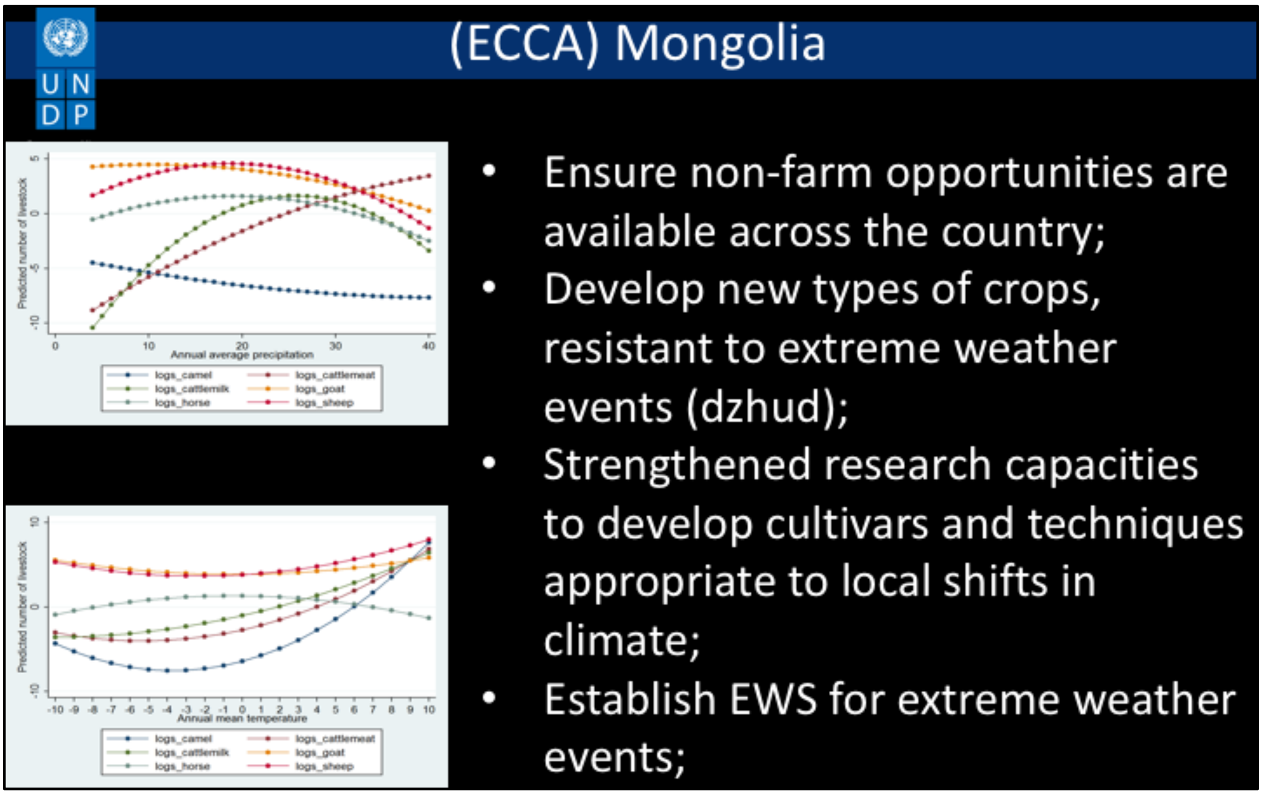
^mean annual P of 10mm in summer →5.73%^ of livestock density; in autumn→ 10.66%



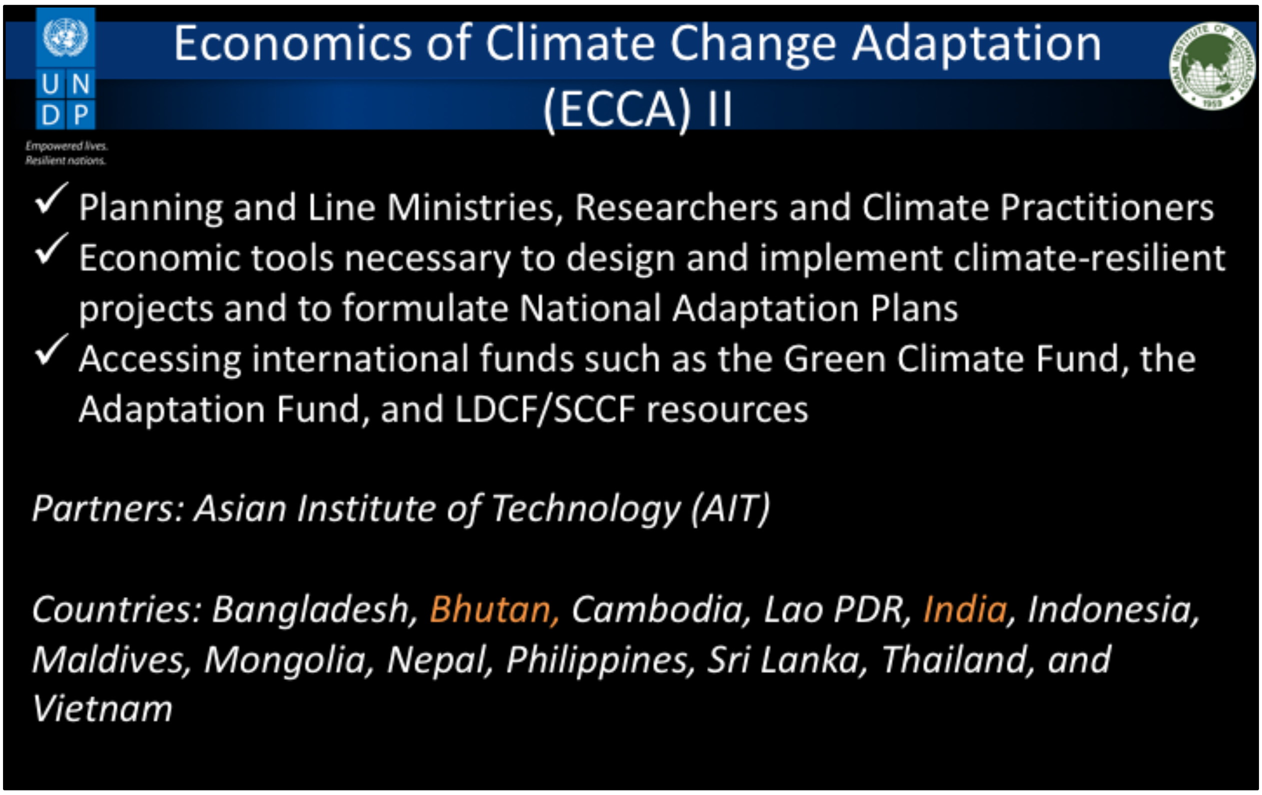
In the past 60 years, the annual average precipitation in Mongolia has decreased by 10 per cent. Dueto lack of rainfall and harsh winter dzud, livestock production has been constrained. This study showsthat water resources are essential for livestock density. An increase in mean annual precipitationbene ts livestock density. This is particularly true for the seasons of summer and autumn. An increase of 10 mm in mean spring precipitation would result in 5.73 per cent increase in livestockdensity, while an increase of 10 mm in mean autumn precipitation would increase livestock density by 10.66 per cent. This study also shows that water conditions and local physical characteristics arepositively related to livestock density. Ef ciently managing the provision of water is an essential taskfor government of cials. Given both the importance of agriculture in the total labour force of thecountry and the livestock dependence of the agriculture sector, local government needs to worktowards the improvement of water access and better infrastructure. Stress on water resources dueto competing demands, from cities, mining and other uses, therefore needs to be managed carefully inorder to minimize harm to livestock herders.



Other relevant non-climatic variables are human population density, which is positively related tolivestock density, and distance to the city, which is negatively related to livestock density. Thesendings imply that cities such as Ulaanbaatar, which are highly populated and dense, have a higherdemand for livestock. However, given that Ulannbaatar is the source of most of the country’s GDP,investments and economic development, the Government needs to ensure that there is good accessto products and markets, particularly in rural areas. A study by the World Bank (2006) indicates thatfrom 1993 to 2002, Mongolia constructed 1,183 km of new rural roads; in contrast, Cambodia built13,000 km of rural roads during the same period. Moreover, because of Mongolia’s severe weatherconditions, particularly during the winter dzud, 7 per cent of its rural roads are closed for nearly twomonths (World Bank, 2006). Based on thesendings, it is important that the Government tacklesthese issues by ensuring year-round access to products and markets for herders and the ruralpopulation of Mongolia.

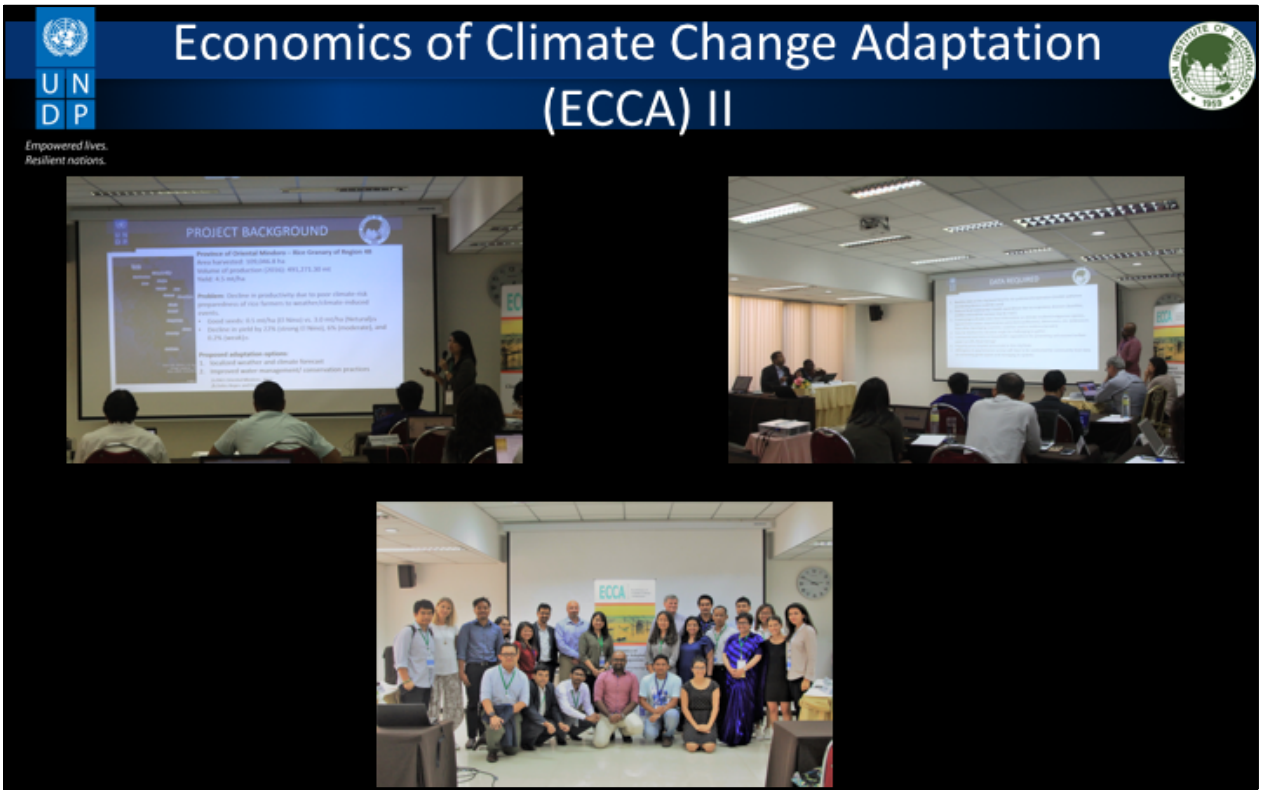


Based on climate projections, the team was able to analyze the impact of future changes intemperature and precipitation on farmers' net revenue. Results indicate that temperature is expectedto rise by 3.5°C in the 2031-2050, by 3.75°C in 2051-2081, and by 5.12°C in the 2071-2100 period.The level of precipitation, as measured in percentage points, would grow signi cantly in 2031-2050
by 15.11, in 2051-2081 by 26.5, and in 2071-2100 by 34.7 (based on BNU-ESM estimator). Thesechanges would result in dramatic losses in farmers' net revenue. The impact of climate change in the2031-2060 projections would result in a loss of US$11,558 in net revenue. Losses would increaseover time, reaching a peak value of US$ 20,581 in 2071-2100 projections. Temperature also plays
an essential role in reducing farmers' net revenue and accounts for 78 per cent in the 2031-2060projections, 71 per cent in the 2051-2081 projections, and 77 per cent in the 2071-2100 projections.



- With a great success in delivering the ECCA programme, we are pleased to partner with AIT in conveying two additional trainings (September 2017 and March 2018).
- AIT will be taking the ECCA programme forward, building on the learning materials and integrating the course into a regular graduate course.

Training 1: The call for applications has attracted strong interest with more than 280 applicants from the 11 ECCA-supported countries, competing for only 25 available seats. While we were faced with a difficult choice of selecting the final participants, the training programme gave a possibility to unite theory with practice, and that the knowledge gained through the ECCA programme will equip government officials, researchers and practitioners with economic tools necessary to design and implement climate-resilient projects and to formulate National Adaptation Plans, as well as to successfully access international funds, such as the Green Climate Fund, the Adaptation Fund and LDCF/SCCF resources.



13 Countries presented their country project proposals, incorporating the learning from the training program on the ECCA. This included the following:

-**Background and context of the climate change** threats or risks key to the proposal

-**Overall objective** of the proposal and Action plan

-**Expected outputs**

-**Methodology** (Ricardian vs. economic (CBA) analysis)

-Data needs

-Procedures and techniques for processing and analysis of information

-Timeframe

Appraisal Tools and Methods

Tool/Method	General thrust
Cost Effectiveness Analysis (CEA)	Measures cost in relation to an isolated outcome. Defines least-cost way to get result. More suitable to CC mitigation.
Risk and Vulnerability assessments	RA – probability or likelihood of occurrence of climate hazards multiplied by potential impacts VA– analysis of sensitivity, exposure and adaptive capacity
Cost Benefit Analysis (CBA)	Overall economic rationale, weighing both costs and benefit streams and effects on all outcomes.
Climate Change Benefit Analysis (CCBA)	Help identify and appraise public investment projects having positive climate change benefits.
Financial Analysis	"Bankability" in financial viability terms, i.e., investment return, debt-serviceability, pay-back time
General Equilibrium Analysis (CGE, IAM …)	Macro-economic effects
Multi Criteria Analysis (MCA)	Supports decision-making with broad view of impacts, often participatory application

Economics on Climate Change Adaptation (ECCA)

Concluding remarks:

- The ECCA reports provides evidence-based policy insights that are targeted towards supporting policymakers involved in the National Adaptation Plan (NAP) process to better understand the impact of climate change on the agricultural sector.
- By separating the analysis on irrigated vs. rainfed farms, the report provides evidence on the agriculture sector with implications for the water sector.

27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