Environmental Efficiency of Traditional Farming with Consideration of Grassland Biodiversity: Implication for the Ukrainian Carpathians

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Mountain hay meadows – economic, social and environmental value

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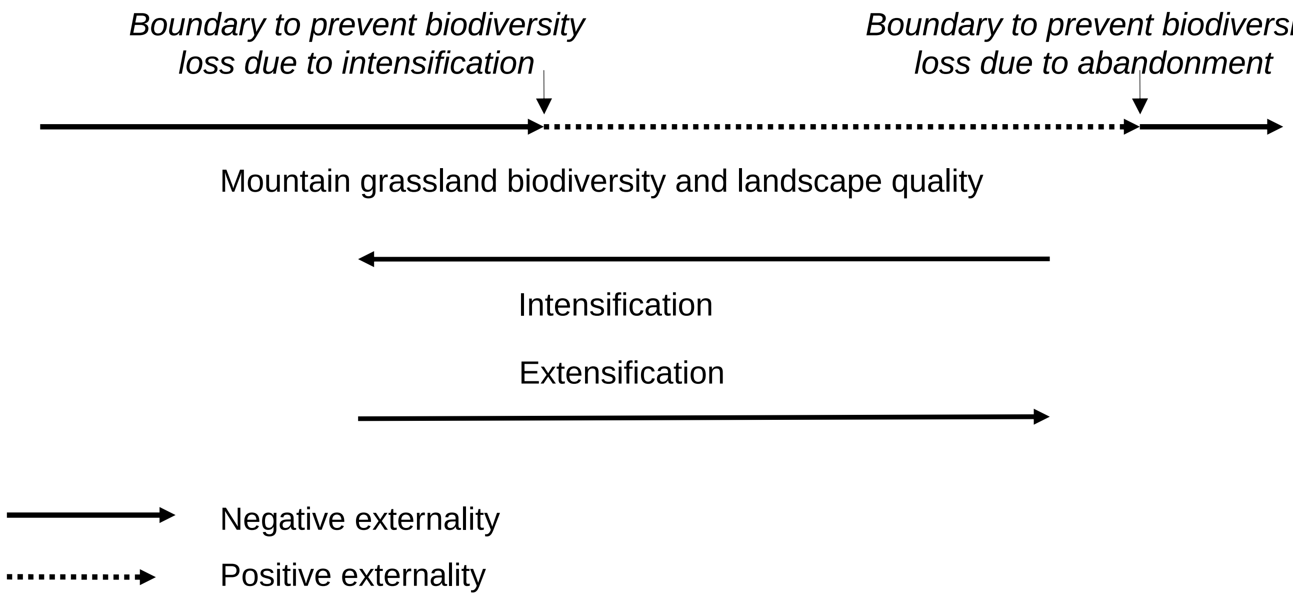
Topic Background

- Research focus: Impact of traditional farming on environment
- → provision of environmental public goods such as mountain grassland biodiversity
- State of the art:
  - Biodiversity declines with increasing land use intensity (Kleijn et al., 2009)
    - *Low-intensity traditional farming is effective in biodiversity provision*
    - *Intensification of agriculture is a threat for existing biodiversity*
  - Most observed scenarios for traditional farming systems are agricultural intensification (Tasser & Tappeiner, 2002) and land abandonment (Dullinger et al., 2003)
  - Land abandonment is usual for disadvantageous areas (MacDonald et al., 2000)
  - Land abandonment can lead to biodiversity loss in semi-natural landscapes connected to traditional farming (Fonderflick et al., 2010, Baumann et al., 2011)

Topic Background

Possible benchmarks for positive and negative externalities



Source: own representation based on Huelenbroeck and Whitby, 1999, p. 27

Study area:
the Ukrainian Carpathians

HNV farming concept
(Beaufoy 2007)

- Low-intensity farming
- Presence of semi-natural vegetation
- Presence of landscape mosaic

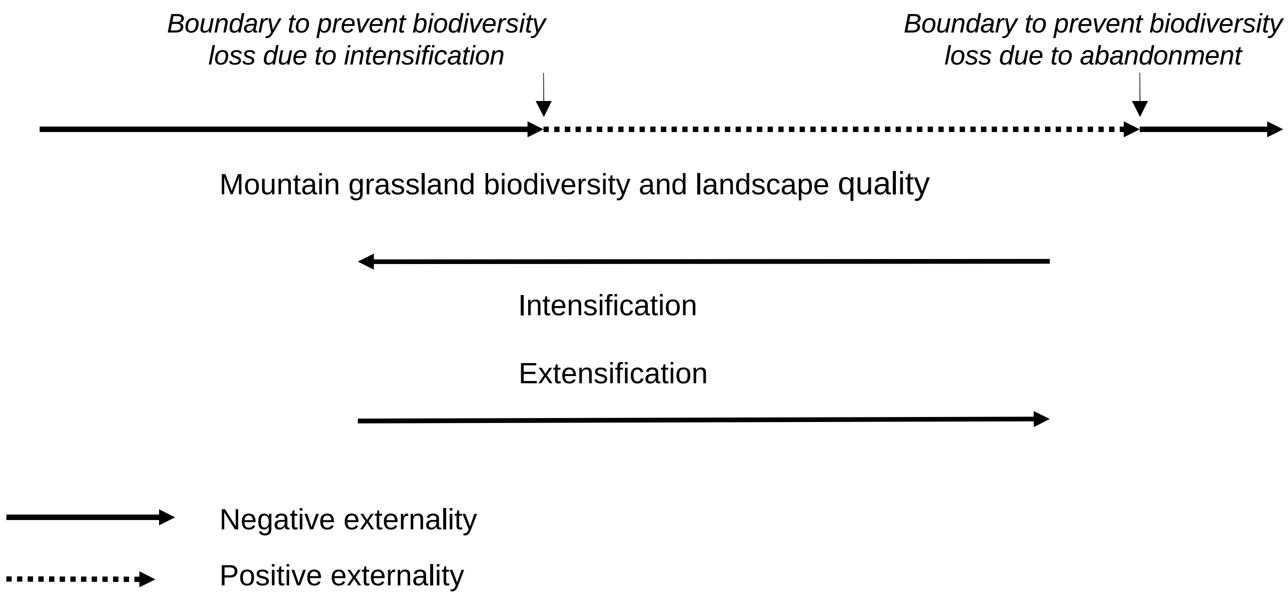
Features of the study area

- Traditional mostly subsistent farming with extensive farming practices (hand mowing, manure fertilization, cropping of small fields, rotation recognition, etc.)
- Limited opportunities for intensification due to geographical and climatic conditions
- Semi-natural landscapes
- Mountain grasslands converted from forests – habitat of conservation interest (hot-spots of biodiversity)

- Mosaic landscape
- Abandonment of grasslands leads to forest succession and loss of the landscape mosaic

HNV farming is regarded as a holistic system of extensive land use practices which includes the notion of connectivity between farming and nature

Topic Background



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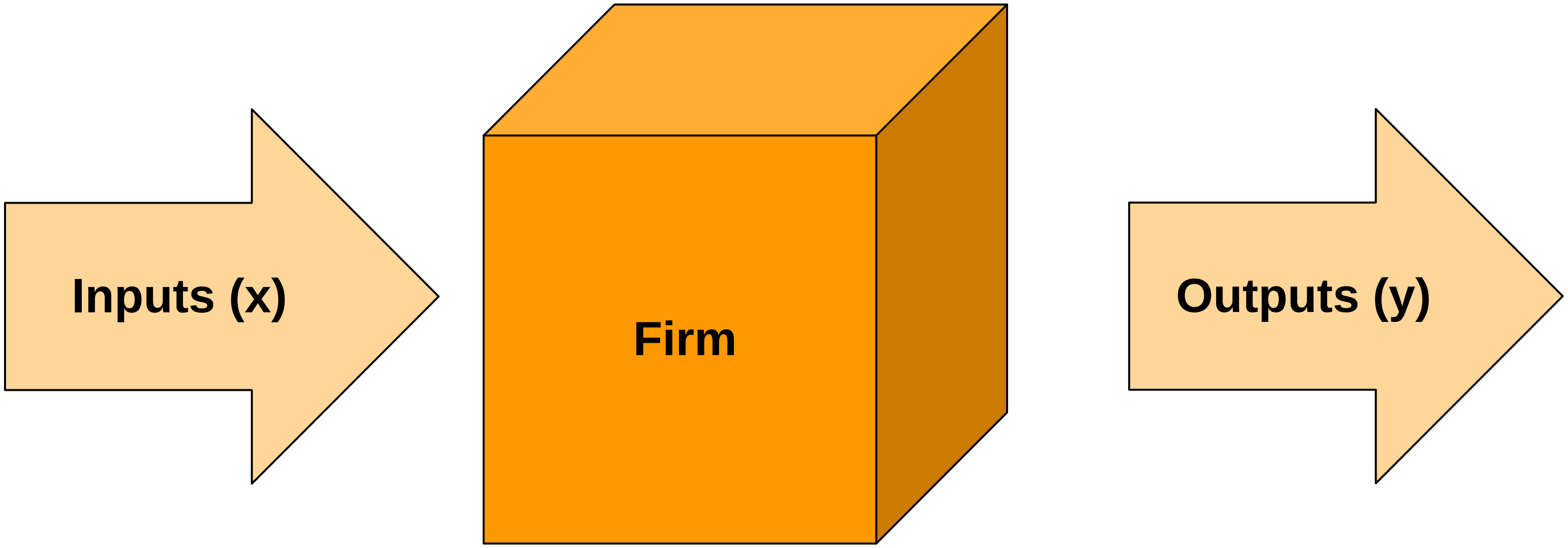
Joint production as a concept complementary to the theory of environmental external effects

Traditional setting of production analysis



Source: Modified from Kuosmanen and Kortelainen, 2004

Environmental performance analysis

Incorporating the environmental externalities provides more complete representation of the production technology

Modification of commonly used measures of technical efficiency

$$Efficiency = \frac{Output}{Input}$$

Positive environmental externalities

Positive externality can be incorporated as an output (Sipilainen et al., 2008, Areal et al. 2012)

Case study (Sipiläinen et al., 2008):
Efficiency in production of agricultural biodiversity was considered to compare organic and conventional practices

Environmental performance analysis

Positive environmental externalities

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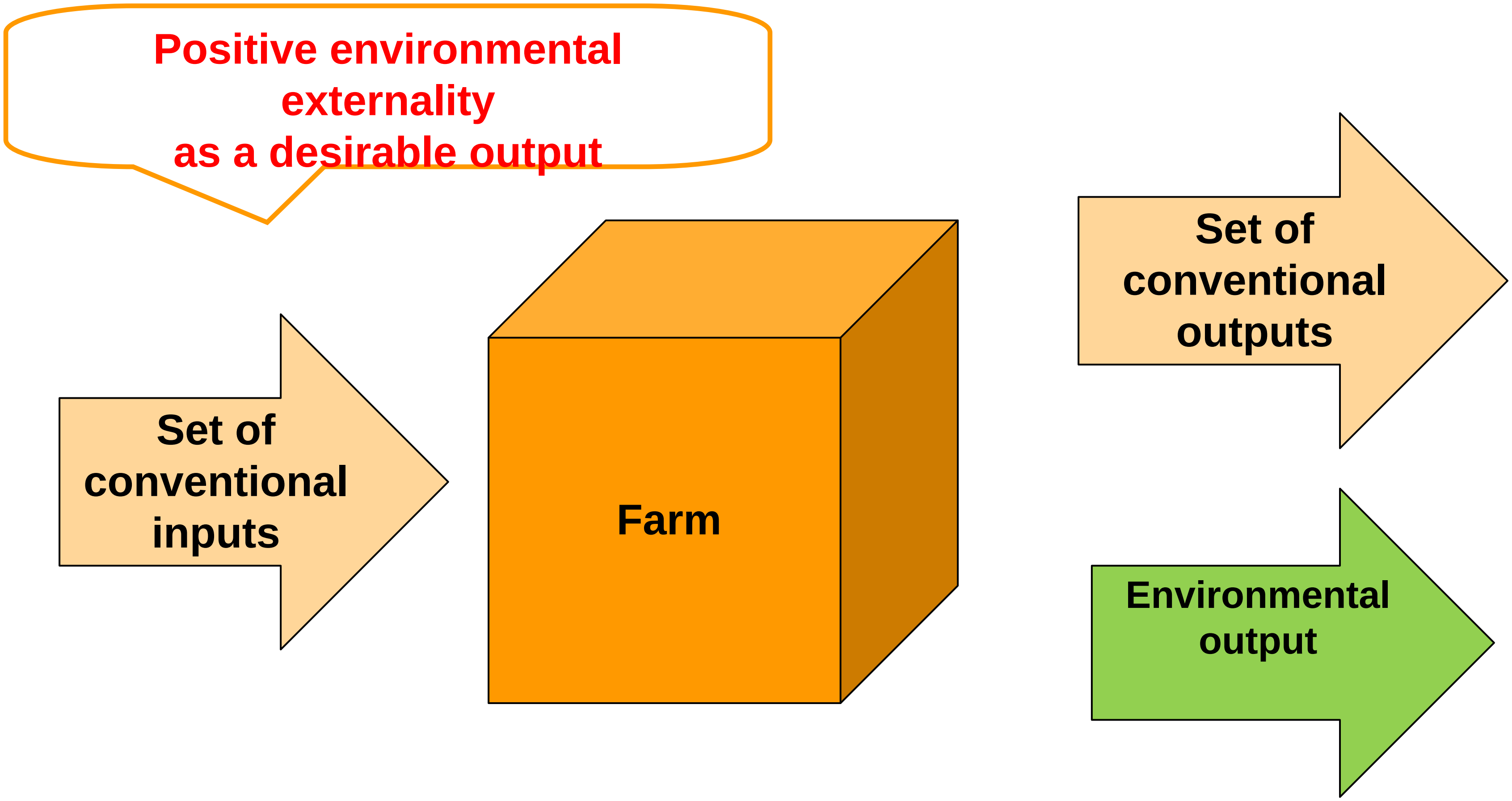
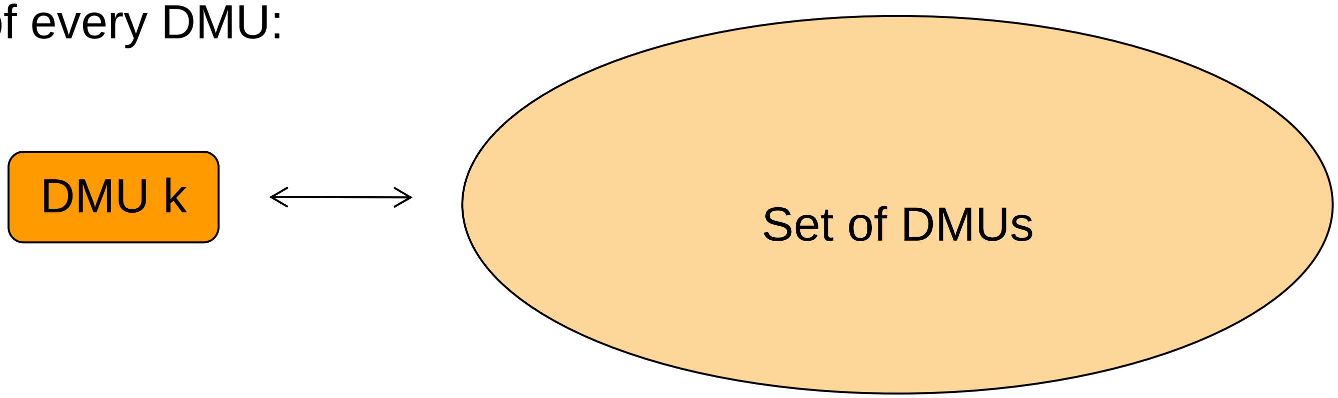
Specification of the model



Source: Modified from Kuosmanen and Kortelainen, 2004

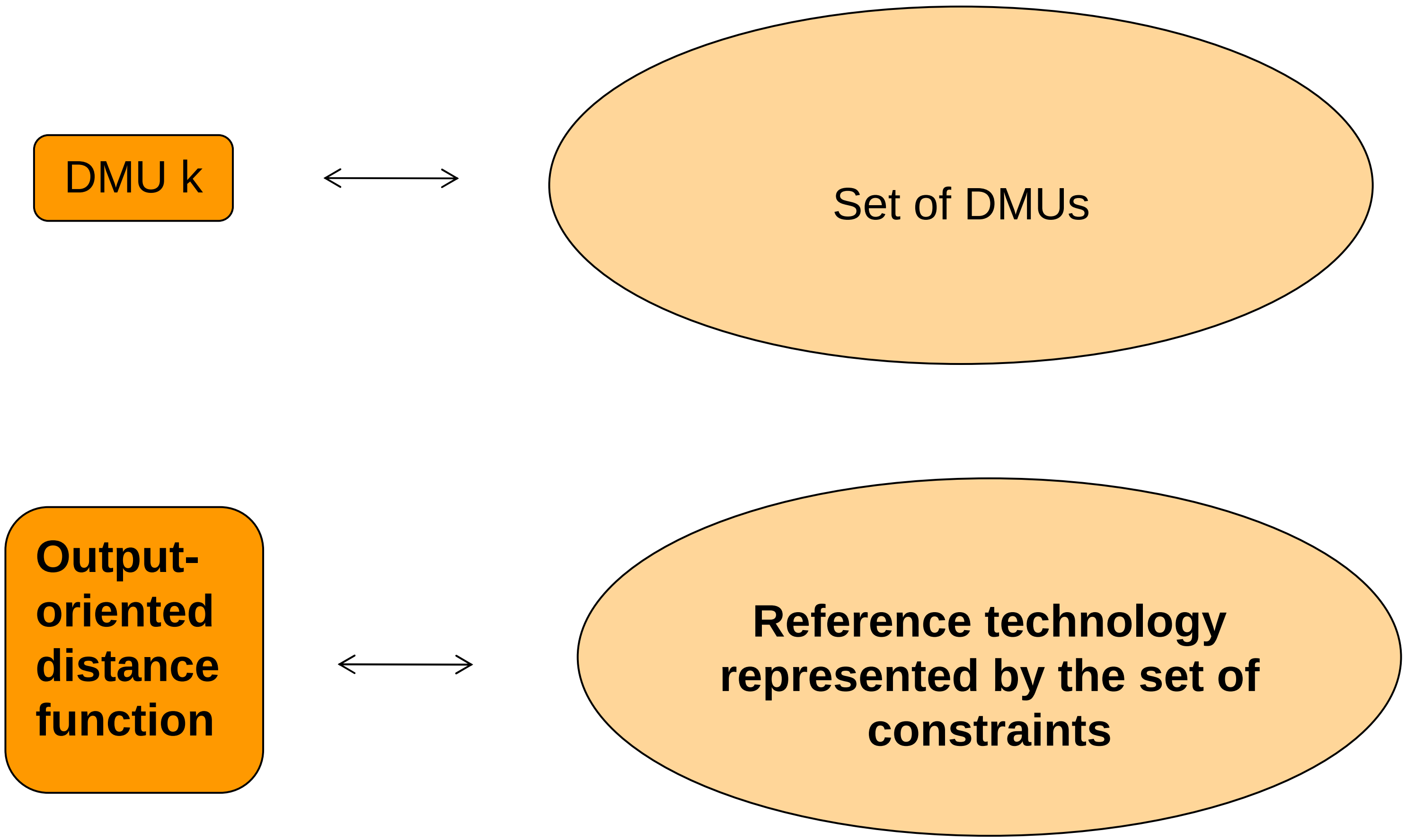
DEA method (Data Envelopment Analysis)

- Efficiency within a homogenous set of decision making units (DMU);
- Consideration of multi-input and multi-output production options;
- Usage of LP (linear programming) models solved for the efficiency measure of every DMU:



  - To construct efficiency frontier (reference technology);
  - To calculate the distance to the frontier for the less efficient DMUs.

DEA environmental efficiency



Data

- **Socio-economic survey**
- 33 households
- Kosiv, Verhovina and Nadvirna administrative regions

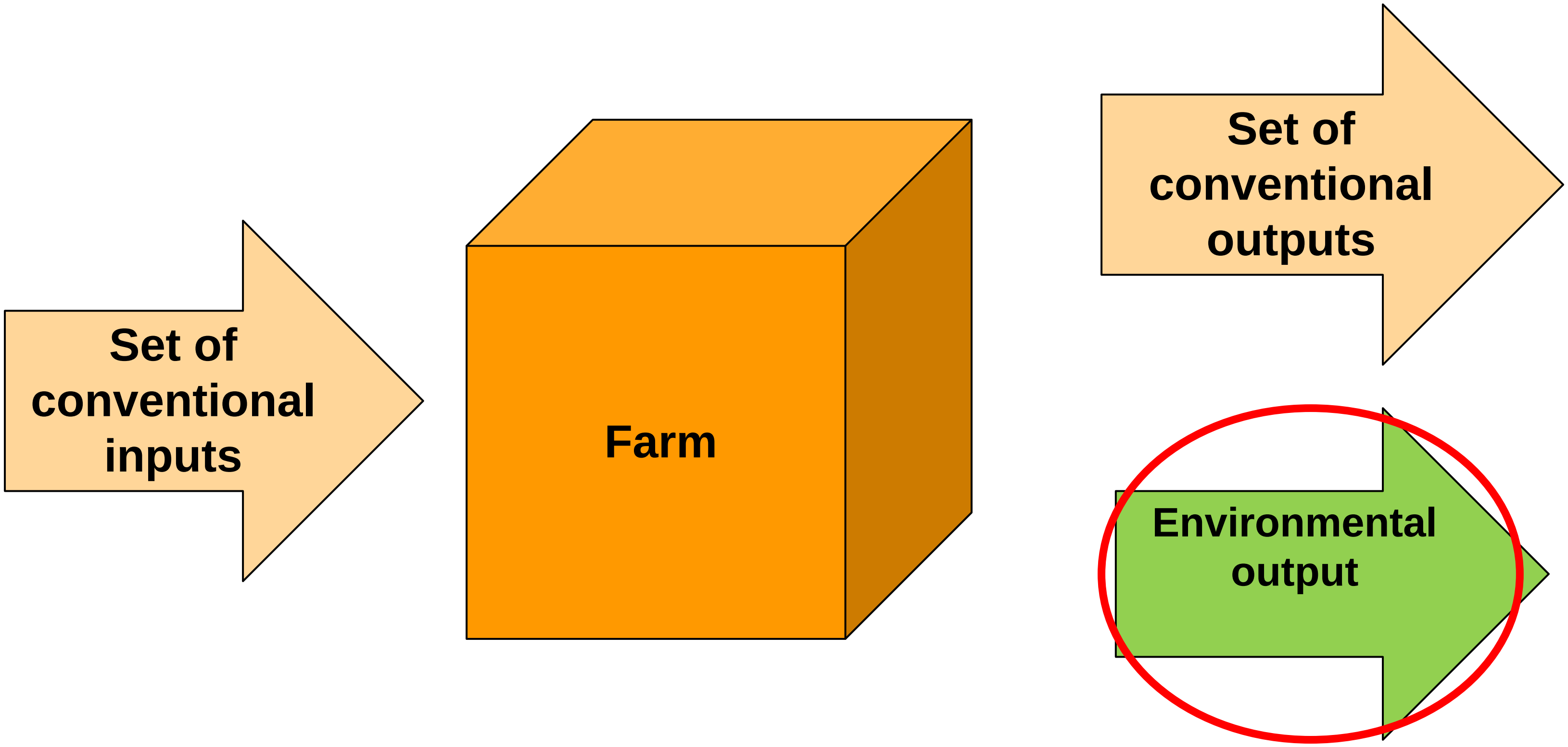
- **Geo-botanic survey**

Research sites in the Ukrainian Carpathians

Data

- **Socio-economic survey**
- 33 households
- Kosiv, Verhovina and Nadvirna administrative regions
- *Questionnaires:* 42 questions covered such topics as land size, details about meadow management, motivation, future plans, selling of products, etc.
- **Geo-botanic survey**
- 60 Sites
- Information collected:
  - Site description
  - Percentage of vegetation cover
  - List of plant species
  - Abundance of these species

Specification of inputs and outputs



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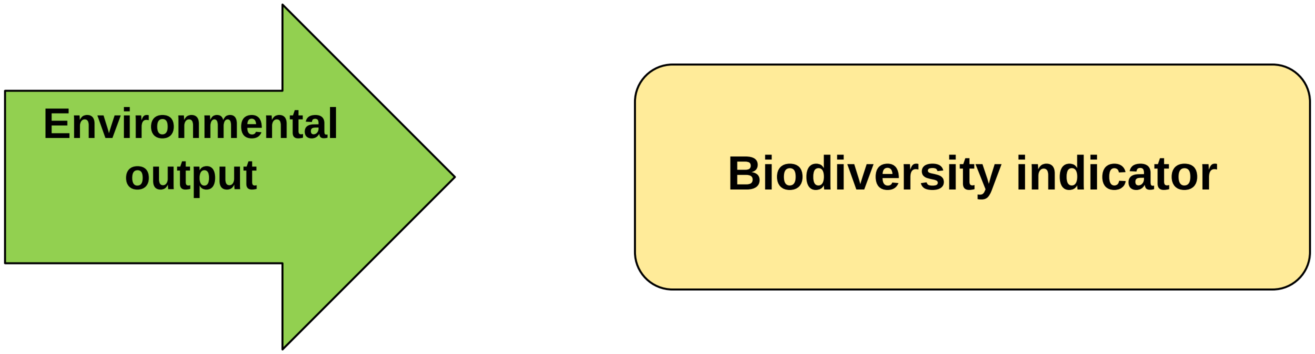
Specification of environmental output



- Literature based
  - Species richness (number of species)
  - Shannon diversity index
  - Presence of rare species
    - The indices are representing the quantitative indicators of a meadow but are not reflecting the quality of species combination

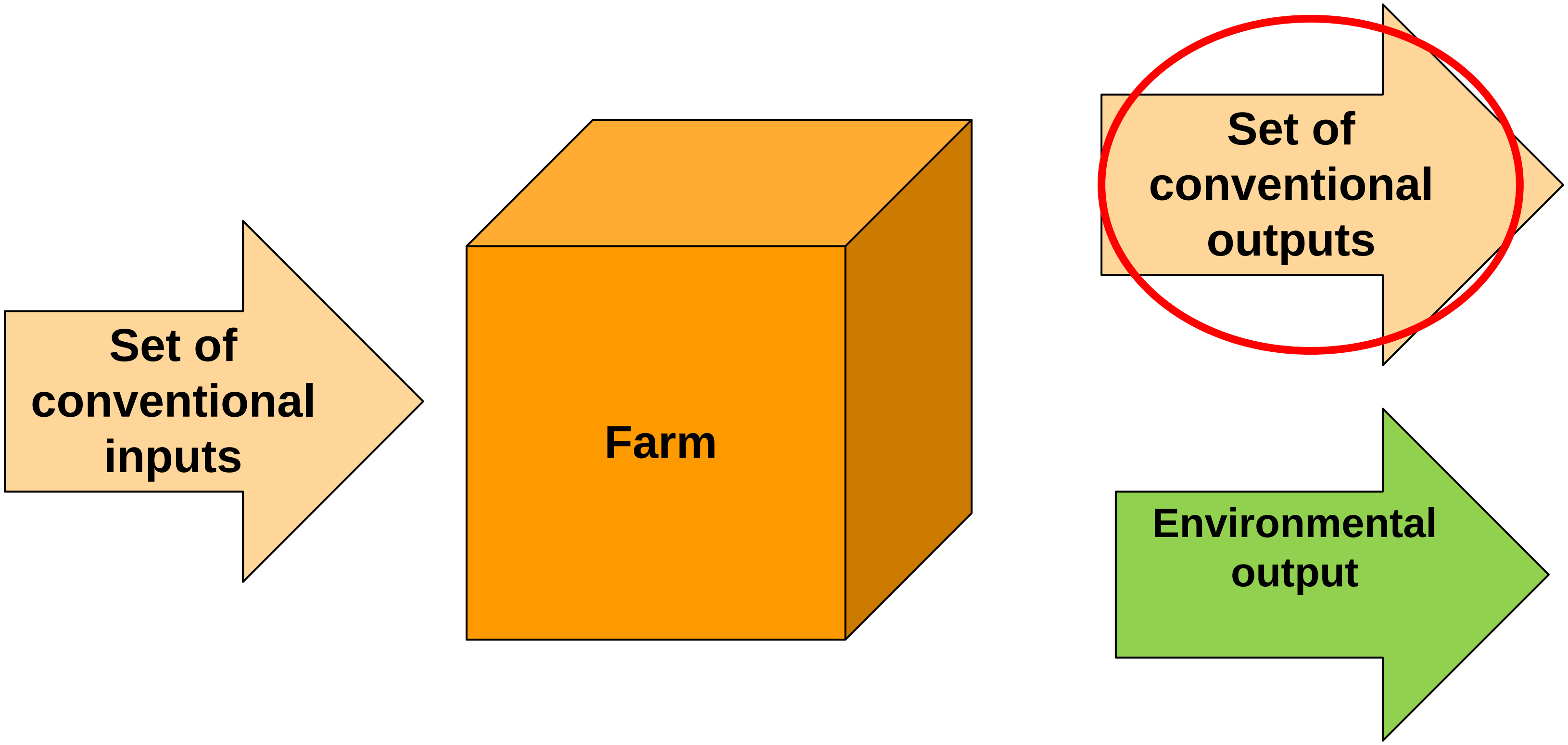
- Suggested aggregated biodiversity index
  - Connection of quantity and quality evaluation – not only the number of species but also their quality matters

Method:
Biodiversity indicator

$$BDI_j = \sum_{i=1}^{5} I_{ij} * w_i$$

	Indicators for evaluation (I_{ij})	Weights (w_i)	Min value	Max value	Scale based scores
1	Number of species	0,5	19	62	Scale 1 to 5
2	Number of productivity species	0,2	5	20	Scale 1 to 5
3	Number of rare species	0,15	0	5	Scale 1 to 5
4	Number of species indicating forest succession	0,1	0	6	Reverse scale with 5 for 0 species and 0 for max.
5	Vegetation cover	0,05	60%	100%	Scale 1 to 5

Specification of inputs and outputs



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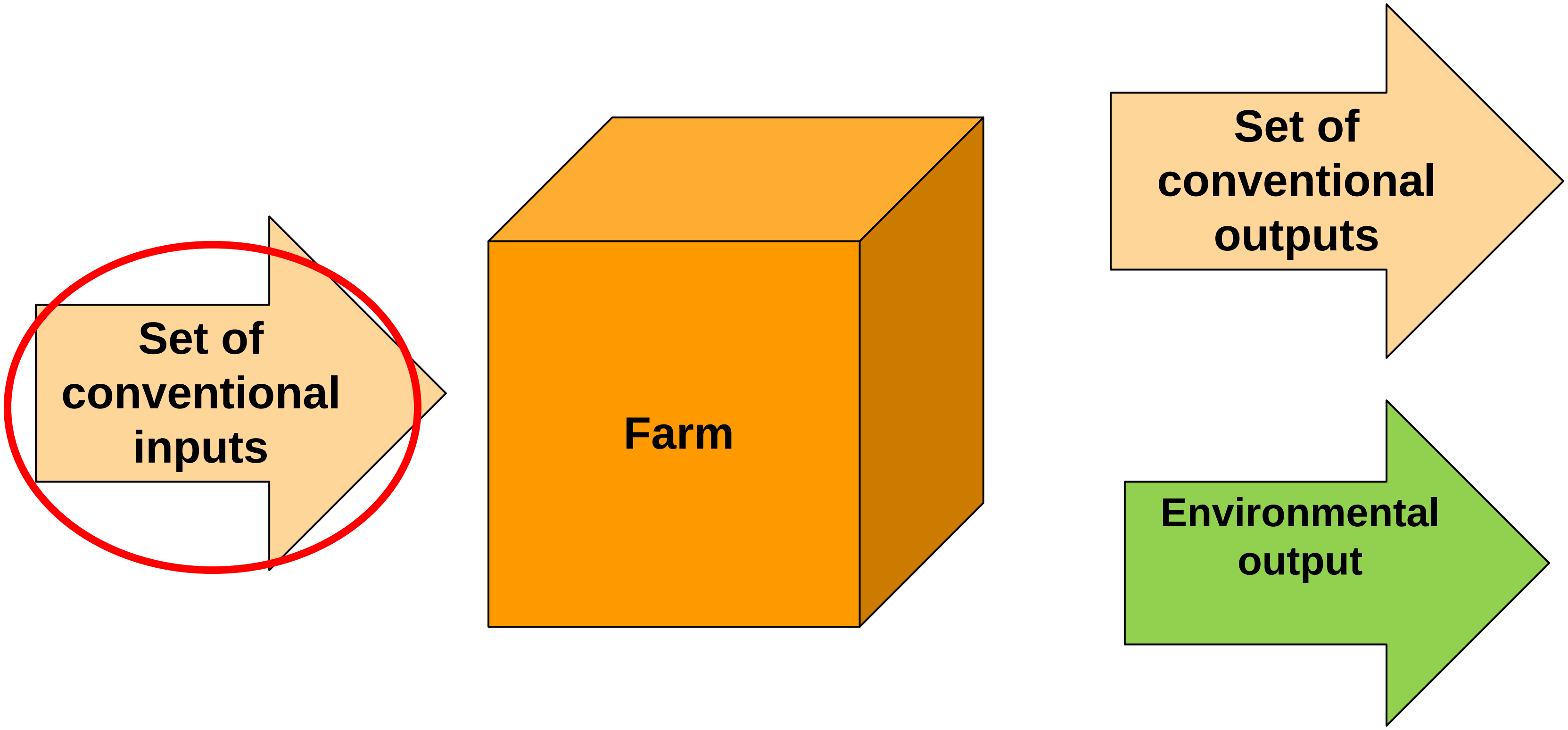
Specification of outputs

Set of conventional outputs

Volume index

Product	Estimation from the questionnaire	Unit	Mean
Milk	Information to the milk amount per cow	liters/ha per year	4370,55
Meat	Information on the meat sold and the meat consumed	kg/ha per year	63,92
Cheese	Information on the cheese sold and the cheese consumed	kg/ha per year	20,65
Potato	Output of potato per ha	kg/ha per year	5156,82
Hay	Output of hay per ha	kg/ha per year	2575,60

Specification of inputs and outputs



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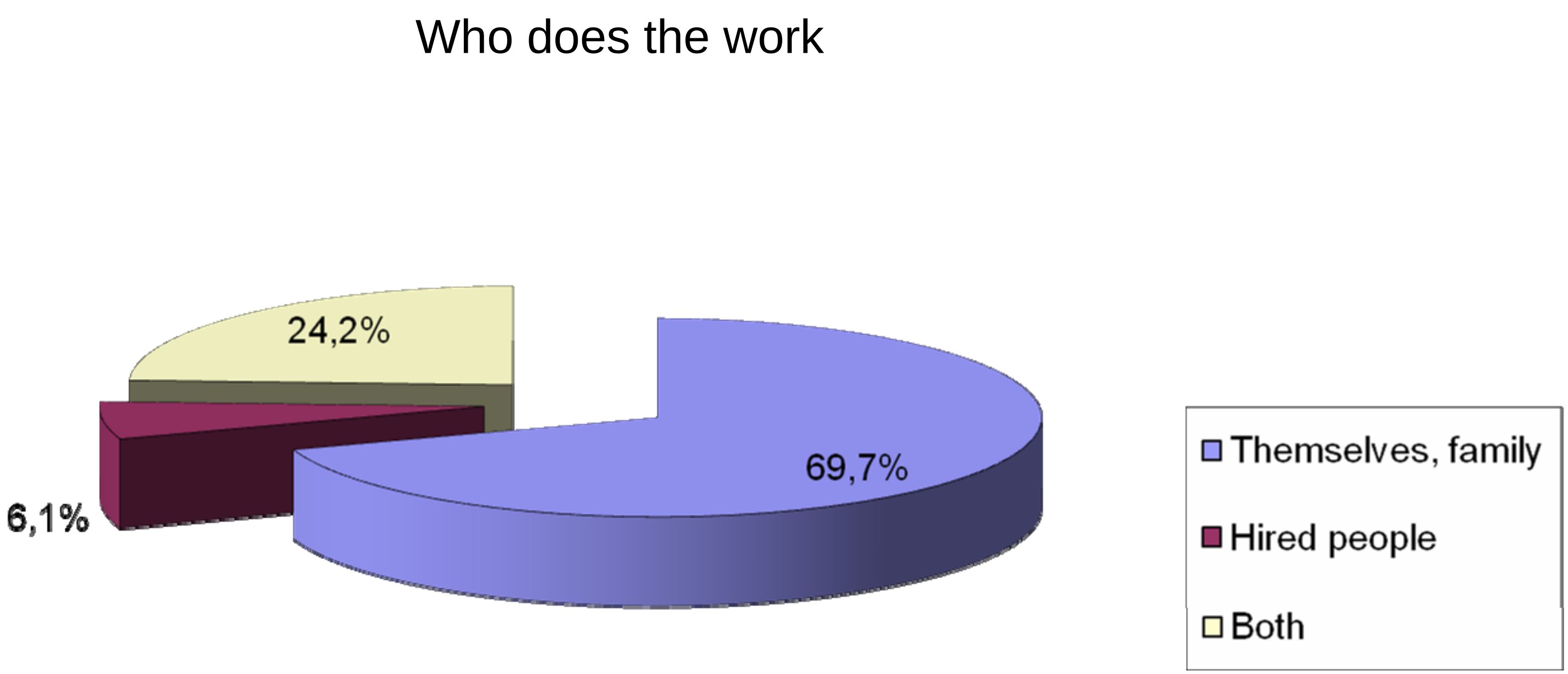
Specification of inputs

Set of conventional inputs

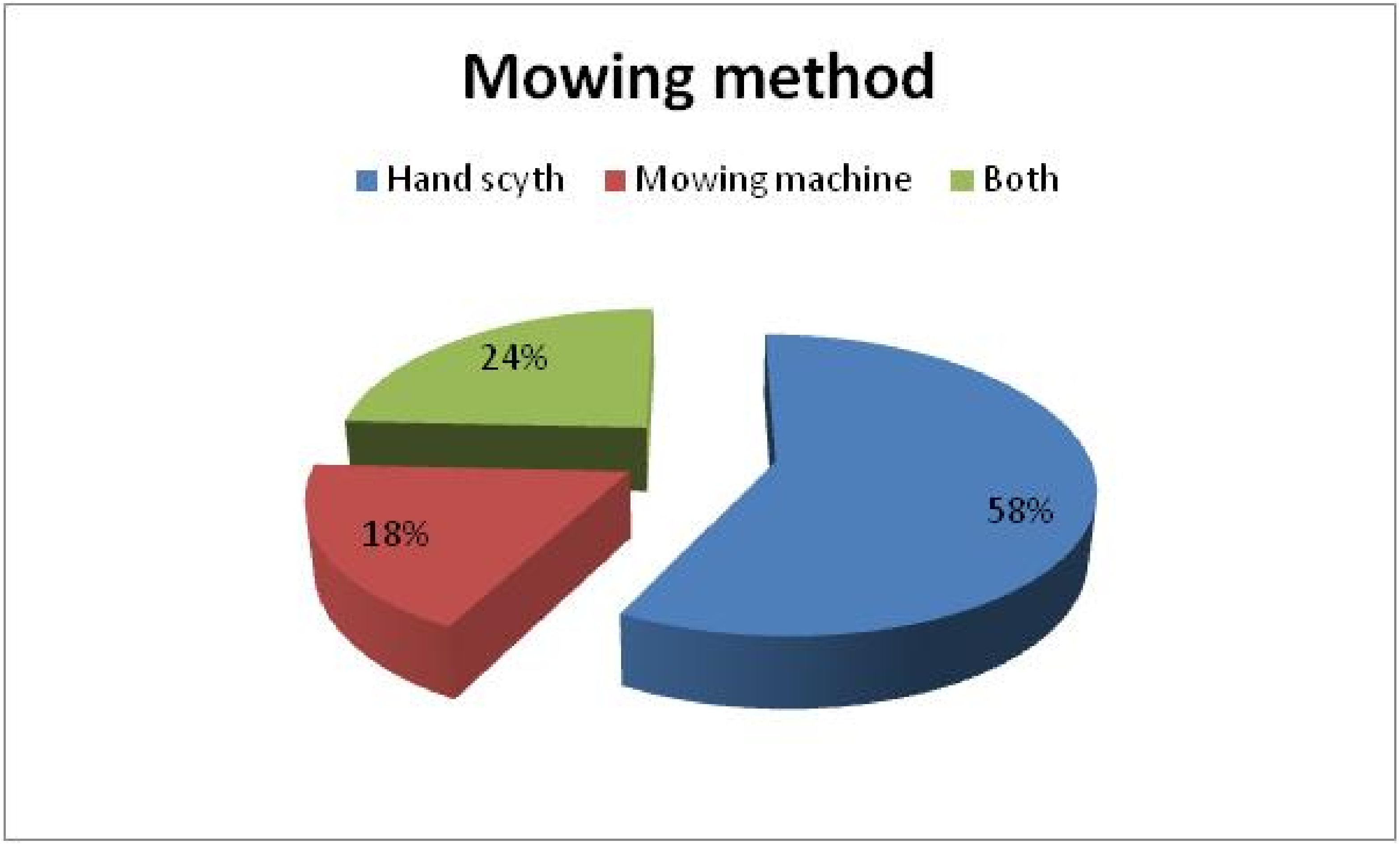
Input	Estimation	Unit	Mean
Labour	Time spent for work connected to grasslands	Man-hours/ha per year	946,64
Capital	Number of machines (mowing machine or truck)	Items	1,15
Fertilizers	Use of the manure or chemical fertilizers	kg/ha per year	897,86
Land	Grasslands (hay meadows and pastures)	ha	9,17 (3,75)*

- *without three largest farmers in the sample

Specification of inputs: Labour

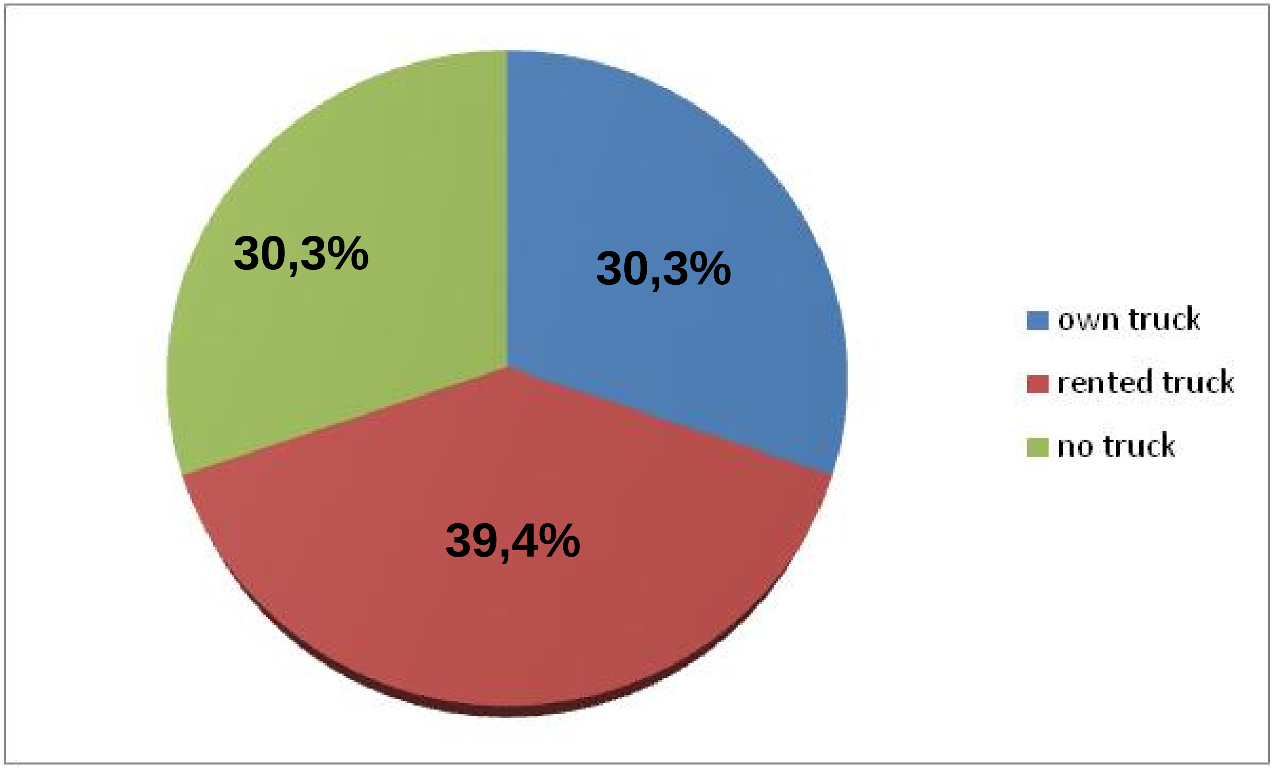


Specification of inputs: Capital



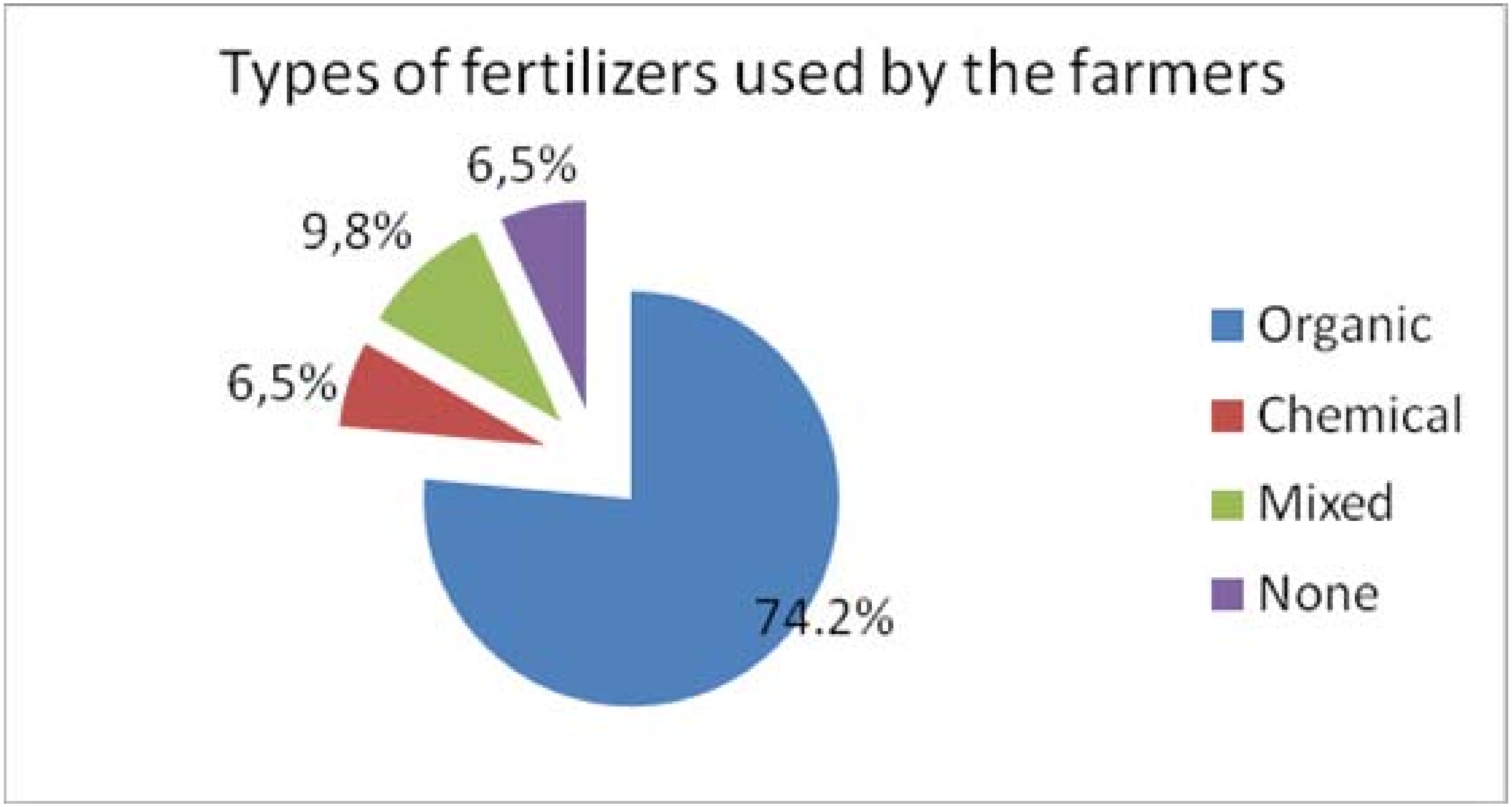
Specification of inputs: Capital

Usage of truck for hay transportation



Specification of inputs: Fertilizers

Fertilization is usually used just for inner meadows



DEA environmental efficiency

Parameter	Definition
Eff1	**Efficiency of production without consideration of environmental output (model with one output)**
EnvEff1	**Efficiency of production with consideration of environmental output: both outputs are maximized (model with two outputs)**

DEA environmental efficiency

Parameter	Definition
Eff1	Efficiency of production without consideration of environmental output (one output-four inputs model)
EnvEff1	Efficiency of production with consideration of environmental output: both outputs are maximized (two outputs-four inputs model)
Eff2	**Efficiency of production with consideration of environmental output: conventional output is maximized**
EnvEff2	**Efficiency of production with consideration of environmental output: environmental output is maximized**

Results: Efficiency scores

Parameter	Definition	Mean	Std. Deviation	Efficiency score =1	Efficiency score below 0,50
Eff1	Efficiency of production without consideration of environmental output (one output-four inputs model)	0,57	0,33	30,10%	48,50%
EnvEff1	Efficiency of production with consideration of environmental output: both outputs are maximized (two outputs-four inputs model)	0,90	0,15	54,50%	0,00%
Eff2	Efficiency of production with consideration of environmental output: conventional output is maximized	0,76	0,30	54,50%	36,40%
EnvEff2	Efficiency of production with consideration of environmental output: environmental output is maximized	0,87	0,18	54,50%	9,10%

Results: Comparison of efficiency rankings

Farm	Rank of Eff1	Rank of EnvEff1	Change in rankings
8	30,5	9,5	21
20	30,5	9,5	21
1	28,5	9,5	19
16	26	9,5	16,5
6	24	9,5	14,5
33	23	9,5	13,5
17	21	9,5	11,5
22	32	21	11
21	28,5	19	9,5
10	33	24	9
7	14	9,5	4,5
2	25	23	2
31	11	9,5	1,5

Results: Comparison of efficiency rankings

Farm	Rank of Eff1	Rank of EnvEff1	Change in rankings
23	15	30	-15
24	18,5	33	-14,5
27	13	27,5	-14,5
11	12	26	-14
25	16	27,5	-11,5
5	20	31	-11
15	18,5	29	-10,5
29	10	20	-10
26	17	25	-8
28	27	32	-5

Implications

- along with the standard efficiency measures, it is important to consider environmental efficiency in case traditional type of farming is concerned;
- different approaches to analysis of environmental efficiency depending on the objectives of the application of the results
- there might be differences in distribution based on the different study regions which are characterized by different climate conditions

- → **Challenges**:

- to exclude the influence of natural site characteristics from the evaluation

- extensive data requirements of the DEA-method

Further questions

- Efficiency analysis and optimising behaviour
- What are the sources of inefficiencies?
- Being rational ?

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THANK YOU
for your attention!