DECISION SUPPORT SYSTEM FOR REPLACING OLD MACHINERIES IN CEREAL FARMS

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Abstract

Farmers take daily decisions with direct impact on farm performance and also on the environment.
Negative environmental consequences are visible in the long term, imposing measures to prevent pollution, and in the same time, do not affect the economic viability of the farm. The project aims to develop a computerized decision support system, to assist farmers, in taking decisions regarding replacing old machineries with new ones, in cereal farms. The research methodology involved: *intelligence phase (*data collection, problem identification), *design phase* (formulate a model, set criteria for choice, search for alternative, predict and measure outcome) and *choice phase* (solution to the model, selection of best alternatives, and plan for implementation). The decision support system can further be used to simulate different scenarios as well as to estimate the economic and environmental impacts.

Key words: efficiency, agriculture, pollution, environment

Agriculture fulfills a variety of functions, such as: it contributes to the supply of citizens with safe and quality food, maintain cultural landscapes through sustainable land management and help rural areas to remain attractive and viable (Situation and prospects for EU agriculture and rural areas, 2010).

Agriculture is an important employment generator in rural areas where unemployment is generally higher than in urban areas and generates jobs in a wide range of farm-related upstream businesses (veterinarians, equipment dealers, mechanics, feed and crop supply businesses, etc.) and downstream businesses (food processors, transportation, retailers, etc). Also, farms provide trainings in a wide range of skills such as practical problem-solving skills applicable in many spheres of daily life (Scott Jennifer et al., 2008).

Developing *decision support systems* in agriculture is not easy and requires different skills (agriculture, economics, computer science, etc.), so that the system developed to be efficient and easy to use by farmers. In the 1960s, researchers began to study the use of computerized quantitative models to assist in decision making and planning. In the 1970s, both practice and theory issues related to *decision support system* were discussed at academic conferences. Beginning in 1980s many activities associated with building and studying the *decision support system* occurred in universities and organizations that resulted in expanding the scope of *decision support system* applications. *Decision support system* practice, research and technology continue to evolve. By 1996, it had been identified five specialized types of *decision support systems*, including text-oriented, database-oriented, spreadsheet-oriented, solver-oriented, and rule-oriented (Power, 2007).

Simulation models estimate what will happen in the future under different scenarios. The tool involves the manipulation of large amounts of data. A decision support system can help convert data from models into knowledge that describes the likely results of alternative courses of action, and apply that knowledge in a framework that helps decision-makers (Heilman et al. 2005). To design a *decision support system*, one has to determine who the decision-makers are, what decisions are to be made, and what information is needed to make those decisions.

Advances in information technology are creating the potential to create much greater net benefits from agricultural research. The decision support system allows farmers to ask "what if" questions and simulates results. In the twenty-first century, agricultural professional using information technologies play an increasingly important role in crop production and natural resource management. Increasingly, agricultural decision support systems are used by producers,

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agricultural consultants, or agribusiness (Ascough et al. 2002).

A new approach is used different from the classic one in which only the economic profit prevails as a basic indicator. The new approach is to relate investments with the sustainable eco-development concept and the new economy based on information society concept (Banacu, 2004).

In their studies, Subić (2006) and Vasiljević (2007) explain the importance of efficiency analysis of investments in agriculture. The main indicators are: Cash flow Return on Investment, Discounted payback**,** Internal Rate of Return, Net Present Value, etc. (Subic et al. 2010). The investment project model must be automatized in order to reduce errors (Mackevičius, 2011).

The aim of the current researches is to develop a computerized decision support system, to asist farmers, in taking decisions regarding replacing old machineries with new ones, in cereal farms.

The results of the research will answer to a few questions:

- ✓ What is the need of founding and loan repayment schedule for a new investment?
- ✓ What is the economic efficiency of a new investment?
- ✓ What is the energy efficiency of a new investment?
- ✓ What is the best investment decision regarding agricultural machineries in a specific cereal farm?
- ✓ How can the agricultural sector work smarter by considering more options?

MATERIAL AND METHOD

A decision support system provides a tool to evaluate the complex systems, perform "what-if" scenario analyses, and aid in choosing an appropriate solution.

Tjia (2009) relates modelling to creative abilities and art, because it is developed to automate the process and doesn't represent a strictly defined research method.

The decision process, used for this research, was divided into three phases (Singh et al. 2008):

✓ Intelligence phase: search and scanning procedure, data collection, problem identification, problem ownership, problem classification, problem statement;

✓ Design phase: formulate a model, set criteria for choice, search for alternative, predict and measure outcome;

Choice phase: solution to the model, selection of best alternatives, plan for implementation.

The indicators used to calculate the economic efficiency of a new investment were: Total investment without VAT, Annual increase of turnover, Turnover, Annual increase of production costs, Production costs, Loan costs, Total costs, Cash flow of the period, Cash flow at the end of the period, Return on Investment (ROI), Discount rate, Discounted payback, Return on invested capital, Coverage rates by cash flow, Indebtedness rate, Internal Rate of Return (IRR) and Net Present Value. The indicators used to calculate the energy efficiency of a new investment were: Total Gas/Diesel oil consumption, CO_2 emissions, CH_4 emissions, N_2O emissions.

RESULTS AND DISCUSSIONS

The created tool (Excel spreadsheet) has the following modules: Interface, Old machineries, New machineries, Founding, Economic efficiency and Energy efficiency (figure 1). Only white cells must be filled in. The rest of the cells will be automatic calculated.

In order to validate the model, it was calculated the economic and energy efficiency of replacing an old tractor in a cereal farm with a new one.

The following data were considered for **60 days of plowing**: costs with fuel, costs with other consumables, costs with taxes, insurance, other costs (personnel, depreciation costs, other costs), incomes, the purchase price of a new tractor and the income from selling the old machinery.

Variant 1: Old tractor U650 with plow

- ✓ Productivity: 4 hectare/day,
- ✓ Fuel consumption: 25 litre/hectare,
- ✓ Cost with fuel: 1.4 euro/litre,
- ✓ Costs with other consumables: 1260 euro,
- ✓ Costs with taxes, insurance: 50 euro,
- ✓ Other costs (personnel, depreciation costs, other costs): 750 euro,
- ✓ Price for plowing 1 hectare: 100 euro,
- ✓ Incomes: 24000 euro.

Variant 2: New tractor with plow

- ✓ Purchase price: 50000 euro,
- ✓ Productivity: 6 hectare/day,
- ✓ Fuel consumption: 18 litre/hectare,
- ✓ Cost with fuel: 1.4 euro/litre,
- ✓ Costs with other consumables: 1360.8 euro,
- ✓ Costs with taxes, insurance: 500 euro,
- ✓ Other costs (personnel, depreciation costs, other costs): 5750 euro,
- ✓ Price for plowing 1 hectare: 100 euro,
- ✓ Incomes: 36000 euro,
- ✓ Income from selling the old machinery: 3500 euro.

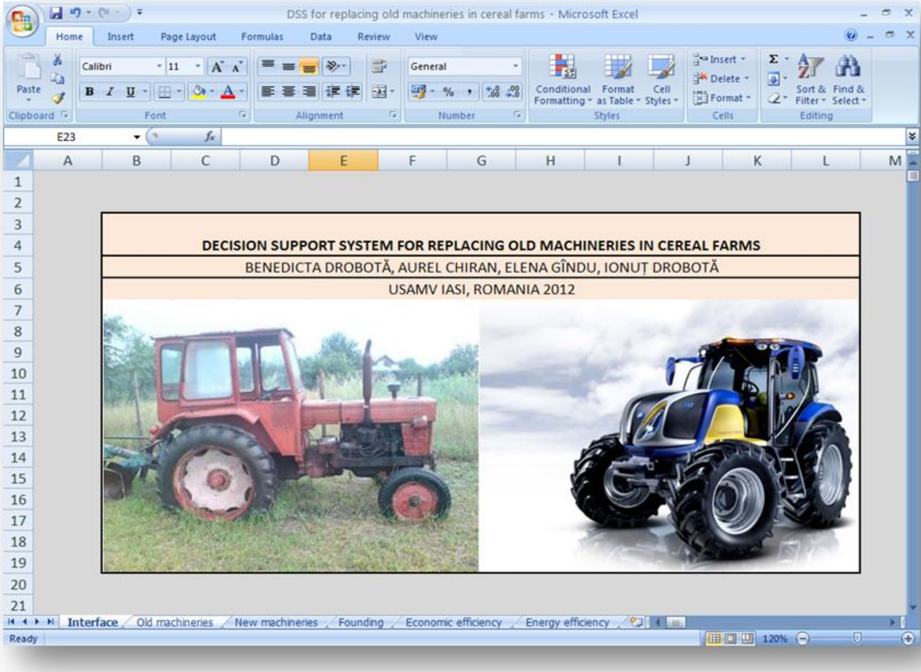


Figure 1 - The interface of the created tool

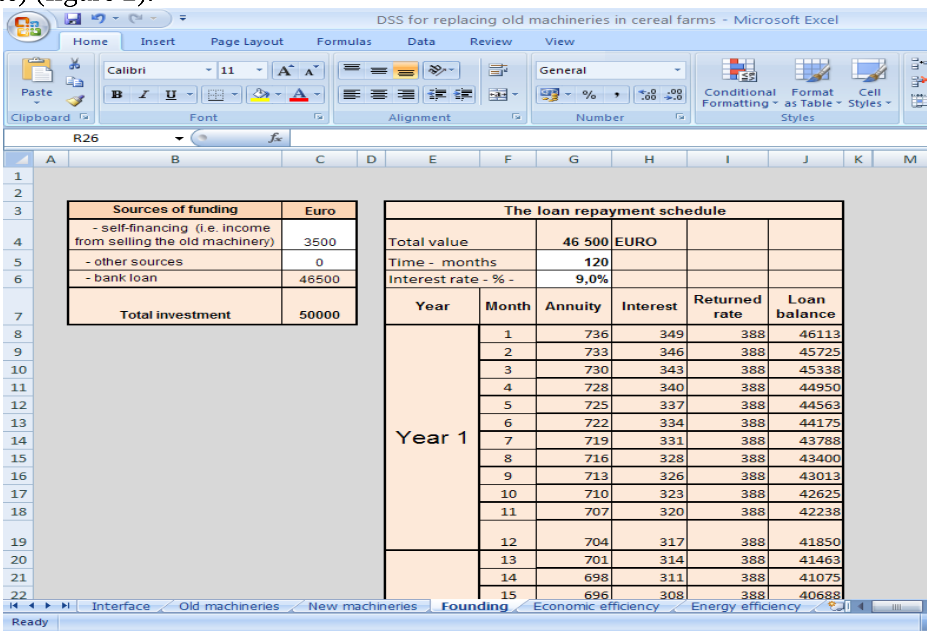
The difference of productivity comes from: the working speed, front-wheel drive advantage, less time resting, easy handling and increased comfort.

The sources of founding are:

- ✓ self-financing (income from selling the old machinery): 3500 euro,
- ✓ bank loan: 46500 euro (120 months, 9% interest rate) (figure 2).

Based on those data, it was automatic calculated the economic efficiency of the new investment. The main indicators are:

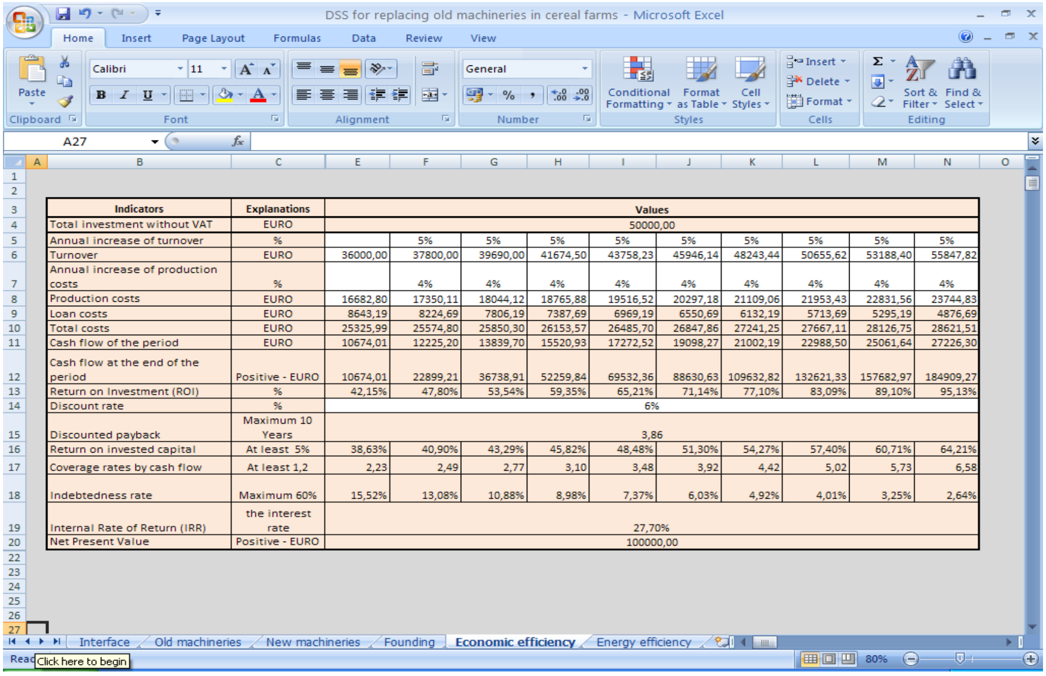
- ✓ Discounted payback (Should be maximum 10 Years): 3.86 years,
- ✓ Internal Rate of Return (IRR) (Should be greater than the interest rate, in this case 9%): 27,70%,
- ✓ Net Present Value (Should be positive): 100000 euro (figure 3).



Sources of funding	Euro
- self-financing (i.e. income from selling the old machinery)	3500
- other sources	0
- bank loan	46500
Total investment	50000

The loan repayment schedule					
Total value		46 500	EURO		
Time - months		120			
Interest rate - % -		9,0%			
Year	Month	Annuity	Interest	Returned rate	Loan balance
Year 1	1	736	349	388	46113
	2	733	346	388	45725
	3	730	343	388	45338
	4	728	340	388	44950
	5	725	337	388	44563
	6	722	334	388	44175
	7	719	331	388	43788
	8	716	328	388	43400
	9	713	326	388	43013
	10	710	323	388	42625
	11	707	320	388	42238
	12	704	317	388	41850
	13	701	314	388	41463
	14	698	311	388	41075
	15	696	308	388	40688

Figure 2 - The sources of founding for a new investment



Indicators	Explanations	Values									
Total investment without VAT	EURO	50000,00									
Annual increase of turnover	%		5%	5%	5%	5%	5%	5%	5%	5%	5%
Turnover	EURO	36000,00	37800,00	39690,00	41674,50	43758,23	45946,14	48243,44	50655,62	53188,40	55847,82
Annual increase of production costs	%		4%	4%	4%	4%	4%	4%	4%	4%	4%
Production costs	EURO	16682,80	17350,11	18044,12	18765,88	19516,52	20297,18	21109,06	21953,43	22831,56	23744,83
Loan costs	EURO	8643,19	8224,69	7806,19	7387,69	6969,19	6550,69	6132,19	5713,69	5295,19	4876,69
Total costs	EURO	25325,99	25574,80	25850,30	26153,57	26485,70	26847,86	27241,25	27667,11	28126,75	28621,51
Cash flow of the period	EURO	10674,01	12225,20	13839,70	15520,93	17272,52	19098,27	21002,19	22988,50	25061,64	27226,30
Cash flow at the end of the period	Positive - EURO	10674,01	22899,21	36738,91	52259,84	69532,36	88630,63	109632,82	132621,33	157682,97	184909,27
Return on Investment (ROI)	%	42,15%	47,80%	53,54%	59,35%	65,21%	71,14%	77,10%	83,09%	89,10%	95,13%
Discount rate	%	6%									
Discounted payback	Maximum 10 Years	3,86									
Return on invested capital	At least 5%	38,63%	40,90%	43,29%	45,82%	48,48%	51,30%	54,27%	57,40%	60,71%	64,21%
Coverage rates by cash flow	At least 1,2	2,23	2,49	2,77	3,10	3,48	3,92	4,42	5,02	5,73	6,58
Indebtedness rate	Maximum 60%	15,52%	13,08%	10,88%	8,98%	7,37%	6,03%	4,92%	4,01%	3,25%	2,64%
Internal Rate of Return (IRR)	the interest rate	27,70%									
Net Present Value	Positive - EURO	100000,00									

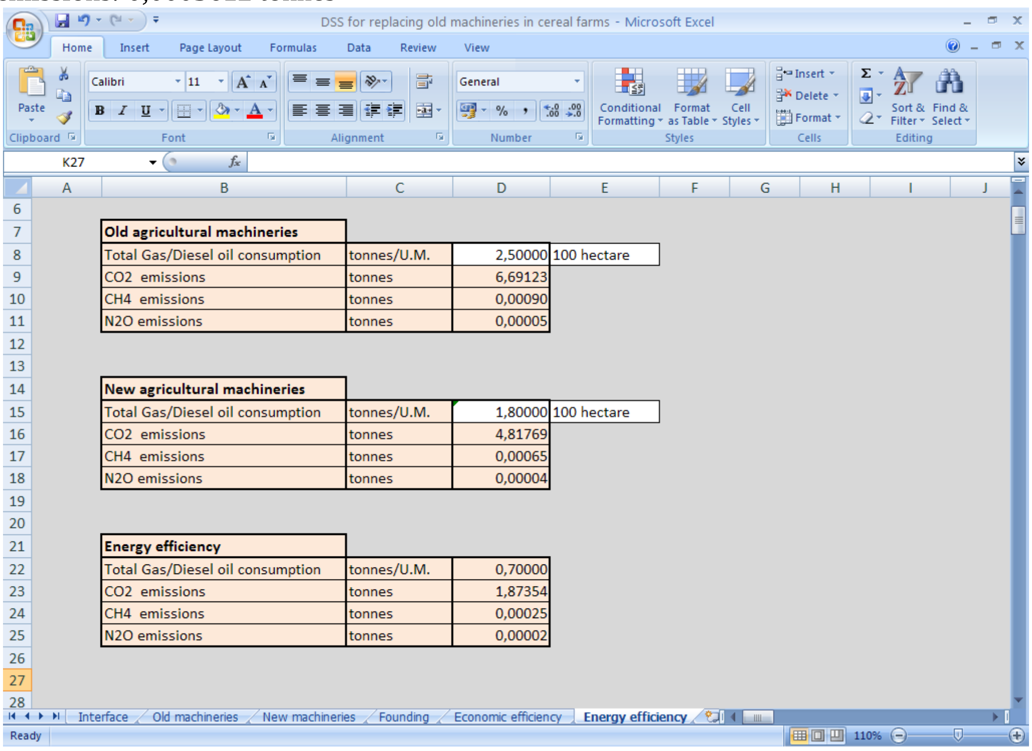
Figure 3 - Economic efficiency of a new investment

The following data were considered for calculated the energy efficiency of the new investment for 100 hectare of plowing: Total Gas/Diesel oil consumption, CO_2 emissions, CH_4 emissions, N_2O emissions. The emissions coefficients of 1 tonne of Gas/Diesel oil consumption are (*GHG emissions from stationary combustion (English) Version 4.0, 2010)*:

- ✓ CO_2 emissions: 2,676492 tonnes
- ✓ CH_4 emissions: 0,0003612 tonnes
- ✓ N_2O emissions: 0,000021672 tonnes

The energy efficiency of the new investment for 100 hectare of plowing is (figure 4):

- ✓ Total Gas/Diesel oil consumption: 0,70000 tonnes/U.M.
- ✓ CO_2 emissions: 1,87354 tonnes
- ✓ CH_4 emissions: 0,00025 tonnes
- ✓ N_2O emissions: 0,00002 tonnes



Old agricultural machineries			
Total Gas/Diesel oil consumption	tonnes/U.M.	2,50000	100 hectare
CO2 emissions	tonnes	6,69123	
CH4 emissions	tonnes	0,00090	
N2O emissions	tonnes	0,00005	

New agricultural machineries			
Total Gas/Diesel oil consumption	tonnes/U.M.	1,80000	100 hectare
CO2 emissions	tonnes	4,81769	
CH4 emissions	tonnes	0,00065	
N2O emissions	tonnes	0,00004	

Energy efficiency		
Total Gas/Diesel oil consumption	tonnes/U.M.	0,70000
CO2 emissions	tonnes	1,87354
CH4 emissions	tonnes	0,00025
N2O emissions	tonnes	0,00002

Figure 4 - Energy efficiency of a new investment

CONCLUSSIONS

The obtained results show the importance of replacing old machineries in cereal farm, not just because of high economic efficiency but also of energy efficiency.

The created tool has the following advantages:

- ✓ Has high applicability at farm level,
- ✓ Can be used personalized database and the user have direct control of the simulation,
- ✓ Takes into account the short and long time horizons in calculating the main indicators of the investment,
- ✓ Can improve the personal efficiency and speed up the process of decision making. It can be tested one or more variants of investment.
- ✓ Can create a competitive advantage over competition by choosing the best alternative of investment after conducting scenario analysis.

The results emerging from the research confirm the utility of the created tool and show that the investment is justified, not only economically but also from pollution point of view, conserving environment and improving farmer's life.

ACKNOWLEDGEMENTS

„This work was cofinanced from the European Social Fund through Sectoral Operational Programme Human Resources Development 2007-2013, project number POSDRU/I.89/1.5/S62371 „Postdoctoral Schole in Agriculture and Veterinary Medicine area."

"The authors contributed equally to the realization of this paper".

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