2021 17th International Conference on Distributed Computing in Sensor Systems (DCOSS) | 978-1-6654-3929-9/21/$31.00 ©2021 IEEE | DOI: 10.1109/DCOSS52077.2021.00051

Precision Agriculture Investment Return Calculation Tool

1st Konstantinos Kiropoulos
Dept. of Electrical and Computing Engineering
University of Western Macedonia
Kozani, Greece
kkiropoulos@yahoo.com

2nd Stamatia Bibi
Dept. of Electrical and Computing Engineering
University of Western Macedonia
Kozani, Greece
sbibi@uowm.gr

3rd Fotini Vakouftsi
Dept. of Mechanical Engineering
University of Western Macedonia
Kozani, Greece
fayvak@yahoo.gr

4th Vassilis Pantzios
Kozani Saffron Producers Cooperative
Kozani, Greece
sinkroko@otenet.gr

***Abstract*—Precision Agriculture (PA) nowadays adopts IoT technology, such as wireless sensors and unmanned aerial vehicles aiming at boosting production and monetary profits by controlling corps inputs such as water, fertilizers or pesticides and minimizing manual labor. Despite the fact that the benefits of Precision Agriculture techniques are widely recognized, we observe that in Europe they are adopted mainly by large farms located in UK that can afford the investment. On the contrary, in countries where the agriculture land is highly fragmented, such as Greece and Italy, the adoption of Precision Agriculture techniques is still very low. In this paper we argue that precision agriculture can be affordable even by small farms, when carefully choosing and deciding upon the technologies that will be adopted. For this reason we developed and present a tool that can help farmers check easily and reliably whether investing in precision farming technologies is feasible and profitable for their business.**

Keywords—precision agriculture (PA), investment returns, cost benefit.

I. Introduction

Precision Agriculture (PA) employs modern ICT technologies for the effective management of farms. PA farm management systems allow the producer to improve production methods and at the same time reduce the environmental burden [1]. The main goals of PA are among others, increasing crop yields, improving the quality of products produced and reducing energy consumption. The technologies that can be used, complementary to each other, may cover all production stages, from sowing to harvest and include GPS and GIS systems, remote sensors for collecting various important data and unmanned aerial vehicles.

Currently in research we can find several trends regarding the application of PA technologies, the deployment of which vary largely across different environmental, cultivation and cultural backgrounds. Therefore, farmers and agronomists have a wide range of choices to make when it comes to selecting the appropriate PA technologies to adopt based on the particular characteristics of the farm that is being cultivated. In order to help farmers test the suitability of PA technologies in this paper we present a Decision Support System (DSS) based on common features for the suitability of PA applications. Such a system will be useful, not only for conducting targeted studies on PA implementation among farmers, but also to identify solutions and future directions when it comes to adopting PA. This will lead to a decrease in the number of farmers who do not yet trust precision farming techniques, mainly due to the difficulty of quantifying the economic benefits coming from adopting them [2].

In this context, we developed an easy-to-use web tool that every farmer can use when considering upgrading the production process. By using this tool, he can check if an investment in precision agriculture technologies will benefit or harm his business. The tool uses the three most common formulas adopted in cost-benefit analysis of an investment: Cost/Benefit Ratio, Net Present Value (NPV) and Internal Rate of Return (IRR).

The interested producer can enter the usual annual expenses and income of his farm and also the required expenses (initial and annual) for the investment in the new technologies. Then he can check directly if the investment is financially advantageous or not.

The on-line tool for the cost-benefit analysis of precision agriculture (PA) application is further used to calculate whether the investment on PA technologies is worth in saffron cultivation, by examining three cases (small, medium and large scale investments) in fragmented farms. The tool was developed under DIAS (Drone Innovation in saffron Agriculture Surveillance) research project. The project's goal is to improve saffron production process, using precision agriculture technology. Therefore the data used to evaluate the different types of investments are actual data collected through a survey from 30 producers, cultivating in the area of Crocus, Kozani, Greece.

II. Calculating ROI

This section analyzes the most common methods used in financial studies to calculate the return of an investment. In our case, the investment concerns the transition from an existing traditional crop to a precision farming crop. We assumed that the area of cultivation is privately owned and that the investment will be made with own funds. Cost elements are the costs of land, labor, the purchase of necessary equipment, as well as any other costs that may incur during the production process [3].

A. Capital Expenditures

The term capital expenditure refers to the value or cost of using the various forms of agricultural capital. These funds and expenses are divided into fixed and variable. The costs of both categories are analyzed below [4].

The term ***fixed capital*** [5] includes all forms of capital whose productive efficiency is not limited to a single use, therefore represent costs that incur during the production period more than once. This means that after each use the properties and their original form, acquire partial wear.

978-1-6654-3929-9/21/$31.00 ©2021 IEEE
DOI 10.1109/DCOSS52077.2021.00051

For example, fixed costs are land rent, interest related to the acquisition of agricultural land, various mortgages and insurance premiums. However, certain types of depreciation in agricultural production (material equipment, machinery) are also defined in fixed costs.

The ***variable cost*** [6] depends on the volume of production. This group of expenditures represents a wide range of different agricultural inputs and expenditures related to the use of pesticides, fertilizers, staff salaries, equipment maintenance and repair.

The total cost (TC) of "installation and use" of precision agriculture consists of the set of variable and fixed costs and can be calculated as following:

$$TC=FC+VC \qquad (1)$$

Where:

FC=Fixed Cost

VC=Variable Cost

The investment cost therefore, shows the amount of each investment.

B. Cost – Benefit analysis

Cost-benefit analysis [7] is the main methodological tool in the process of evaluating specific agricultural projects or investments made in the agricultural industry. The comparative analysis of total revenue and total cost provides an answer to the question of selecting certain investment projects in agriculture. All possible costs and revenues must be determined, as a decision must be made as to which investment projects will be selected and which will be rejected. The most important elements of this analysis are the *Benefit / Cost ratio* (BCR), the *Net Present Value* (NPV), and the *Internal Rate of Return* (IRR). All three types are noteworthy because they are used in all studies in which economic and technical analysis is performed.

Benefit/Cost Ratio Method (BCR). The Benefit / Cost ratio determines the relationship between the total revenue and expenses of the project. The investment is considered profitable if the ratio is greater than the unit and is not acceptable otherwise. It is defined by the formula [8]:

$$BCR=\frac{\sum_{t=1}^{n}\frac{R_t}{(1+i)^t}}{inv} \qquad (2)$$

Where:

Rt=net cash inflows during a single period t

inv=amount of initial investment

i=discount rate or return that could be earned in alternative investments

t=current time period

n=number of total time periods

Net Present Value (NPV) Method [9]. In economic terms, NPV is defined as the sum of Present Values (PV), incoming and outgoing cash flows over a period of time. Incoming and outgoing cash flows can also be described as profit and cost cash flows, respectively. Calculating this method is a basic rule for making financial decisions. The Net Present Value Method includes the concept of time value of money taking into account its present and future value, as in periods of inflation.

Net Present Value is determined by calculating the cost for each period of an investment and after calculating the cash flow, the present value (PV) of each period is achieved by discounting its future value at a periodic rate of return. The NPV is the sum of all discounted future cash flows. It is also a useful tool to determine if a project or investment will result in a net profit or loss. A positive sign of NPV results in a profit, while a negative sign, leads to a loss. In case of a zero value, the investment is considered marginal.

$$NPV=\sum_{t=1}^{n}\frac{R_t}{(1+i)^t}-inv \qquad (3)$$

Where:

Rt=net cash inflows during a single period t

inv=amount of initial investment

i=discount rate or return that could be earned in alternative investments

t=current time period

n=number of total time periods

Internal Rate of Return (IRR) Method [6]. Internal Rate of Return is the third most important decision making tool. It is related to the concept of Net Present Value and it refers to the internal rate of return, which is not reflected in a nominal value but in a percentage (interest). IRR determines the financial success of the implementation of a particular investment in agriculture. Simply put, the Internal Performance Percentage is a percentage where the NPV of the project is zero. If the internal rate of return is greater than or equal to the required return, the investment is accepted. Otherwise, the proposal is rejected. IRR is calculated with the following formula:

$$IRR=\sum_{t=1}^{n}\frac{R_t}{(1+i)^t}-inv=0 \qquad (4)$$

These formulas where used initially in an excel file, where the user can input all the data of his business (inflows, outflows) and with the help of the built-in functions NPV and IRR, he can calculate the return on his investment for a number of time periods.

III. TOOL DEVELOPMENT

The tool comes in the form of a website and also as an excel file that the user can download and use from a link in the site. The primary goal in building a website is to create an easy-to-use and generally user-friendly environment. This means that the page will not be complicated or difficult to use for an average user.

The ultimate goal and purpose of this tool is the application of financial formulas (in terms of an investment) such as NPV, IRR and Cost-benefit ratio, to calculate the efficiency of the investment in the precision agriculture technologies after a number of time periods. More specifically, by using the page the user will be able to adapt the above formulas to his business data, like Investment Expenses, Annual Business Expenses and the Annual Business Income. The Investment Expenses include the following amounts: purchase cost of necessary equipment (Hardware) and purchase cost of necessary software. The Annual Business Expenses are the following:

- annual staff salaries (farmers and/or precision agriculture specialists)
- fertilizer costs
- packaging costs

- operating costs (equipment maintenance, electricity, petrol)
- other expenses (1% risk of unexpected weather damage)

The Annual Business Income is the farm's revenue of one year's production.

In the home page of the website the user is required to insert the investment and annual expenses and the tool prints the total amounts.

Figure 1. Investment Expenses Calculation

Figure 2. Production Cost Calculation

There is a static menu on the top with links for the calculation of the three formulas, return to home page and about page.

Figure 3. Menu

For the Cost-benefit ratio, the user must give the interest rate and the annual income of a number of years. These data will be used also in the NPV calculation.

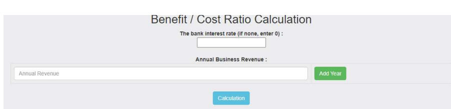

Figure 4. BCR Calculation

He will then be able to calculate the Net Present Value (NPV) filling in the number of years he wishes the NPV type to be applied (e.g. 10). Net Present Value is the sum of the present values of incoming and outgoing cash flows over a period of time. That is, it calculates the surplus or lack of cash flows, in terms of present value always in relation to the cost of capital used for an investment.

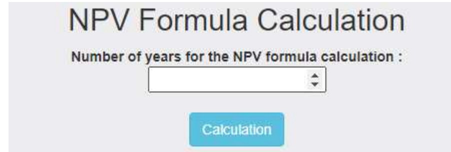

Figure 5. NPV Calculaion

Finally, the user can see the Internal Rate of Return (IRR), i.e. the index that measures the return on a long-term investment, thus equating the present value of future cash flows plus the final market value with the current market value of the investment. In simpler terms, it is the price at which the carrying amount of a bond is equal to the present value of future cash flows.

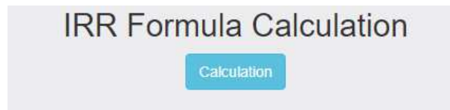

Figure 6. IRR Calculation

In conclusion, by using the page "Calculation of Economic Profitability of Precision Agricultural Investment" the candidate producer-investor will be able to know the efficiency and economic return that the investment will bring in a desired number of years.

IV. CASE STUDIES

The tool was implemented under the DIAS project which goal is to improve the production process of the saffron cultivation by applying precision agriculture technologies, so we will use data acquired from saffron farmers in kozani region. There are about 1000 farmers in the area and we asked randomly 20 of them about their crop area, their yearly expenses and revenues.

The necessary PA equipment for a saffron cultivation includes remote ground sensors, unmanned aerial vehicles and the corresponding software.

We will test our tool using three different case studies:

- *Low* scale investment- A saffron cultivation of 5 stremmas.
- *Medium* scale investment- A saffron cultivation of 20 stremmas.
- *Large* scale investment- A saffron cultivation of 50 stremmas.

For each of them we will calculate the formulas for three time depths, 3, 5 and 7 years. For the sake of the case studies, we will make the assumption that one sensor covers an area of about 0,5 stremma and for every sensor we need one microprocessor, one communication unit and one transceiver unit. Table 1 shows the lowest prices for every type of the equipment we used for the case studies [10].

TABLE 1. EQUIPMENT LOWEST COST

	Lowest Price
Humidity sensor	5 €
Temperature sensor	50 €
PH Measuring sensor	190 €

Electrical Conductivity Sensor	54 €
luminosity sensor	5 €
Carbon Dioxide (CO_2) Sensor	117 €
Microprocessor	9 €
Wireless Communication Unit	2 €
Transceiver Unit	4 €
Drone	1.092 €
Software	0 € - 2.400/ year
Total	12.286 €

According to [11] PA application saves the producer up to 18 €/ acre (4 stremmas), so we will take that data also in to account.

A. Low scale investment

A saffron farmer with 5 stremma cultivation area has about 3.138€ yearly expenses and 6.500€ revenues. Taking in to account the savings from the PA technology adoption, the yearly costs are reduced to 3.116€. So yearly benefits are about 3.385€. For this field size, we will need 10 of every sensor and we choose open source software, so the total initial investment cost is 5.457€ and 0€ extra yearly cost.

We begin with the 3 year time frame by inserting the buying cost of the hardware (5.457€) and 0€ for the next fields. So the "Total expenses" button will give as the 5.457€ amount.

Figure 7. Investment Expenses Input

Next we enter the farmer's yearly expenses and pressing the "Total production expenses button" will give as 3.116€ amount:

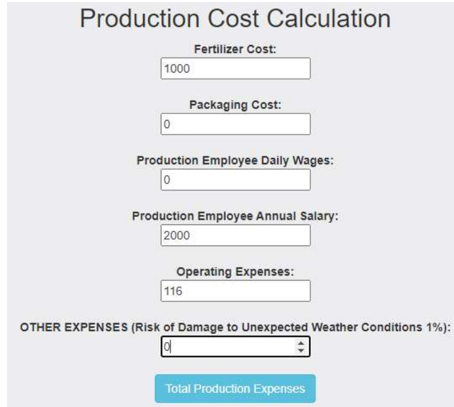

Figure 8. Production Cost Input

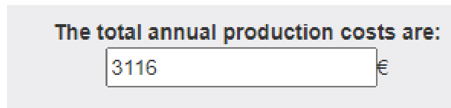

Figure 9. Total Production Cost

The next step is to calculate the three formulas with a usual 5% discount rate. We repeat the steps for the 5 and 7 year time periods. The results are shown in Table 2.

A. Medium scale investment

For the medium scale investment we consider the case of a farmer with 20 stremma agriculture area, who has about 7.000€ yearly expenses and 17.875€ revenues. Taking in to account the savings from the PA techniques adoption, the yearly costs are reduced to 6.910€, so yearly benefits are about 10.965€.

For the 20 stremma area we need 40 of every kind of sensors and lets again choose to acquire the free software. So the investment expenses are about 18.551€ with no additional annual costs. The calculation results for the tree formulas are presented in Table 2.

B. Large scale investment

The last case study concerns a farmer with an area of 50 stremmas. His annual expenses are approximately 20.966€ with the PA adoption benefits included. His yearly revenues reaches the amount of 59.995€ and profits are 39.029€. Calculating the formulas for these data, we came with the results shown in Table 2.

TABLE 2. COST / BENEFIT ANALYSIS FOR THE THREE CASE STUDIES

		3 Years	5 Years	7 Years
Low	***BCR***	1,69	2,69	3,59
	NPV	3.760 €	9.197 €	14.127,4 €
	IRR	39%	55%	60%
Medium	***BCR***	1,61	2,56	3,42
	NPV	11.309,1 €	28.921,4 €	44.896,3 €
	IRR	35%	52%	57%
Large	***BCR***	2,19	3,48	4,65
	NPV	54.175 €	113.009,4 €	166.374,1 €
	IRR	61%	76%	79%

Table 2 shows that all values are in favor of the investment and as the time depth increases, so does the return for the farmer.

V. Conclusions

The aim of this study was to present and test a web tool which can be used by farmers or any stakeholder to assess the economic feasibility of the adoption of precision agriculture technologies and help in decision making about going on with the investment. It was developed under the DIAS project of the University of Western Macedonia which aims to help saffron farmers optimize their production process.

We examined three different case studies as examples for the tool's function. First we calculated the economic formulas for a 5 stremma field, then 20 and lastly 50 stremmas. We applied the three formulas for all cases in three different time depths, 3, 5 and 7 years.

The values of the three formulas are presented visually in figures 10, 11 and 12 below for every case study and time depth:

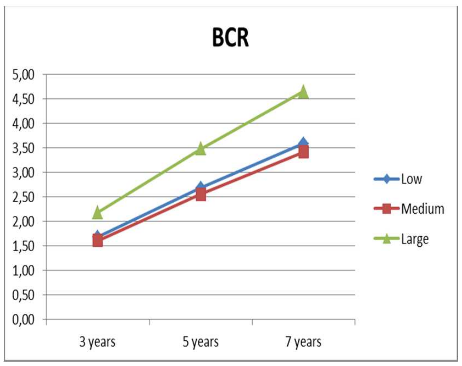

Figure 10. Benefit / Cost Ratio

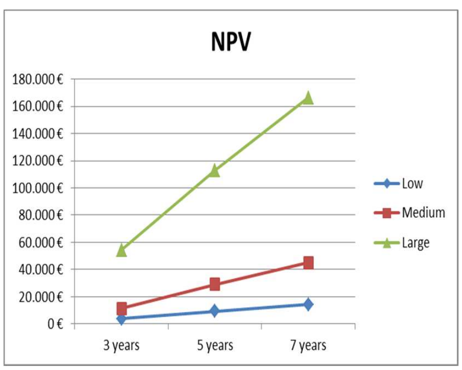

Figure 11. Net Present Value

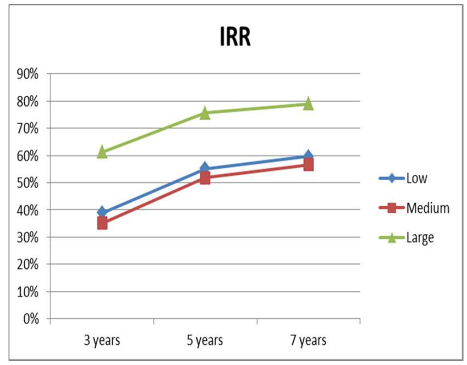

Figure 12. Internal Rate of Return

Results show that an investment in PA technologies is not prohibitive even for farmers with small fields, as long as they carefully choose the equipment that will optimize their production process at a tolerable cost. They can invest individually choosing less expensive equipment, or invest in groups through cooperatives such as the compulsory cooperative of Kozani saffron producers, in order to lower the otherwise unbearable cost of a large investment.

Acknowledgment

This research was co-funded by the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship, and Innovation, grant number T1EDK-04873, project "Drone innovation in Saffron Agriculture," DIAS.

References

[1] Fountas, S., Gemtos, Th., 2015. "Precision Agriculture". [e-book] Athens: Association of Greek Academic Libraries. Retrieved April 2021. http://hdl.handle.net/11419/2670.

[2] Fountas, Spyros, et al. "Farmer experience with precision agriculture in Denmark and the US Eastern Corn Belt." Precision Agriculture 6.2 (2005): 121-141.

[3] Shockley, Jordan M., Carl R. Dillon, and Scott A. Shearer. "An economic feasibility assessment of autonomous field machinery in grain crop production." Precision agriculture 20.5 (2019): 1068-1085.

[4] SZOT-GABRYŚ, Teresa. "Application of the feasibility study in project finance on the basis of a selected investment project." Hyperion International Journal of Econophysics & New Economy 6.1 (2013).

[5] Almas, Lal K., et al. Economic feasibility of precision irrigation in the Northern Texas High Plains. No. 1363-2016-107892. 2003.

[6] Pažek, Karmen, et al. "Financial Feasibility Analysis of Natura Rab Business: Case Study." Operations Research: the Art of Making Good Decisions (2016): 87.

[7] Shruthi, K., G. M. Hiremath, and Amrutha T. Joshi. "Financial Feasibility of Precision Farming in Paddy-A Case Study." Current Agriculture Research Journal 5.3 (2017): 318-324.

[8] Benefit-Cost Ratio Formula. EDUCBA, Retrieved 23 March 2021. https://www.educba.com/benefit-cost-ratio-formula.

[9] Fernando, Jason. "Net Present Value (NPV)." Investopedia, 13 Nov. 2020, Retrieved April 2021. https://www.investopedia.com/terms/n/npv.asp.

[10] Seitanidis, Ioannis. (2021). Feasibility study of investment of modern technologies for high precision agriculture in saffron crops (thesis).

[11] Crummett, Dan. (2017, February, 11). Ahead of the Curve: Economic Benefits of Using Precision Farming. Retrieved April 2021. https://www.farm-equipment.com/blogs/6-opinions-columns/post/13649-ahead-of-the-curve-economic-benefits-of-using-precision-farming