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PREFACE

Information technology is an everyday means that is found in all walks of life today. This is also true for almost all areas of agricultural management. The aim of this Journal is to improve scientific knowledge dissemination and innovation process in the agri-food sector. The Journal of Agricultural Informatics has been established in 2009 by the HAAI within a project of the Hungarian National Development Plan Framework. The peer-reviewed journal is operating with international editorial and advisory board supported by the EFITA (European Federation for Information Technology in Agriculture Food and the Environment).

Agricultural informatics serves not only the development of the management systems of the industry but also obtaining and publicising information on production, organisation and the market for the producer.

Technologies into network based business systems built on co-operation will ensure up-to-date production and supply in food-industry. The sector-level approach and the traceability of processed agricultural products both require the application of up-to-date information technology by actors of domestic and international markets alike.

This journal serves the publication as well as familiarization the results and findings of research, development and application in the field of agricultural informatics to a wide public. It also wishes to provide a forum to the results of the doctoral (Ph.D) theses prepared in the field of agricultural informatics. Opportunities for information technology are forever increasing, they are also becoming more and more complex and their up-to-date knowledge and utilisation mean a serious competitive advantage.

These are some of the most important reasons for bringing this journal to life. The journal "Agricultural Informatics" wishes to enhance knowledge in the field of informatics, to familiarise its readers with the advantages of using the Internet and also to set up a forum for the introduction of their application and improvement.

The editorial board of the journal consists of professionals engaged in dealing with informatics in higher education, economists and staff from agricultural research institutions, who can only hope that there will be a demand for submitting contributions to this journal and at the same time there will also be interest shown toward its publications.

Dr. Kálmán Rajkai

Chair of the Editorial Board

Content

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Investigating the long memory property of the Hungarian market pig prices by using detrended fluctuation analysis

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A B S T R A C T

Within the scope of this study we test the Long Memory property on monthly average pig market prices including piglet, young pig, sow and slaughter pig. We also calculate the Hurst exponent using Detrended Fluctuation Analysis (DFA) method. DFA is a method for determining the statistical self-affinity of a time serie. It is a useful technique for investigating time series with long memory (diverging correlation time and power-low decaying autocorrelation function. The obtained exponent by DFA is similar to those Hurst exponents estimated by other methods such as Rescaled Range (R/S) and AutoRegressive Fractionally Integrated Moving Average (ARFIMA), except the fact that DFA may also be applied to non-stacionary time series (mean and variance is changing with time) as in our case. We study the long memory property of the market pig prices. Data consist of four time series (piglet, young pig, sow, slaughter pig) between 1991 and 2013. Before the econometric analysis all the series were seasonally adjusted by using TRAMO/SEATS method. Data preparation was followed by differencing the time series and testing the normality and stationarity of them. In the next step we divided the analysed period to four parts and determined the Hurst exponent for each sub-period with the DFA method. So as to sum it up, slaughter pig prices are random, young pig and piglet prices developed similarly and have long memory, while sow price changes have definitely short memory.

1. Introduction

The literature studies analysing the pig sector mentions that the emission of the sector and the prices are described by cyclical movements. Nyárs (2005) analysed the significant pig-keeping member states of the EU and the characteristic processes of the Hungarian and Polish pig sector thoroughly and stated that in the examined states the pig cycle could be revealed in different length in the tendency of buying up prices. The experts on the regulation of market processes have been examining for decades the formation price oscillations and pig cycle. The theory of the cobweb model can be found in classical economic literature. The sense of it is that the loss of market information has an effect on the behaviour of the cycle. The price of slaughter pig, crop prices and portion compared to each other have a significant effect on the decisions of pig-keepers, mainly in the case of the activity of small-scale producers. The formations of home buying-up prices are described by shorter cycles than the member states of EU having advanced pig-keeping. In the EU there are 9 year periods, while in Hungary 3 or 4-year-periods are repeated. The reason of long cycles is on the one hand the predictable market regulation and the other hand the concentrated production structure. Therefore we chose the monthly average Hungarian market prices of the period after the change of the system as a basis of our examinations.

Simply knowing that a time series has the so called long term dependence or long memory could have a strong significance when the main goal is to forecast the prices. Beside the presence of the long

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memory is crucial information in making business decisions and creating portfolios as well. Long memory could be measured by calculating the so called Hurst exponent. In our article we studied the Detrended Fluctuation Analysis (DFA) and calculate the Hurst exponent (Hurst, 1952) by using this method. In order to detect long-range correlations properly, it is inevitable to separate trends from the long-range fluctuations in the data. Trends are caused by external effects – e. g. the greenhouse warming and seasonal variations for temperature records – and they are usually supposed to have a smooth and monotonous or slowly oscillating behaviour (Kantelhardt et al., 2001). It is the advantage of the DFA that it can systematically eliminate trends of different order and we can gain insight into the scaling behaviour of the natural variability in the considered time series (Kantelhardt et al., 2001). In this paper, we study systematically different orders of the DFA technique, that allow eliminating different orders of trends.

1.1. The long memory property

A stationary time series has the Long Memory property if the autocorrelation function decays to zero very slowly for a very long time period. The rate of decay is determined by the so called Hurst exponent (H) according to the following expression (Beran, 1994):

$$(1) \quad \rho(k) = Ck^{-\alpha} \text{ , where } H = 1-\alpha/2 ,$$

while C is a finite constant and $\rho(k)$ is the autocorrelation function of the time series with lag k. According to Hurst's conclusions, if H=0.5 than data points of the time series are independent and the series is a random walk.

If 0.5<H<1, the series indicates persistent behaviour or long memory. If there is an increase from time step t_{i-1} to t_i there will be probably be an increase from t_i to t_{i+1} (Alptekin, 2006). The same is true for decreases. A decrease will tend to follow a decrease, while an increase will tend to follow an increase.

When the Hurst exponent is positive and below 0.5 then the series is called anti-persistent. In this case, an increase will tend to be followed by a decrease or a decrease will be followed by an increase (Alptekin, 2006). This behaviour is sometimes called mean or trend reversion as a low H value indicates that the process could not go far from the seasonal trends and the effect of the reversions is strong.

The Hurst exponent has already been employed in many fields in Mathematics such as chaos theory and fractal analysis (Mandelbrot, 1969). As the theory of fractals has been developed, the methods for calculating the Hurst exponent have spread away widely.

2. Data and methodology

The agricultural prices often show irregular behaviour which refers to the nonlinear interdependency of the markets. The nonlinear interdependency in economics is not a specified concept the literature gives only some hints referring to it: the distribution of prices is in a usual way non-normal, the autocorrelations of time series even in case of long time periods are long term dependence, the time series includes non-periodical cycles and is not stationary. The long term time series involve the above mentioned characteristics so the examination of long term memory is capable of characterising the above phenomena.

Our main goal was to study the pig market prices regarding data from the past. We have already known the major deterministic factors influencing the prices but in our analysis we suppose that information on these factors is unavailable or unreliable. By this supposition we intended to give acceptable estimation on the development of the prices regarding long-memory property. The causes of trends can also be modelled by other methods (Lampe, 1998). Within the scope of our study DFA have been employed as a simple stochastic method.

2.1 Data

Table 1 includes the descriptive statistical indexes of four differentiated time series (piglet, young pig, sow, slaughter pig). On the basis of this it can be stated that at the whole time period the average of

the change of pig price was the highest 2.61 (HUF/kg), which can be in connection with the fact that also the unit price was here the highest. The value of the median was on the contrary since at the young pigs 50% of the monthly changes were lower than 2.26 HUF/kg. The standard deviation was the most significant in case of sow price changes. The minimum and maximum of changes could also be observed here (-244.99 and 201.39HUF/kg price change).

In Table 1 we included not only the characteristics of the whole time period but also the characteristics of each period. Similar to the fact observed in the whole time period the average of piglet price change was the highest except for the 3rd period. The value of the median fluctuated between 0 and 1 in the second period while the other periods were described by higher fluctuation. It is interesting to observe that the value of standard deviations is becoming higher and similar to the whole period while the average deviation was the highest in case of the sows in every time period. The formation of minimum values is in connection with this since in the 3rd period the smallest price difference between the two time points -244.99 HUF/kg was in case of the sows. This value shows how large loss the producers suffered month after month if they were forced to sell their animals in the given period. In the case of maximum values it can be stated that except for the 4th period the highest price movement between the two months appeared at the piglet. That is the producers could reach the highest income by selling their piglets if they exploited the advantages coming from the price change. So on the basis of the Table 1 it can be stated that the differentiated price data in the various periods showed a big difference in case of the certain products.

Table 1. Descriptive statistical values of the differentiated price data.

Unit.: HUF/kg

Denomination	Piglet	Young pig	Sow	Slaughter pig
Whole period				
Mean	***2.61***	1.76	1.40	1.36
Median	0.82	***2.26***	0.54	1.29
Standard Deviation	35.32	23.16	***49.94***	24.02
Minimum	-156.76	-86.07	***-244.99***	-86.51
Maximum	144.37	149.74	***201.39***	84.08
First period				
Mean	***4.97***	2.68	1.78	2.08
Median	3.09	2.91	1.25	1.19
Standard Deviation	10.23	5.93	8.03	6.66
Minimum	-10.34	-14.29	-16.08	-8.61
Maximum	***32.33***	19.35	19.99	20.96
Second period				
Mean	***2.68***	2.18	1.21	1.49
Median	***0.15***	***0.76***	***0.15***	***0.69***
Standard Deviation	30.86	21.08	42.57	25.30
Minimum	-58.76	-51.48	-128.23	-86.51

Maximum	***123.02***	65.00	103.62	77.96
Third period				
Mean	-1.38	-0.23	0.44	0.06
Median	-1.42	2.01	-3.18	0.44
Standard Deviation	50.22	24.31	66.01	25.82
Minimum	-156.76	-61.72	***-244.99***	-75.65
Maximum	***130.68***	39.08	128.75	55.67
Fourth period				
Mean	***4.20***	1.42	2.90	1.52
Median	-6.05	1.84	7.09	5.56
Standard Deviation	***50.65***	***40.95***	***82.24***	***33.04***
Minimum	-78.86	-86.07	-165.30	-71.07
Maximum	144.37	149.74	201.39	84.08

Source: Own calculation

Before examining economically the time series we must filter the season effects out. During this process we simplify time series in a way not losing important information in order to show the main processes. The time series used by us involves 21.5 whole years and it did not contained missing observations. Before the econometric analysis we adjusted the series seasonally by using TRAMO/SEATS (Golinelli–Parigi, 2008). We applied a trading day adjustment (5 day and length of month effect) and an Easter adjustment only if significant. We also detected the additive outliers, the temporary changes and the level shifts automatically. For the further investigations we used the adjusted series and Figure 1 also presents the seasonally adjusted series.

2.2. Detrended Fluctuation Analysis (DFA)

The basis of DFA was established by Peng et al. (1992) and was called fluctuation analysis. It was first developed for studying DNA-sequences and nucleotides (Peng et al., 1993; Peng et al., 1994). DFA is a bit different to the fluctuation analysis in such way that it removes the local trends in the series. The first application was also presented by Peng et al. (1994) and Peng et al. (1995).

The DFA procedure consists of four step. Let us suppose that we have a time series (xi) of N elements measured at regular intervals. In the first step we determine the cumulative sum (which is called the profile) of the time series:

$$(2)\quad y_j = \sum_{i=1}^{j} x_i \qquad (j=1,...,N)$$

In the second step we split the profile into l-length parts (time windows), so the maximum number of the segments is $s = \left[\frac{N}{l}\right]$, where f(x) = [x] means the floor function (it gives the largest integer not greater than x. Since N need not be multiple of the time scale l , in most cases a short part will remain at the end of the profile. In order to solve this problem, the same procedure is repeated starting from the other end of the profile (altogether 2s segments are applied).

In the third step we calculate the local trends denoted by $f_{k,j}^{p}$ for each segment, where j is the actual time point (j=1,..l) in k segment (k = 1,..,2s), p is the degree of the polynomial. Then we define the detrended time series for segment duration l as follows:

$$(3)\quad y_{l,j} = y_j - f_{k,j}^{p} \quad (j=1,\ldots,N)$$

Given the order of the fitted polynomial the method can be called DFA-1 (first order polynomials are used) or DFA-2 (second order polynomials are used).

In the fourth step, we calculate the fluctuation for each segment k as the variance of $y_l(j)$ (Peng et al., 1993; Peng et al., 1994; (J. W. Kantelhardt et al., 2001):

$$(4)\quad F_{l,k}^2 = \frac{1}{l}\sum_{j=1}^{l} y_{l,[(k-1)l+j]}^2$$

Finally, we average over all segments and take square root to obtain the DFA fluctuation (where p is the order of the fitted polynomials) as follows:

$$(5)\quad F_{p,l} = \sqrt{\frac{1}{2s}\sum_{k=1}^{2s} F_{l,k}^2}$$

We are interested in l-dependence of *Fp(l)*. In case of long range dependence we suppose that is the power of l with the DFA-p exponent δ $/F_p(l) \approx l^{\delta}/$. Short-range dependent time series have δ=0.5, long-range dependent series are characterized by a $\delta > 0.5$, while anti-persistent series have $\delta < 0.5$ (Koscielny-Bunde et al., 1998; Talkner-Weber, 2000; Király, 2005).

3. Results

The observed prices were as follows the average price of piglet, young pig, sow, slaughter pig in the animal markets and fairs. To the empirical analysis there were in all the four categories 270 observations that is monthly average market prices observed between January 1991. and June 2013. at our disposal.

3.1 The monthly formation of seasonally adjusted market pig price data between January 1991. and June 2013.

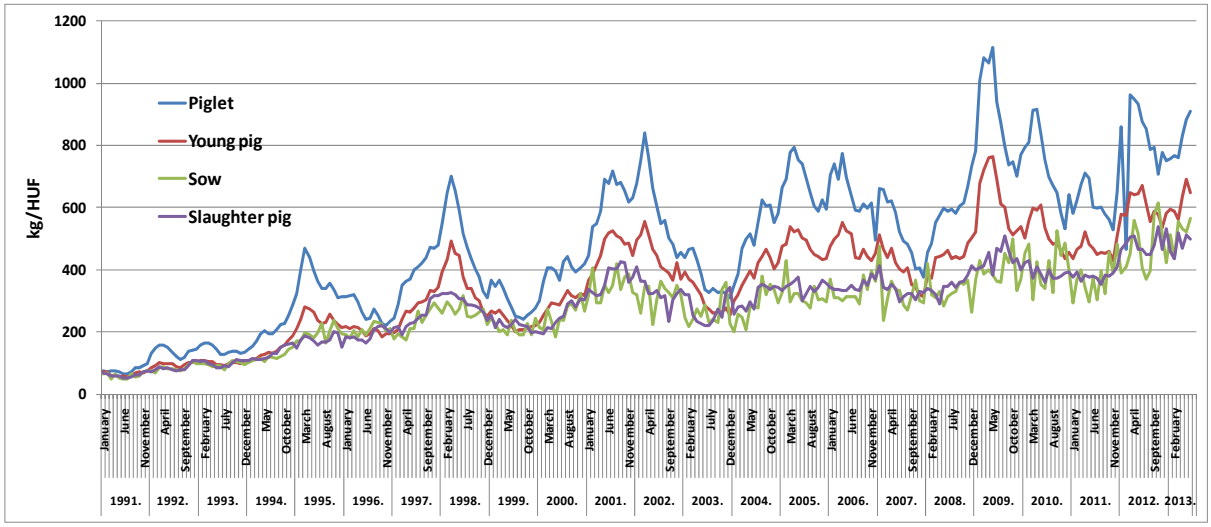
Figure 1 shows that during the period after the regime change the basic trend in pig market prices is slightly increasing. According to Bakucs – Fertő (2005) the market is still basically the buyer's market which affects the development of the prices apart from the seasonal and cyclical effects. In each case the average prices have changed according to a 3-years cycle which turned to a 4-years cycle after joining to the EU. Price developments show a large fluctuation over the 20 years so we had to divide the whole period to 4 sub periods from a professional standpoint and analyse the four series even in these sub periods. The first part contains data from 1991 to 1994 as prices were almost continuously increasing without any cyclical affect. The second part involves data from 1995 to 2004. In this period there had been a large cyclical effect which caused a 3-years movement in the prices. It is also observable that slaughter pig prices and sow prices developed the same way.

The third period covers the first stage after the EU joining in which the prices had been decreased or stagnated. There had been a dramatic decrease in case of the pig and piglet prices. The final sub-period as a second stage after the EU joining lasts from July in 2008 to June in 2013. In this stage we can observe a steady increase in pig and piglet market prices, while slaughter pig prices increased in a modest way (Figure 1) and sow prices follow a random movement.

3.2 Economical analysis of the data

Long memory is not a clearly specified concept in the financial theory authors only give hints to the signs which could indicate it. For example the prices are usually distributed normally, the autocorrelation

function decays zero very slowly even for a very large period, the series has non periodic cycles and not stationary (Taylor, 1986). According to these symptoms we would further test the seasonally adjusted time series in order to find more evidence of long memory.



Remark: The seasonal adjustment was used by the TRAMO/SEATS-program.
Source: Magyar Statisztikai Évkönyv [1991 - 2006] and KSH stAdat táblák (2013).

Figure 1. Seasonally adjusted monthly average pig prices /1991- 2013/ (in HUF/kg).

Table 2. Normality test results of the seasonal adjusted time series.

Tests	Piglet	Young pig	Sow	Slaughter pig
Doornik-Hansen*	7.985 (0.018)	12.155 (0.002)	9.168 (0.010)	15.227 (0.000)
Shapiro-Wilk	0.969 (0.000)	0.965 (0.000)	0.969 (0.000)	0.959 (0.000)
Lilliefors**	0.062 (0.030)	0.075 (0.000)	0.085 (0.000)	0.114 (0.000)
Jarque-Bera	8.26 (0.016)	8.799 (0.012)	6.296 (0.043)	9.229 (0.010)

*Remark: Econometric Software GRETL was used to test normality, significances are in parenthesis *Doornik and Hansen (2008); ** Lilliefors (1967)*

The normality and stationarity of the series were tested as well as the decay of their autocorrelation function. Long memory processes exhibit non-normality and non-stationarity, their autocorrelation function decays to zero very slowly. Normality test results can be seen in Table 2.

The null hypothesis of the normality tests is that data is normally distributed. All the tests proved significant at 5% significance level so we can reject the hypothesis of normality in each case.

Table 3. Stationarity test results of the seasonal adjusted time series by ADF-test.

Model	Piglet	Young pig	Sow	Slaughter pig
Constant	-2.39509	-2.134	-1.587	-1.547
	(0.1431)	(0.231)	(0.488)	(0.509)
Constant and trend	-4.57618	-4.446	-3.274	-2.962
	(0.001)	(0.001)	(0.071)	(0.143)
Differentiated series	-8.19323	-7.549	-10.917	-7.544
	(0.000)	(0.000)	(0.000)	(0.000)

Remark: Econometric Software GRETL was used to test normality, we employed the Augmented-Dickey-Fuller test, significances are in parenthesis

The null hypothesis of the ADF test is that the time series has a unit root as the time series is non-stationary. The test proves non-stationarity in all cases as the null hypothesis can not be rejected at 5% significance level (Table 3). Pig and piglet market prices are trend stationary, the other series are not. On the other hand, the differenced series are all stationary, so it was reasonable to difference the seasonally adjusted series and apply the Hurst exponent estimations to them.

Before we turn to the results of the estimations one thing must be strongly emphasized. In case H=0.5 the original data follows a random movement as it is non-stationary. The differenced series (price change) is stationary so can not follow a random movement.

Table 4. DFA-2* estimated Hurst exponents.

Sub period	Piglet	Young pig	Sow	Slaughter pig
1.	0.839	0.765	0.459	0.824
2.	0.852	0.785	0.223	0.477
3.	0.397	0.555	0.256	0.497
4.	0.588	0.686	0.274	0.525
Whole period	0.750	0.709	0.162	0.402

**Remarks: Estimations were made by the DFA Software with p=2, quadratic polynomials were used for detrending the series (PhysioNet [2010]).*

Average sow market price changes have short memory in all sub-periods and in the whole period (Table 4). Slaughter pig price changes did not have long memory except in the first sub-period. The Hurst exponents of the pig and piglet price changes are very similar to each other, except the third sub-period in all other sub-periods and in the whole period they had long memory. The slaughter pig price changes had short memory in the whole period, and the original prices show random movement in all sub-period except the first one. These statements are in a great balance with Figure 1.

4. Conclusions

In order to detect long-range correlations properly, it is inevitable to separate trends from the long-range fluctuations in the data. The major advantage of the DFA is to systematically eliminate trends of different order and to gain better insight into the scaling behavior of the variability in a given time series.

On the basis of our analysis it can be stated that the DFA method applied for the examination of long term memory exactly proved the characteristics described on the certain periods of seasonally adjusted time series. During the examination of the change of the sow prices the DFA-2 showed short-term memory in price changes. The explanation for this can be that the price of sows appearing on the market

is partly independent of the breeding animal prices of the earlier periods. Piglet and young pig price changes have long-memory across the whole time period except after the joining to the EU (the 3rd period). The changes of slaughter pig prices between 1991-1994 (first period) turned to be having a long term memory. The data of the original time series in the 2-4th periods are similar to random walking and the price changes in total have short term memory on the basis of the DFA-2 method.

So as to sum it up, slaughter pig prices are random, young pig and piglet prices developed similarly and have long memory, while sow price changes have definitely short memory, which means that a decrease will probably be followed by a decrease in the long run.

Information on the long-memory dynamics will support the decision making process of different economic operators as producers, traders, publicauthorities. Sales revenues of stock farms fluctuate due to the short memory of the prices but it is still calculable. On the other hand, the acquisition costs of slaughter-pig farms are much more stable because of the presence of the long-memory in the prices. As the slaughter pig prices are almost random, the sales revenues of slaughter-pig farms fluctuate randomly.

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Analysis of Economic Risks in Sow Production

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A B S T R A C T

We prepared a model farm based on the data of a young pig production farm which has 1300 breeding sows in order to examine the main risk factors affecting the profitability of young pig production. Farrowing and mortality rates, as well as cost and price data were recorded as the inputs for the model used. Revenue of the farm, total costs, total income and the prime cost of young pig production were used as outputs. Monte-Carlo simulation was used in the model for risk assessment. Based on the results of the analysis, we concluded that the total income was most affected by the number of piglets per litter (ß=0.691), the total farm costs were most influenced by the indexes related to piglet output (number of piglets per litter: ß=0.455, price of piglet feed: ß=0.443, and feed consumption of piglet: ß=0.364) while the change of the total income of the farm was most determined by young pig price (ß=0.578).

1. Introduction

Agricultural production is one of the riskiest production activities, since producers have to face numerous risks both in crop production and animal husbandry sectors.

In Hungary, there were significant changes in terms of the distribution of agricultural production between different sectors during the past decade. The role of animal husbandry has been decreasing constantly. Before 2004, its share in the gross output of agricultural production exceeded 40% and it has been fluctuating between only 33-37% since 2004 (KSH, 2013a). However, this decline is mainly the result of the continuous decrease which can be observed in the amount of livestock (in 2012, only the amount of cattle livestock was higher than its 2004 level (KSH, 2013b)). This change has struck the swine livestock the most: the amount of swine livestock was more than 5 million in 2002, while it did not even reach 3 million by the end of 2012 (KSH, 2013c). Further problems of the sector include inefficient production, improper swine keeping technology and foraging technology, while the problems with the economies of scale are also significant problems of the sector. In general, it can be stated that swine progeny is low in Hungary while the increase in body weight is slow, swine reach slaughter age later and the feed conversion efficiency is also weak in Hungary. All these factors create uncertainty for producers, forcing them to end their activity.

It is a well-known fact that the basis of economical swine breeding and pork production is the proper quantity and quality of swine progeny. Consequently, the Hungarian government prepared the so-called “National Swine Strategy” in 2012, with the aim to double the amount of the Hungarian swine livestock. Furthermore, the strategy contains strategic improvement measures in order to work out a breeding, production integration and research and development program (Magyar Közlöny, 2012).

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In this study, we aim to examine the conditions of profitable piglet production; i.e., the circumstances under which breeding sows are able to achieve the best production results. Based on the production data of a real breeding farm and the unit prices related to production, we prepared a swine farm simulation model which helps in preparing predictions of profitability indexes while taking various risk factors into consideration.

2. Risk modelling

The main task of mathematical modelling is to set up the most accurate models of the processes and phenomena going on in the technical system, as well as to evaluate their results. However, when establishing this model, one always has to consider a certain type and amount of uncertainty.

There are several risk factors in animal husbandry mainly due to the uncertainty of yields and market factors. Producers can do little to nothing to prevent these risks. Especially for this reason, it is important to be knowledgeable about how the system works.

Modelling makes it possible to get to know and characterise reality more accurately; therefore, the extent of risk can be quantified, thereby providing information to decision-makers (Pocsai and Balogh, 2011).

Nowadays, due to the development of computers, it is possible to determine and handle risks more easily, faster and also more accurately (Beaver and Parker, 1995). Various complex risk assessment and risk management and simulation strategies are available to users, such as the Monte-Carlo simulation which is a rather widely used numerical procedure. The greatest advantage of the method is that there is no need to set up a model which often uses very complex analytical and numerical methods, but the posed questions can be answered by "only" generating random numbers quickly and efficiently (Kovács and Csipkés, 2010; Takács and Felkai, 2010; Takács-György and Takács, 2011; Vizvári et al., 2011; Huzsvai et al., 2012).

2.1. Monte-Carlo simulation

Simulation means that the examination of a process or a system is done by using a substitute model whose aim is to make it possible to study the behaviour of the original system. During simulated procedures, the model run and executed temporally (as opposed to the exact results provided by analytical models). The results are representative samples of the performance indexes describing the functioning of the system (Winston, 1997).

One of the alternative methods of risk assessment is the Monte-Carlo simulation, during which the modelling of the system is followed by computerized simulations which use random values in accordance with the system. The way the system works is that values are chosen randomly based on the probability distributions attributed to each uncertain factor. These values are then used in each experiment of the simulation analysis (Russel and Taylor, 1998; Vose, 2006).

As the first step of the simulation, the influential (input) variables, their possible range, probability distribution and the correlation between each variable are recorded in the model to be analyzed. The values of the variables in the given interval and distribution are generated by a random number generator (Szőke et al., 2010). Furthermore, result (output) variables are also recorded. Finally, the model is run several consecutive times on a computer, usually with experiment numbers of 1000-10000. As a result of simulation, an expected value and standard deviation range is obtained for each response variable. Furthermore, the distribution function will make it possible to determine the probability of whether the value of the given variable will fall within the given range (Winston, 2006).

By increasing the number of model runs, the distribution of the response variable can be set with optional accuracy in accordance with the following (Watson, 1981; Jorgensen, 2000):

$$\psi = E_{\pi}\{U(X)\} = \int U(x)\pi(x)dx \quad (1)$$

where X = {θ, ø} is a vector with θ decision parameters and ø condition parameters, π is the distribution of x and U(x) is a utility function which usually refers to income. Based on these, the Eπ () function provides the expected utility with given distribution.

The running and practical implementation of the simulation is done with a simulation software, several of which is based on the well known spreadsheet application Excel. An example is @Risk (Palisade Corporation). We used version 4.5 of this software to perform the simulation analysis of our swine farm model (Palisade, 2005).

2.2. Description of the farm which served as a basis of the model

Our model was set up based on the 2013 data of a breeding farm located in the Northeastern region of Hungary. The farm has 1300 sows and it produces more than 26 000 young pigs a year. The young pigs are sold at the age of 90 days when their body weight is 36 kg. The main production indexes of the farm are shown in Table 1. The intervals used in the simulation were determined by the aid of the experts.

Table 1. Values of the farm indicators and market factors and intervals used in the simulation

Indicators	Values in farm examined	Intervals used in the simulation
Farrowing/sow/year	2,3	2,1-2,4
Litter size (Number of piglets born alive/litter)	9,6	9-11
Piglet mortality %	6,5	4-8
Weaner mortality %	2,5	1,5-4
Sow culling rate %	40	35-50
Selling price of young pig (HUF/kg)	600	550-650
Selling price of culled sow (HUF/kg)	330	330
Selling price of culled boar (HUF/kg)	300	300
Selling price of culled young pig (HUF/kg)	350	350
Feed consumption of piglet (kg/day)	1,5	1,3-1,6
Feed consumption of sow (kg/day)	4	3,8-4,5
Piglet feed unit price (HUF/kg)	120	110-135
Sow feed unit price (HUF/kg)	81,5	70-90

2.3. Structure of the model

Using the indexes of the farm, we used Excel to prepare our model for production and profitability of the breeding farm. This was followed by providing the variables to be used in the simulations, as well as their potential ranges and probability distributions which were set using @Risk 4.5 running in the spreadsheet application. The following input parameters were involved in the model as influential factors:

- Farrowing/sow/year (FSY)
- Litter size (LS)
- Piglet mortality (PM)
- Weaner mortality (WM)
- Sow culling rate (SCR)
- Selling price of young pig (PYP)
- Feed consumption of piglet (FCP)
- Feed consumption of sow (FCS)
- Piglet feed unit price (PFP)

- Sow feed unit price (SFP)

The assumed distribution of the parameters can be chosen from several distribution types of which we decided to use the triangular distribution. This type of distribution is a continuous probability distribution with lower limit a, upper limit b and mode c, where $a < b$ and $a \leq c \leq b$. The probability density function is given by

$$f(x|a,b,c) = \begin{cases} 0 & for \quad x < a, \\ \dfrac{2(x-a)}{(b-a)(c-a)} & for \quad a \leq x \leq c, \\ \dfrac{2(b-x)}{(b-a)(b-c)} & for \quad c < x \leq b \\ 0 & for \quad b < x, \end{cases} \tag{2}$$

whose cases avoid division by zero if $c = a$ or $c = b$ (Evans et al., 2000). This distribution is generally used if both the minimum, maximum and most probable values are known. The ranges used by us are shown in Table 1 and the most probable values were considered to be the mean farm values.

Of the input data, we set a correlation value of 0.9 between the piglet and sow feed unit prices, thereby showing the strong positive correlation between feed prices.

Five farm indexes were provided as output variables of the simulation:
- Total farm revenue (HUF)
- Total farm costs (HUF)
- Total farm income (HUF)
- Prime cost (HUF/young pig)

After setting the above parameters, the simulation model (Figure 1) was run with 10 000 replications and sensitivity analyses were performed on the output variables.

The sensitivity analysis was carried out based on standardized coefficients of regression (ß) and Spearmann's rank correlation coefficients. The former is an index expressing the impact of the explanatory (input) variable which is obtained if both the dependent and the explanatory variables are used in a standardized form and not in their original measurement units (Moksony, 2006). The significance of this index is that it shows the rank of importance of the explanatory variables independently of their measurement units (Hajdú, 2003). Also, this index made it possible to rank the input variables from the aspect of risk. The sign of the coefficient also gives information about the direction of change (Szőke et al., 2010). If the sign is positive, an increase of the input results in an increase of the output variable. However, if the sign is negative, an increase of the input causes the decrease of the output.

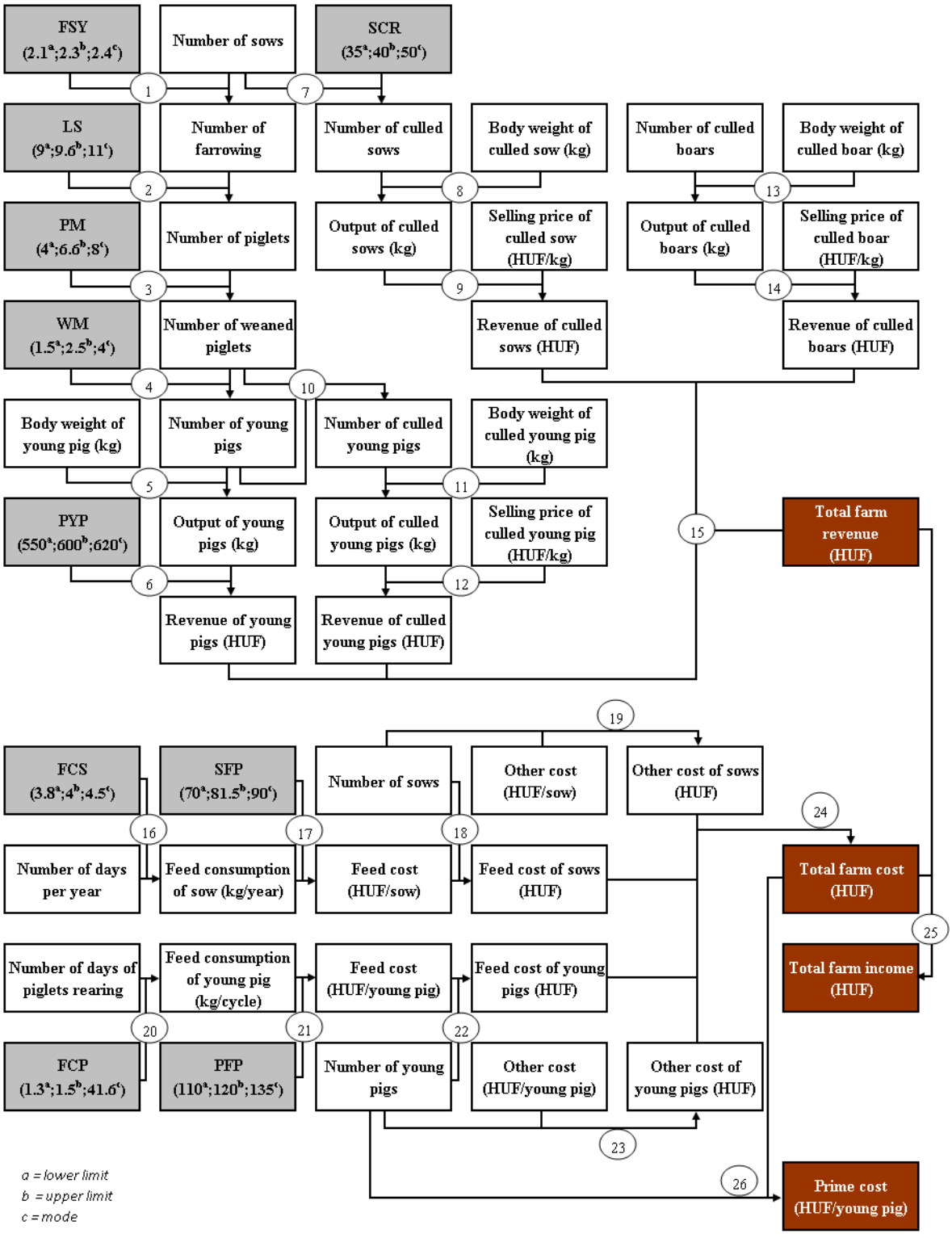

Figure 1. Description of the simulation model

Equations in the simulation model:

1: Number of sows x Farrowing/sow/year (FSY)
2: Number of farrowing x Litter size (LS)
3: Number of piglets x [1 - Piglet mortality % (PM)]
4: Number of weaned piglets x [1 - Weaner mortality % (WM)]
5: Number of young pigs x Body weight of young pig (kg)

6: Output of young pigs (kg) x Selling price of young pig (HUF/kg) (PYP)
7: Number of sows x [1- Sow culling rate % (SCR)]
8: Number of culled sows x Body weight of culled sow (kg)
9: Output of culled sows (kg) x Selling price of culled sow (HUF/kg)
10: Number of weaned piglets - Number of young pigs
11: Number of culled young pigs x Body weight of culled young pig (kg)
12: Output of culled young pigs (kg) x Selling price of culled young pig (HUF/kg)
13: Number of culled boars x Body weight of culled boar (kg)
14: Output of culled boars (kg) x Selling price of culled boar (HUF/kg)
15: Revenue of culled sows (HUF) + Revenue of culled boars (HUF) + Revenue of young pigs (HUF) + Revenue of culled young pigs (HUF)
16: Feed consumption of sow (kg/day) (FCS) x Number of days per year
17: Feed consumption of sow (kg/year) x Sow feed unit price (HUF/kg) (SFP)
18: Feed cost (HUF/sow) x Number of sows
19: Other cost (HUF/sow) x Number of sows
20: Feed consumption of piglet (kg/day) (FCP) x Number of days of piglets rearing
21: Feed consumption of pig (kg/cycle) x Piglet feed unit price (HUF/kg) (PFP)
22: Feed cost (HUF/young pig) x Number of young pigs
23: Other cost (HUF/young pig) x Number of young pigs
24: Feed cost of sows (HUF) + Other cost of sows (HUF) + Feed cost of young pigs (HUF) + Other cost of young pigs (HUF)
25: Total farm revenue (HUF) - Total farm cost (HUF)
26: Total farm cost (HUF) / Number of young pigs

3. Results

During the performed modelling, the first step was to examine the factors affecting the amount of total farm revenue. Based on the tornado diagram of the sensitivity analysis (Figure 2), it can be concluded that the average litter size affects the total revenue the most. The change of standard deviation of the number of piglets per litter by 1 results in a 0.691 (ß) change of the standard deviation of the total revenue. Furthermore, the change of piglet price (ß=0.539) and the number of farrowing per sow per year (ß=0.435) also has a significant impact on the total revenue. All three indexes are in a moderately close correlation with revenue, (Spearmann's rank correlation coefficient: 0.43 - 0.69), showing that the increase of these indexes will result in the increase of revenue.

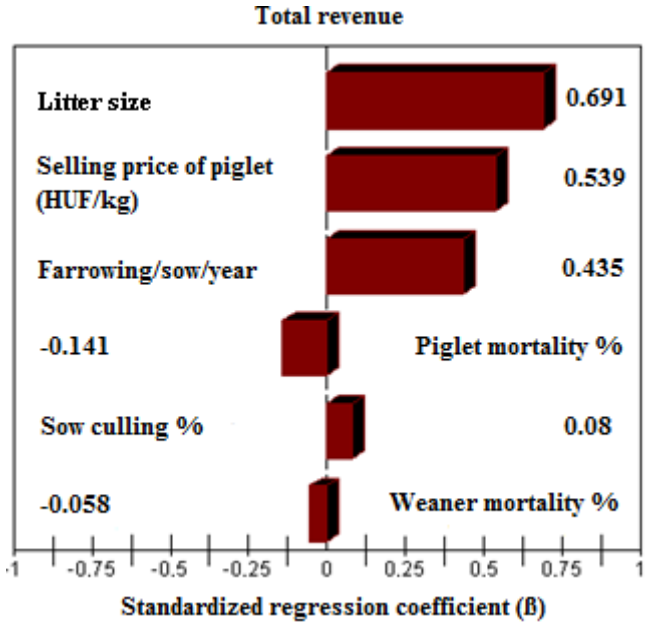

Figure 2. Tornado chart of the standardized regression coefficient pertaining to the total revenue

Mortality/culling rates also affect revenue. The ß coefficient with the highest absolute value was obtained in the case of piglet mortality, meaning that the change of the standard deviation of mortality by 1 results in a 0.141 change in the standard deviation of revenue in the opposite direction, since the negative sign refers to the fact that the decrease of the mortality rate results in the increase of revenue. As regards the other indexes, the value of the standardized coefficient of regression was nearly zero (|ß|<0.1).

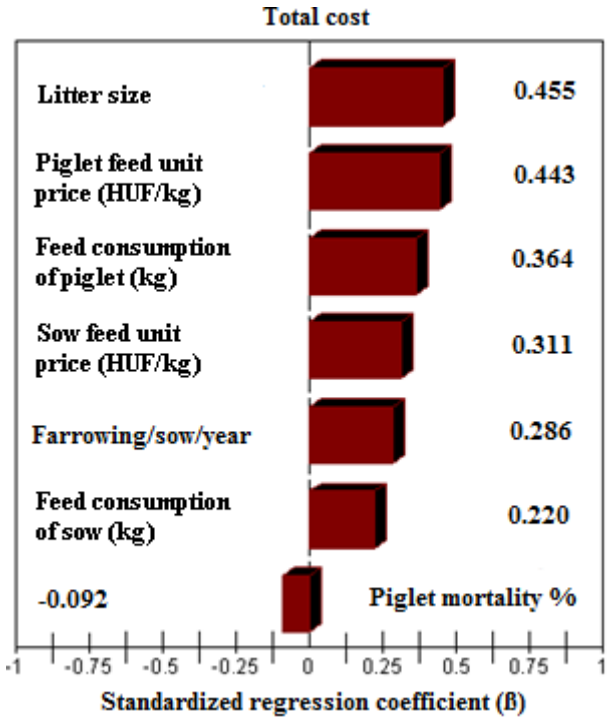

Figure 3. Tornado chart of the standardized regression coefficient pertaining to the total cost

The next examined output was the total farm costs (Figure 3), the value of which was affected by the number of piglets per litter (as farm index) and piglet feed price (as market index) the most. In both cases, it can be stated that the change of standard deviation by 1 results in a change of more than 0.4 in the standard deviation of the total farm costs.

The feed consumption of piglets, the sow feed price, the farrowing/sow/year ratio and the feed consumption of sows also play an important role (ß=0.22-0.44) in shaping farm costs; therefore, the increase of these values also result in the increase of total costs.

The result of the sensitivity analysis of the income calculated from the difference between the farm revenue and total costs is shown in Figure 4. Based on the obtained values, it can be established that income is most affected by the change of piglet price of the variables, greatly determining the amount of revenue (Spearmann's rank correlation: 0.57). The change of the standard deviation of piglet price by 1 results in a 0.578 change in the standard deviation of total income. The increase of the number of piglets also causes the income to increase (ß=0.395), but to a lower extent than in the case of revenue, since the higher amount of piglets also results in increasing expenses.

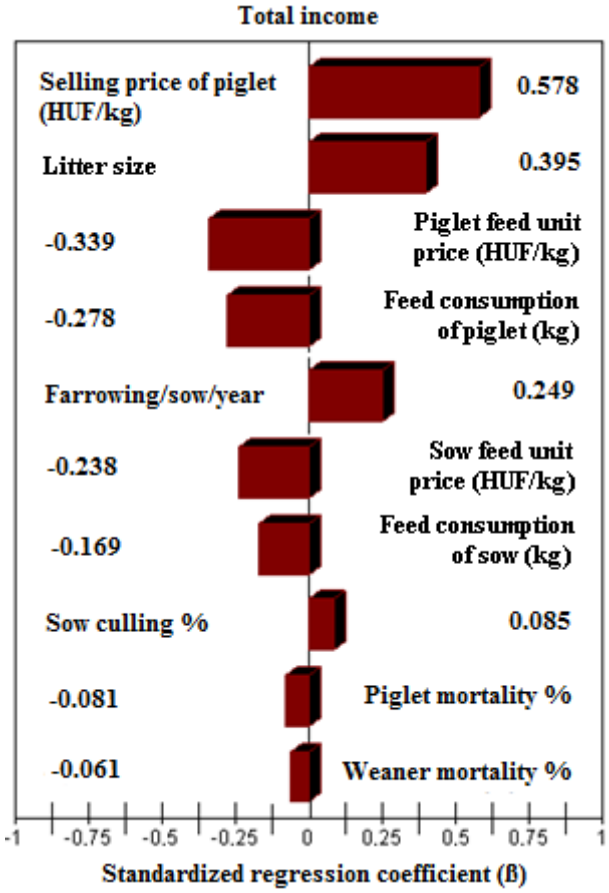

Figure 4. Tornado chart of the standardized regression coefficient pertaining to the total income

The input factors which positively affected the total costs are shown in the figure of income with the same rank, but with an opposite sign. The absolute value of the standardized coefficient of regression was around 0.3 in the case of the factors affecting the feeding of piglets. Factors affecting the feeding of sows caused a somewhat smaller change ($|ß|=0.2$).

The standardized coefficient of regression and the Spearmann's rank correlation coefficient were close to zero ($|ß|<0.1$) in the case of all other input variables.

Since the main profile of the farm is young pig production, we considered it to be important to examine also the factors affecting the prime cost of young pig. Figure 5 shows the tornado diagram of the sensitivity analysis of the specific prime cost of young pig production.

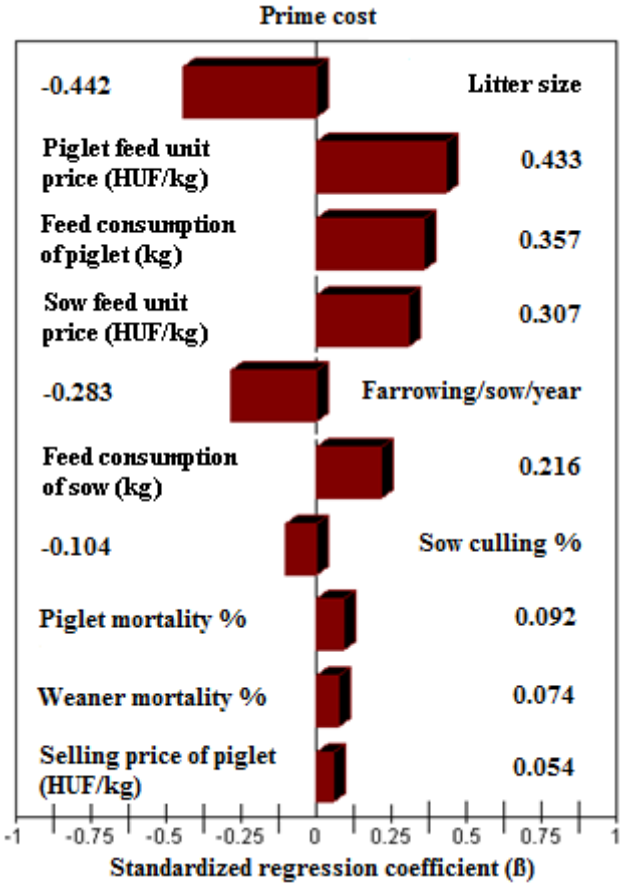

Figure 5. Tornado chart of the standardized regression coefficient pertaining to the piglet prime cost

It can be seen in the figure that the highest value of the standardised coefficient of regression was obtained in the case of the number of piglets per litter (|ß|=0.442), but it has a negative sign. This value can be interpreted in a way that the increase of the standard deviation of the litter size by 1 results in a 0.442 decrease in the standard deviation of the prime cost of young pig production. Changes in the unit price of feed and feed consumption also show significant influence (the rank of significance of each variable and the values of the standardised coefficient of regression are the same as in the case of total costs). As opposed to the negative value of the number of piglets, these indexes have positive ß values, i.e., the increase of the index results in increasing specific prime cost. Furthermore, the impact of the change in case of the number of litters per sow is also worth mentioning. The increase of the standard deviation of this index by 1 results in a 0.283 decrease in the standard deviation of the prime cost.

The main descriptive statistic of the response variables employed in the simulation analysis are summarized in Table 2.

Table 2. Descriptive statistic simulation outputs

Outputs	Min	Mean	Max	Std. Dev.	Skewness	Kurtosis
Total revenue (million HUF)	511,6	612,5	753,1	35,9	0,29	2,87
Total cost (million HUF)	498,6	575,5	687,5	25,6	0,19	2,84
Total income (million HUF)	-70,2	37,1	158,2	33,4	0,09	2,85
Prime cost (HUF/young pig)	17 519	20 361	23 438	921,7	0,06	2,78

The widest range can be observed in the case of the total income with a relative standard deviation value of 90%. This means that the value of the simulated mean does not properly characterize the expected income.

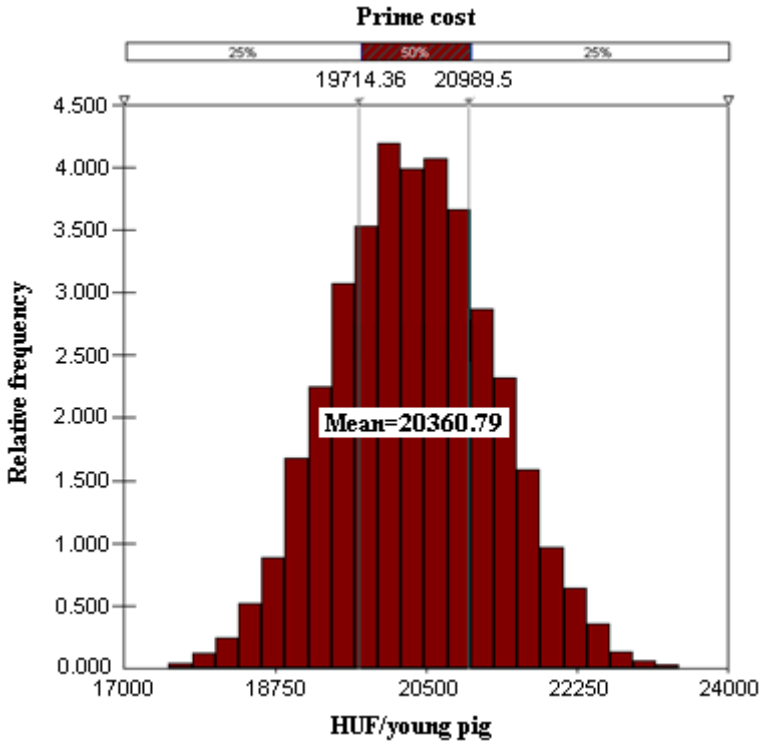

Figure 6. Relative frequencies of the prime cost (HUF/young pig) after 10.000 simulation runs

Figure 6 shows the prime cost histogram of one young pig after performing the 10 000-simulation experiment. The mean value was 20 361 HUF per young pig which equals 565.68 HUF per kg prime cost if it is related to 36 kg body weight. The interquartile range is between 19714 - 20989 HUF per piglet which equals 548-583 HUF per kg.

4. Conclusion

The consideration and measurement of risk elements help in making a more informed decision. In this study, we performed the analysis of the occurring risks of sow breeding using simulation modelling. The main production and economic parameters were incorporated into the model as stochastic variables. After the Monte-Carlo simulation was run, we examined how each risk factor affects the farm revenue, risk and income, as well as the specific prime cost of piglets.

Based on our results, it can be stated that the litter size was the most influential factor of the natural farm indexes. The number of piglets per litter had the following ß values, representing its influence on the following factors: the variability of total revenue: 0.691; variability of total costs: 0.455; variability of total income: 0.395; variability of the specific prime cost of young pig production: -0.442. Consequently, the management of the farm is recommended to pay more attention to satisfying the needs of the sows at the farm in order to reach the highest possible progeny in the case of each breeding sow.

Of the influential market factors, the selling price of young pig had the highest impact on the variability of total revenue (ß=0.539) and total income (ß=0.578). Furthermore, the impact of piglet feed price is worth mentioning, showing an influence of ß=0.443 on the standard deviation of total costs and ß=0.433 on the standard deviation of the prime cost of young pig production. The safety of production is necessary to be increased both from the aspect of acquisition and sales by means of minimizing the change of input and output prices. This could be facilitated by arranging collective acquisition and sales with other producers.

Of the data modelled by us, the mortality/culling rates had the lowest significance, as the coefficient of correlation of the tornado diagrams was nearly zero ($|r| \leq 0.1$).

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Internet functions in marketing: multicriteria ranking of agricultural SMEs websites in Greece

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A B S T R A C T

The invasion of new technologies combined with the high cost for running shop force enterprises to search for new sales methods. Network applications and ICT (Information and Communication Technology) can help achieve e-commerce goals. In Greece, many enterprises in the agro-food and drink sectors are already present on the internet. This paper studies the adoption of e-commerce on websites that support e-commerce activities within the agro-food and drink sectors. Therefore, the paper aims to identify and evaluate their qualitative and quantitative content characteristics, rank them according to 6 content characteristics/criteria using the multicriteria method of PROMETHEE II and classify them in groups of similar adoption. The findings of this study reveal the rate of adoption of e-commerce in the sectors and can serve as a valuable model for the designers of websites that promote e-commerce activities within the wider areas of food and drinks

1. Introduction

Nowadays, the internet has emerged as a key channel for enterprises (Soto-Acosta and Merono-Cerdan, 2006) as it has become a means of promotion and consequently, an effective business tool (Tsekouropoulos et al., 2012a; Tsekouropoulos et al., 2012b). Enterprises use the internet not only for retrieving information and marketing but also for the enhancement of their communication with business-partners and customers (Tsekouropoulos, Tzimitra-Kalogianni, and Manos, 2005).

The world of business is changing rapidly (Marri, Irani, and Gunasekaran, 2007). Traditional manufacturing and service environments have been transformed into more physically distributed enterprise environments, which include supply chains, electronic commerce (e-commerce), electronic marketing (e-marketing) and virtual enterprises (Gunasekaran and Ngai, 2007). These portals can extend their reach to potential customers worldwide (Chan and Chung, 2002) through the use of the internet as a marketing tool. As technology, market and regulation conditions change rapidly, e-business companies frequently have to reinvent their business models (Reuver, Bouwman, and

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Maclness, 2009). Thus, the internet has become a major resource in modern business and many businesses are creating a web presence (Calitz and Scheepers, 2002).

The enterprises aim at their participation in the internet society since the benefits are high and electronic systems are ready to serve customers all over the world 24 hours per day 7 days a week (Andreopoulou, 2012), when the cost keeps decreasing. Enterprises and individuals have lately become familiar to do business transactions the way and time they prefer, thus, long-established enterprises in all areas of interest are continually searching to enable the provision through internet for their products and services (Krueger and Swatman, 2004). Dialog between two parties, the company that offers a service or a product and the customers, represents a vitally important element of relationship marketing which helps to build customer loyalty. A great advantage of a webpage consists in the possibility to update it with current information whenever it is required.

For consumers, internet can reduce clutter, which could mean that content will more closely match their interests; while for sellers it facilitates a one-to-one marketing approach, allowing them to target each individual with a specific message (O'Connor, 2007). It plays an important role mediating between customers and enterprises as a place for information acquisition and business transactions (Liang and Law, 2003).

According to recent studies, the internet is most effective when used as an advertising and marketing tool (Cai, Card, and Cole, 2004; Garces et al., 2004; Law and Hsu, 2005; Lee, Cai, and O'Leary, 2006; Bui, Le, and Jones, 2006; Buhalis and Law, 2008).

1.1. E-marketing

E-marketing is a subset of e-Business that utilizes electronic medium to perform marketing activities and achieve desired marketing objectives for an organization (Petrovic, 2010). E-marketing can be defined as the use of internet and related digital technologies to achieve marketing objectives and support the modern marketing concept (Eszes, 2010). It includes both direct response marketing and indirect marketing elements, and uses a range of technologies to help connect businesses to their customers. By such a definition, e-marketing encompasses all the activities a business conducts via the worldwide web with the aim of attracting new business, retaining current business and developing its brand identity (Quirk eMarketing, 2006). E-commerce is also a part of e-business. It is the purchasing, selling, and exchanging of goods and services over computer networks, such as the internet, through which transactions or terms of sale are performed electronically (DigitSmith, 2006). The aim of e-business applications is to make businesses agile by supporting dynamic internal and external boundary-crossing business processes (Baghdadi, 2006).

The growth of e-business presents enterprises with both opportunities and challenges. In this environment enterprises need timely and sound e-business strategies (Ha and Forgionne, 2008). E-marketing gives business of any size access to the mass market at an affordable price and allows truly personalized marketing. Specific benefits of e-marketing include (Department of Trade and Industry of United Kingdom, 2004; The National B2B Centre, 2011):

a. *Global reach*. A website allows finding new markets and trading globally.
b. *Lower cost*. A properly planned and effectively targeted e-marketing campaign can reach the right customers at a much lower cost than traditional marketing methods.
c. *Trackable, measurable results*. Web-analytics and other online metric tools make it easier to establish how effective the campaign has been.
d. *24-Hour marketing*. With a website the customers can find out about the products even if the office is closed.
e. *Shorter lead times*. If there is a website or an e-mail template, the reaction to events will be more quickly, giving a much more contemporary feel.
f. *A level playing field*. With a well-designed website, the enterprise could look like professional and credible as the larger competitors.

g. *Personalization*. If the customer database is linked to the website, then whenever someone visits the site, can be greeted with targeted offers. DataBase Management System (DBMS) is a software package that allows data to be effectively stored, retrieved and manipulated (Andreopoulou, Koliouska and Tsekouropoulos, 2012).

h. *Openness*. By having a social media presence and managing it carefully, the entrepreneur can built customer loyalty and create a reputation for being easy to engage with.

i. *Social currency*. E-marketing lets the entrepreneur create engaging campaigns which can gain social currency-being passed from user to user and becoming viral.

j. *Improved conversion rates*. If the enterprise has a website, then the customers are only ever a few clicks away from completing a purchase.

Together, all of these aspects of e-marketing have the potential to add up to more sales.

However, e-marketing does have few disadvantages such as (Eszes, 2010): lack of personal approach, dependability on technology, security-privacy issues, maintenance costs due to a constantly evolving environment, higher transparency of pricing, increased price competition and worldwide competition through globalization.

Small and Medium-sized Enterprises (SMEs) are critical to the economies of all countries (Akhavan and Jafari, 2008), and especially the developing ones (Fathian, Akhavan and Hoorali, 2008; Gadenne and Sharma, 2009; Andreopoulou, Koliouska and Tsekouropoulos, 2012). SMEs in Greece are using e-business not only to enable growth through extended and refined offerings but also to expand their markets (Kindstrom and Brege, 2008). SMEs that have already adopted e-marketing applications may vary significantly in terms of the scope and extent of incorporating e-business applications into their business processes and benefiting from them (Wand and Shi, 2009).

In Greece, specifically in the sector of food and drink several enterprises have already a presence in the internet. That facilitates the increase of their total sales as they attract costumers not only locally at shops but also on the e-shops in the internet. There are also enterprises without physical shop for holding transactions with the public thus they exist only in the internet (Seretakis, Tsekouropoulos, and Andreopoulou, 2010).

A literature review on internet adoption in Greek agri-food enterprises is also described by Manthou, Matopoulos and Vlachopoulou (2005), while a literature review on e-business adoption is described by Fritz and Canavari (2008), by Matopoulos, Vlachopoulou and Manthou (2009). An extensive literature review that concerned the Business-To Business relationships journal articles that were published between 2009 and 2012 was presented by Meixner et al. (2009), Canavari et al. (2010) and by Saprikis and Vlachopoulou (2012). However, a multicriteria analysis on evaluating the performance of Greek agricultural enterprises has been applied by Baourakis et al. (2002) and by Kalogeras et al. (2005).

This paper provides the case study of e-marketing and internet adoption by the agro-food and drink SME sector in Greece. Therefore, the paper aims to optimize and evaluate the Greek SMEs in agro-food and drink sector, qualitatively and quantitatively according to e-marketing features and internet functions used as criteria, based on the multicriteria method of PROMETHEE II and further to classify them in groups. Finally we identify and describe the optimum group of SMEs to be used as a model with enhanced customer communication policies.

2. Methodology

The SME websites of the Greek agro-food and drink sector were retrieved using the large-scale hypertextual search engine “Google” which provides much more satisfying results than other existing search engines (Berry and Browne (2005), Langville and Meyer (2006)). Some of the keywords that were used are: e-marketing, agro-food and drink, website activities, e-shop, e.t.c.. The study was conducted in 2011.

Initially, qualitative analysis was performed in order to examine the type of common characteristics that is found in these corporate websites. There are various material website characteristics introduced in the retrieved websites, aiming to promote the enterprise involved. These criteria/characteristics are further attributed to variables X1 to Xn that describe a group of common website characteristics. The typical qualitative analysis and evaluation of the content introduced in the Greek SME websites identified 6 different types of characteristics and they are presented in Table 1. Yet, the number of characteristics could possibly vary according to the special thematic and the relative penetration in the market.

Table 1. Variables attributed to e-marketing services to be achieved by each website

Variable	E-marketing services
X_1	Autonomous internet presence
X_2	Quality policy / Quality certificate
X_3	Provision of product information to consumers
X_4	Links to other companies etc
X_5	Online communication form / FAQ
X_6	E-shop

Then, a quantitative analysis was carried out, in order to examine the presence or absence of these criteria/characteristics. Additionally, a 2-dimentional table was developed and was used in order to examine the existence of criteria and evaluate the services of the websites.

Whenever a criterion was achieved for a website the value 1 was attributed to the respective variable aiming at justifying the relative service within the evaluation of the website.

The total amount of e-marketing criteria achieved in each website was also studied. For each food and drink enterprise website, the total number of achieved criteria is attributed to a new variable, named t. Variable t presents the sum of e-marketing services achieved, therefore takes a value between 1 and 6.

Then, the total ranking of the websites was studied. The method that was used for the total ranking was the multicriteria analysis named *PROMETHEE II*. That method applies a linear form of service in the particular case, using the e-marketing services of the websites identified as criteria. The PROMETHEE II method is part of outranking relations theory (Brans and Vicke 1985; Brans, Vincke, and Mareschal, 1986; Siskos and Zopounidis, 1987; Brans et al., 1987; Brans et al., 1998; Zopounidis, 2001). A similar multicriteria method was used for the total ranking of websites for agricultural products (Andreopoulou et al., 2008). The PROMETHEE II method for multi criteria analysis uses six types of general criteria with the corresponding criteria services, in order to determine the superiority (outranking) between two alternative solutions.

In this specific case, the aim was to determine the superiority of one website over another website. The general level test criterion was selected for this project, corresponding to a criterion service, which has an interval region for the determination of superiority (Brans and Vicke, 1985; Roy, 1991). The websites that were retrieved in the internet concerning enterprises in food and drinks sector were examined in pairs as alternative solutions (ki, kj) with i= 1, 2, 66 and j=1, 2……66 as to their supremacy, i.e. which of the two websites excelled based on the criteria used.

The service H (d), which was used to express superiority, was the following:

$$H(d) = \begin{cases} P(vi, vj), \text{ outranking of website vi , if } d \geq 0 \\ P(vj, vi), \text{ outranking of website vj , if } d < 0 \end{cases} \quad (1)$$

Where $P(v_i, v_j)$, $P(v_j, v_i)$ are the services of preference, and d is the difference between the values of each pair of websites (v_i, v_j), for the criterion under evaluation. When we examined which of the two websites (v_i, v_j) is superior, the superiority service H(d) was applied according to the value d (positive or negative) for each criterion.

In this study, variables $X_1,\ldots..,X_6$ were used, which are the criteria described in Table 1. The variables are unambiguous and are marked with either 0 or 1. For this reason, the service used is of linear form $\rho=1$.

The multicriteria indicator of preference $\Pi(v_i, v_j)$ which is a weighted mean of the preference services $P(v_i, v_j)$ with weights w_i, express the superiority of website v_i against website v_j after all the criteria have been tested.

The values of $\Pi(v_i, v_j)$ are calculated using the following equation (Brans, Vincke, and Mareschal, 1986):

$$\Pi\left(v_i, v_j\right) = \frac{\sum_{t=1}^{k} W_t \cdot P_t\left(v_i, v_j\right)}{\sum_{t=1}^{k} W_t} \quad (2)$$

We receive 50 scenarios of weights (one scenario of weights w_i corresponds to all criteria) and for each scenario of weights we receive 10 scenarios on the standard deviation for every criterion. In total, we have 500 different net flow values for each website of food and drinks sector enterprise. We use the average of these 500 values as the final net flow value for each website of enterprise.

K is defined as the number of criteria and $P_t(v_i, v_j)$ the preference services for the k criteria. The multicriteria preference indicator $\Pi(v_i, v_j)$ takes values between 0 and 1. When two websites (v_i, v_j) are compared, one is assigned two flow values: outgoing flow and incoming flow. The outgoing flow is calculated by the following equation (Baourakis et al., 2001):

$$\Phi^{+}\left(v_i\right) = \sum_{v_j \in A} \Pi\left(v_i, v_j\right) \quad (3)$$

In both cases, A is defined as the number of alternative solutions for websites v_j. The outgoing flow expresses the total superiority of website v_i against all other websites v_j for all criteria. The incoming flow is determined by the following equation (Baourakis et al., 2001):

$$\Phi^{-}\left(v_i\right) = \sum_{v_j \in A} \Pi\left(v_i, v_j\right) \quad (4)$$

The incoming flow expresses the total superiority of all other websites v_i against website v_j for all criteria. The net flow for each website v_i is estimated by the following formula:

$$\Phi\left(v_i\right) = \Phi^{+}\left(v_i\right) - \Phi^{-}\left(v_i\right) \quad (5)$$

The net flow is the final number that is used for the comparison between the websites in order to obtain the ranking. The ten values (scenarios) range between 0.25s and 2.5s with step 0.25s, where s is the standard deviation of all differences d for each criterion. In total, we take 500 net flow values for

each website and find the website's average value. Each website with a higher net flow is considered superior in the final ranking. Finally, they were classified in groups according to their net flow.

The PROMETHEE II methodology was selected in order to perform evaluation and ranking tasks, for the following reasons (Zopounidis, 2001):

a. because the estimated relation of superiority (of one website over another) is less sensitive in small changes and that offers an easier analysis and discussion of the results
b. the use of the superiority relation in the PROMETHEE method is applied when the alternative solutions (websites) have to be ranked from the best to the worst
c. the procedure of assessing and ranking complicated cases of websites is proper for the application of the above methodology in the sense that it is closer to reality.

In fact, there exist two types of the PROMETHEE methodology, the PROMETHEE I that ranks partially and also, the PROMETHEE II, which performs a full and complete ranking, based on all of the input data. The PROMETHEE II methodology was applied in this project because an overall ranking was required. It is also important that our variables concern qualitative data and PROMETHEE II methodology can successfully deal with that prerequisite (Koutroumanidis, Iliadis, and Arabatzis, 2004; Andreopoulou, Kokkinakis, and Koutroumanidis, 2009).

Moreover, regarding the application of PROMETHEE II in the field of agriculture and environment, there are recent research papers in Greece where the method is successfully applied (Koutroumanidis, Papathanasiou and Manos, 2002; Polyzos and Arabatzis, 2006; Andreopoulou et al., 2008; Tsekouropoulos et al., 2012a; Tsekouropoulos et al., 2012b).

The PROMETHEE methodology fits better to the targets of the project even if it is compared to other well-established methods. For example the ELECTRE methods are methods of superiority that use the rule of majority inside a relation of superiority. The target in the ELECTRE is to determine an alternative website, which is relatively "good", based on a majority of criteria without been too "bad" according to the rest of the criteria. Nevertheless this is not the objective of this project where the objective is the total evaluation of the websites. The AHP method is also well-known and broadly applied (Koutroumanidis, Iliadis, and Arabatzis, 2004). But, according to Alphonce (1997) the ability of the AHP to analyze different decision factors without the need for a common numerate, other than the decision maker's assessments, makes it one of the favorable multicriteria decision support tools when dealing with complex socioeconomic problems in developing countries.

3. Results

Research through search engines on the Greek internet resulted in the retrieve of 66 websites concerning enterprises in the Greek agro-food and drink sector that have an internet presence through a website.

In Figure 1, the achievement of each one of the 6 e-marketing services, expressed in variables x_1 to x_6 is presented.

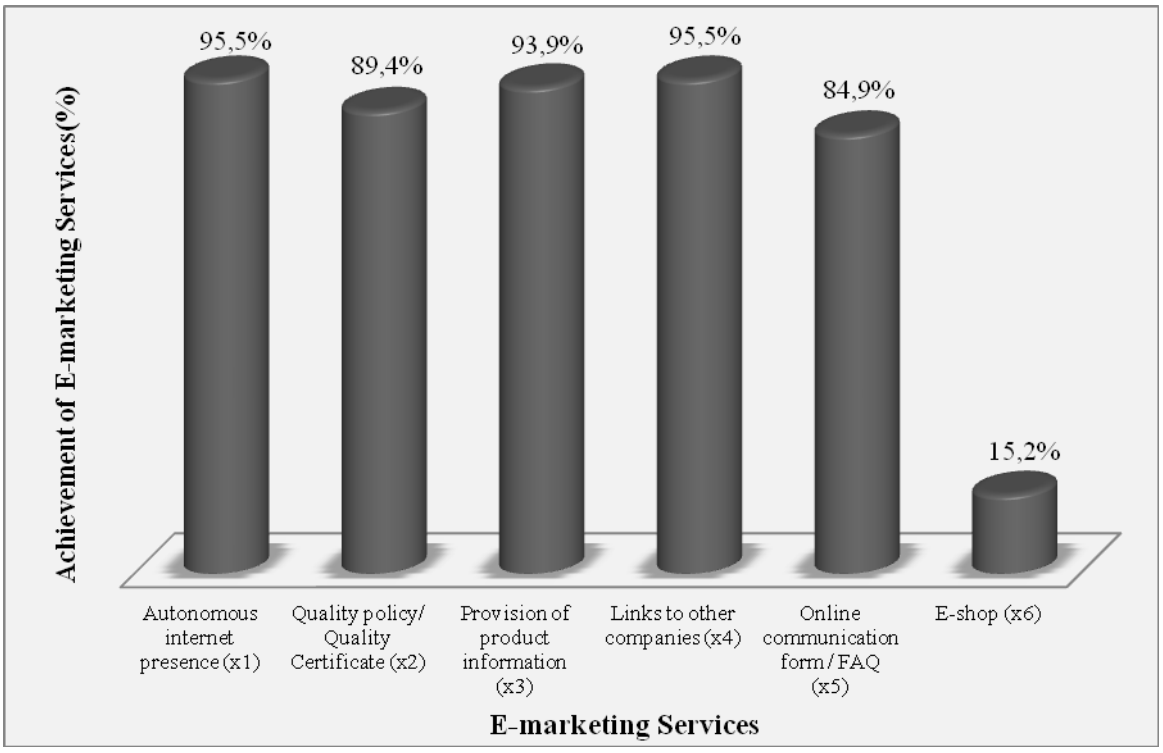

Figure 1. Achievement of e-marketing criteria about the SME websites

Regarding physical and internet presence of an enterprise (x_1), 95.5% of them fulfill that criterion.

Quality certificates for the agro-food and drink products are promoted through the enterprise website in 89.4% of the sample and so as the reliability of the recipes. These services often go hand in hand and are represented with variable x_2.

Most enterprises (93.9%) promote their products by providing various information to the consumers. E-promotion of the products is shown through variable x_3.

Concerning now the feature about the presence or the absence of other links in the website of each enterprise, represented with variable x_4, 95.5% of the enterprises offer the possibility of access in other websites.

Moreover, almost 85% of these enterprises, within the framework of qualitative policy applied, support the communication with the consumer through online communication forms (x_5) aiming to provide additional information for the products, services and transactions, to receive complaints, to give advice and to also support after sales service. There is also the function of Frequently Asked Questions (FAQ) for provision of further information.

Finally, variable x_6 represents the capability of e-shopping through a shoppping cart. A shopping cart is a software application that typically runs on the computer where the website of the enterprise is located and allows the customers to do things such as searching for a product in the store catalogue, adding selected product to a basket and placing an order for it.

Regarding variable t, which is the sum of e-marketing services accomplished by the enterprise websites, they are shown in Figure 2. Only seven enterprises accomplishes all seven e-marketing services (t=7). 48 enterprises of the sample accomplish six e-marketing criteria (t=6) while seven enterprises accomplish five characteristics (t=5). Moreover, one enterprise accomplishes four e-marketing services (t=4) and three enterprises accomplish only one characteristics (t=1). Finally, none of the enterprises accomplish two (t=2) or three (t=3) e-marketing services.

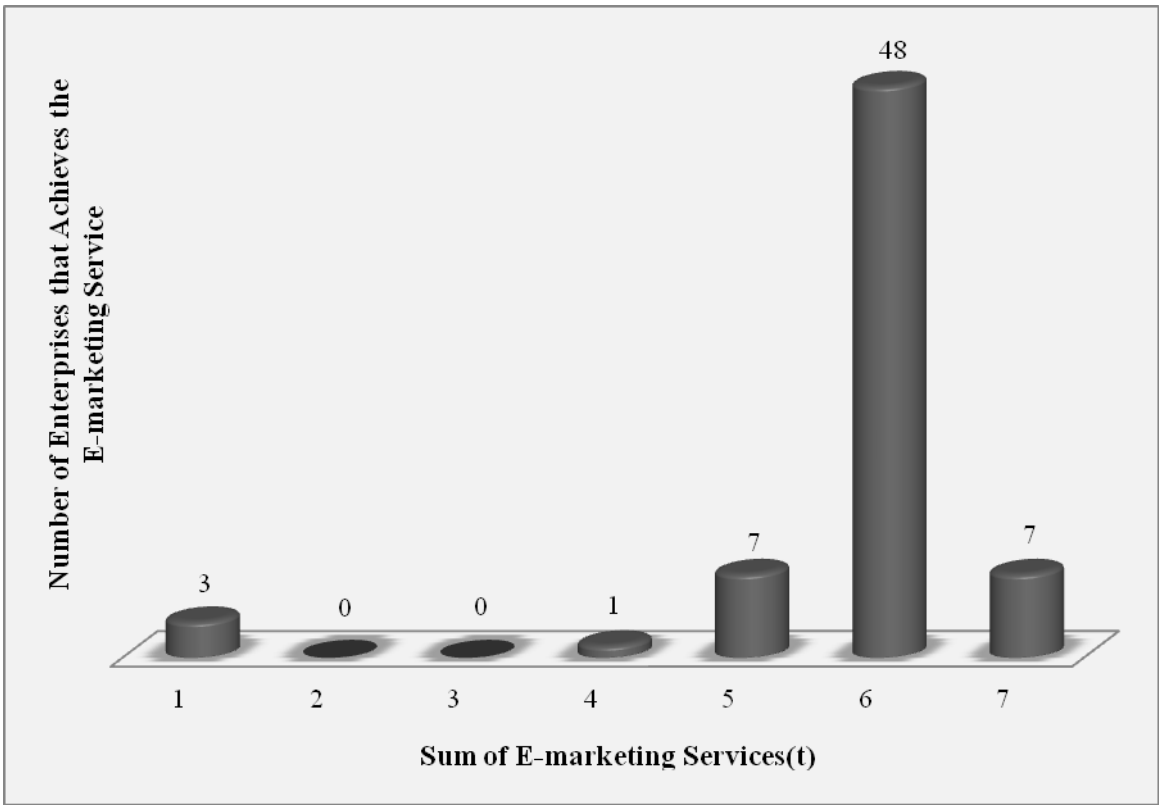

Figure 2. Sum of the e-marketing services accomplished by enterprises

3.1. Ranking and classifying e-shops websites using the multicriteria method PROMETHEE II

Based on the multicriteria analysis method PROMETHEE II, the total ranking of the e-shop websites is presented in Appendix (Table 1). In the same Table it is also presented the total net flow that is estimated for each website and it is used for the comparison between the websites in order to obtain the total ranking, as each website with a higher net flow is considered superior in ranking. Also, I the same table, the sum of the achieved criteria for each website and the classification in groups appear.

According to these findings, the values that were estimated for the total net flows Φ present a great spectrum of values between (+9.936) to (-47.846) and that indicates a great difference concerning the 'superiority' between the first and last case in the ranking of the enterprises' websites. Moreover, the total flows Φ of the enterprises' websites, as derived from the application of the PROMETHEE II method, allow a further grouping of the cases and generate four groups (Figure 3):

- Group 1: In this group, 8 enterprise websites are classified, that achieve 5-6 e-marketing services and very high total flows (+9.936) to (6.943) that present a 'high superiority" against the rest of the cases.
- Group 2: In this group, 47 websites of the enterprises are classified, that achieve 5 e-marketing characteristics and medium total flows (+3.218) to (0.466) that present a 'low superiority' against the rest of the cases.
- Group 3: In this group, 6 enterprise websites are classified in this group, that achieve 4 e-marketing characteristics and average negative total flows (-0.426) to (-3.156) that present an 'average lag' against the rest of the cases.
- Group 4: In this group, 5 websites are classified, that achieve 0-4 e-marketing services and average negative total flows (-8.478) to (-47.846) that present a 'high lag' against the rest of the cases.

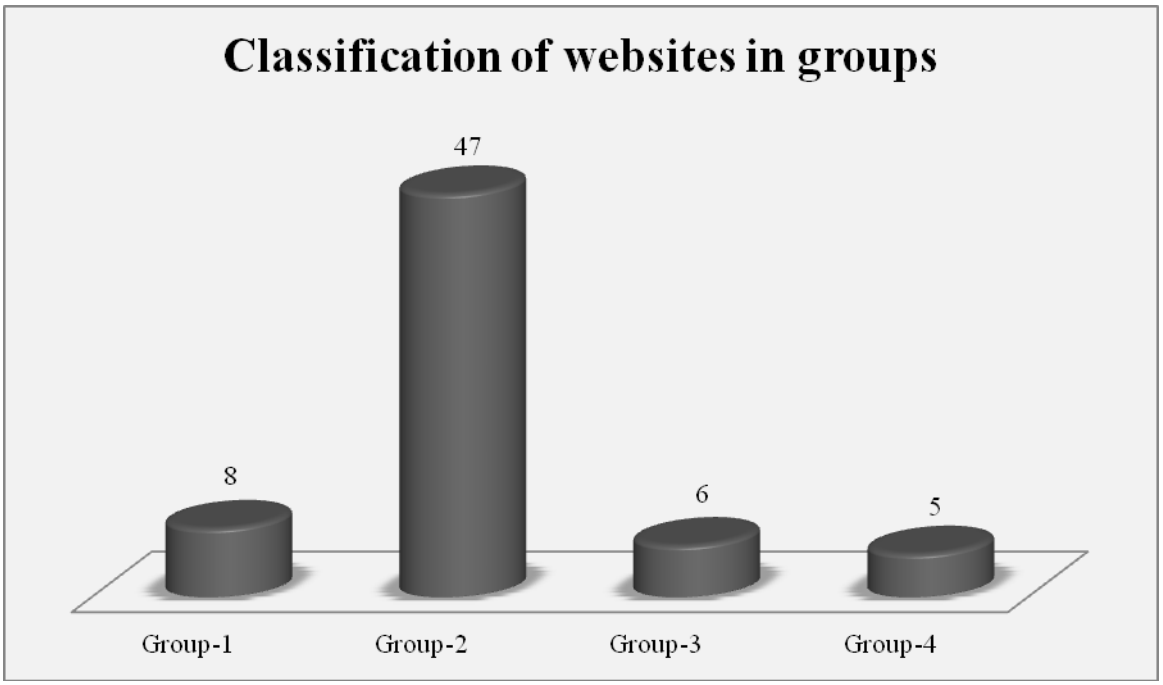

Figure 3. Classification of enterprise websites in groups according to their total Net flow

4. Conclusions

Internet has become a most effective means for promoting and enhancing purchasing via the promotion of products and the provision of any possible information existing, before selling. Also it contributes in facilitating the customers when buying and ordering, it helps financial transactions, secures delivering of products and preserves the prestige of the company while keeping clients satisfied after sales service (Andreopoulou, Koutroumanidis, and Manos, 2009).

Internet research has retrieved 66 websites that represent Greek SME in agro-food and drink sector. With the aim of studying the adoption of e-marketing and internet services, the websites were qualitative studied and 6 different characteristics that promote e-marketing and e-commerce activities.

Findings show that the majority of the websites achieve 5 criteria while 83% of the enterprise websites achieve 5-6 e-marketing and internet services. Quality certificates for the agro-food and drink products are promoted through the 89.4% of the websites. E-promotion of the products is found in 93% of the enterprise websites.

Most websites (47) were classified in the second group, that presents low superiority. In the third and the fourth group, 17% of the cases are classified, which means that few websites present a lag, achieve few criteria and occupy negative total net flows. The enterprises, that belong to these groups, should be optimized considering group 1 as a model. Although only 12% of the enterprise websites are classified in the first group and achieve 5-6 e-marketing services, they consequently appear to have a high superiority against the rest of the cases, representing a high level of e-commerce and e-marketing adoption.

According to the findings, the values that were estimated for the total net flows Φ present a great spectrum of values and that points out a great difference that concerns the 'superiority' between the first and last case in the ranking of the enterprises' websites. Besides, the total net flows Φ of the enterprises' websites, as derived from the application of the PROMETHEE II method, allow a further grouping of the cases and the initial creation of four groups, plus a single case that would be considered as the fifth group.

The results of this study can be an efficient tool while designing similar websites for an enterprise aiming to initially or further involve itself in the e-commerce/e-marketing activities in the agro-food

and drink sector. Therefore, it is pointed out that these Greek enterprises have to adjust to the new 'information era' and aim to become more effective while accomplishing e-marketing activities. As the majority of the enterprises in this sector are generally still in the initial adoption stage (usually a promotional level), they should further mature in the next stages of e-commerce adoption, as those stages of adoption characterized for their dynamic interaction with potential clients and finally, the total integration of e-commerce activities and the optimization of the supply chain. The findings are useful in improving e-commerce adoption through the improved design and implementation of a website to fulfil certain features and characteristics.

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Appendix

Table 1. The total ranking of the websites, the total net flows of each website and the classification in groups

Final Ranking	URL of SME	Net flow Φ	Groups
1	www.e-anemos.gr	9,936	group-1
2	www.foccacia.gr	7,91	group-1
3	www.aristeos.gr	7,91	group-1
4	www.agapitos.gr	7,91	group-1
5	www.absinthe.gr	7,037	group-1
6	www.agelidiscava.gr	7,037	group-1
7	www.cavaarion.gr	7,037	group-1
8	www.stivos.net	6,943	group-1
9	www.skouna.gr	3,218	group-2
10	www.tragakis.com	3,218	group-2
11	www.papmar.gr	3,077	group-2
12	www.helmos.com	3,003	group-2
13	www.golden-sandwich.gr	3,003	group-2
14	www.trofodosia.gr	3,003	group-2
15	www.mastfoods.com	3,003	group-2
16	www.provinco.gr	3,003	group-2
17	www.troficom.gr	3,003	group-2
18	www.pitenis.gr	3,003	group-2
19	www.aretousa.gr	3,003	group-2
20	www.AristonFoods.gr	3,003	group-2
21	www.thymiopoulos.gr	3,003	group-2
22	www.lena.com.gr	3,003	group-2
23	www.tropis.gr	3,003	group-2

24	www.biofresco.gr	3,003	group-2
25	www.bioshop.gr	3,003	group-2
26	www.arvanitis.gr	3,003	group-2
27	www.fikas.gr	3,003	group-2
28	www.metsovosa.gr	3,003	group-2
29	www.agrovim.gr	3,003	group-2
30	www.filippos-sa.gr	3,003	group-2
31	www.fresca.gr	3,003	group-2
32	www.chrisanidis.gr	3,003	group-2
33	www.elinos.gr	3,003	group-2
34	www.greek-ouzo.com	2,53	group-2
35	www.coffee-nettos.gr	2,53	group-2
36	www.ellvino.gr	2,101	group-2
37	www.pilavas.gr	2,101	group-2
38	www.karoniswineshop.gr	2,101	group-2
39	www.fileloinon.gr	2,101	group-2
40	www.kavapergola.gr	1,928	group-2
41	www.cava-semeli.gr	1,928	group-2
42	www.onassis-foods.gr	1,879	group-2
43	www.sisitis.gr	1,879	group-2
44	www.kordonismarket.gr	1,879	group-2
45	www.nektar.gr	1,879	group-2
46	www.amphion.gr	1,879	group-2
47	www.minosfoods.gr	1,173	group-2
48	www.melissa.gr	1,173	group-2
49	www.biotrofos.gr	1,173	group-2
50	www.elgeka.gr	1,173	group-2
51	www.sunspices.gr	1,173	group-2

52	www.ionikigr.com	1,173	group-2
53	www.konva.gr	1,173	group-2
54	www.trofotechniki.gr	1,173	group-2
55	www.mi-alpha.gr	0,466	group-2
56	www.pikounis.gr	-0,426	group-3
57	www.seafood.triton.gr	-0,426	group-3
58	www.antonio.gr	-2,512	group-3
59	www.aromathellas.gr	-2,512	group-3
60	www.cava-sfetsiou.gr	-3,156	group-3
61	www.boikos.gr	-3,156	group-3
62	www.cibshellas.com	-8,478	group-4
63	www.cookieman.gr	-18,708	group-4
64	topalis@kar.forthnet.gr	-40,495	group-4
65	mamas@mamas.gr	-46,143	group-4
66	alcosa@otenet.gr	-47,846	group-4

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Complex Vegetation Survey in a Fruit Plantation by Spectral Instruments

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A B S T R A C T

Health condition and vegetation activity are very important indicators to know the primer production of plants and fruit trees as well. There is a very close relationship between the dynamism of fruit tree development and their photosynthetic activity. Some traditional and modern instruments and methodology were used to survey vigor condition of the vegetation. We surveyed an intensive apple orchard at the Regional Research Farm of the University of Debrecen near Pallag by three spectral instruments. The spectral surveys were at the early senescent stage of the apple plantation. Investigation results were analyzed by different software environments; normalized differential vegetation index (NDVI) map was created and spectral point sampling was carried out in the test site. Spectral results were compared and strong linear correlations ($r>0.7$) were detected between each spectral measurement. The applied instruments gave information about vigor condition of the fruit trees in a non-destructive way.

1. Introduction

To determine the vigor condition of vegetation is a very important factor by plant production consideration. The aim of these investigations is to minimize disturbance to naturally occurring populations. Presently, some useful instruments are available to survey the health status of agricultural plants and horticultural trees by non-invasive methods.

Today, IT provides the farmers such tools, like global positioning system (GPS), geographic information system (GIS) and remote sensing (RS) (Milla et al. 2005), which, at the same time, develop rapidly, in a great integration. Using this ternary technology at agricultural or horticultural specialty is the so-called precision agriculture (Tamás 2001).

RS, also called earth observation, refers to the obtaining of information about objects or areas at the Earth's surface without being in direct physical contact with the object or area. The basis of remote sensing is incoming electromagnetic radiation (E_I) to the object. When the radiation incident upon the object's surface, it is reflected (E_R) by that surface, transmitted (E_T) into the surface or absorbed (E_A) by the surface. Thus, it could be established that the reflection, absorption and transmission are equal

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to the total incoming radiation on a given wavelength (Aggarwal 2004). So, it could be created the equation (1):

$$E_R(\lambda) + E_A(\lambda) + E_T(\lambda) = E_I(\lambda) \quad (1)$$

Most remote sensing systems are designed to collect reflected radiation (Short 2011). The reflectance and absorbance values are depending on the physical characteristics and the geometric structure of the object (Molenaar 1993). Depending on the incoming light, remote sensing can be either passive or active. Reflected sunlight is the most common source of radiation measured by passive sensors, while active sensors emit a certain radiation, so it could be measured with these instruments in day or night.

Remote sensing is an effective tool for monitoring the biomass production and health status. By using certain reflectance values of adequate spectral bands vegetation indices can be calculated, which correlate well with the vigor. Plants reflect the visible (VIS) band in a small compass, but in the near infrared (NIR) band, the reflectance increases according to the chlorophyll content of leaves and changes proportionally to chlorophyll concentration. Using the reflection of the RED (630-690 nm) and the NIR bands (760-900 nm), a plant's green mass can be determined (Tucker, 1979). One of the most frequently used indices for investigating surface coverage and biomass is the Normalized Difference Vegetation Index (NDVI) (Rouse et al. 1973).

Many authors have investigated agricultural crops and horticultural trees with special remote sensing instruments to conclude the vigor status of plants. Flynn et al. (2008) used a special NDVI-meter (GreenSeeker) to collect information and assess the spectral properties of pasture biomass. Coventry et al (2011) used GreenSeeker to establish the rate and schedule of nitrogen and water application for winter wheat.

To investigate the pigment activity of plants in a non-destructive and quick way the SPAD meter was widespread. SPAD values are correlated with the chlorophyll concentration of the leaves Campbell et al (1990) compared the chlorophyll content and the growing condition of apple's leaves. Van den Berg & Perkins (2004) estimated chlorophyll and nitrogen content in sugar maple's leaves. Imagine sensors are effective tools for vegetation analysis, hence it could get information about the environment of investigated plants.

Other spectral imaging systems are appropriate for vegetation analysis. Lehoczky et al (2006) long term experiments were carried out by Tetracam ADC to assess the fertilization effect weed biodiversity. There are few studies, which compared different devices, which measure vegetation activity of plants, between horticultural conditions.

The aim of this study is to investigate the spatial variation canopy vigor status in an intensive apple orchard, and to compare three NDVI sensor systems.

2. Applied methods

The spectral surveys were carried out at the Study and Regional Research Farm of the University of Debrecen, near the town of Pallag. The study area was an intensive apple orchard with drip irrigation system, protected with a hail net. The measurements were at the early senescent stage (after the first autumn frost in this year) of the apple plantation at 01.10.2013 and 30.10.2013.

To investigate the spectral features of the whole study area, GreenSeeker 505 vegetation indexmeter was used (Figure 1). The instrument is suitable for measuring several vegetation indices, but the most information was provided by the NDVI value. Every row of the apple orchard was surveyed at both sides by the instrument. Because of the GreenSeeker 505 is an active remote sensing tool, it has got an internal light for calculating the NDVI. The sensor operates by emitting light (red band – 656 nm and near infrared band – 774 nm) from the rectangular window onto a crop's canopy. Reflected light from the canopy is focused on a detector behind the circular window. The system calculates the NDVI from the given reflectance values, based equation (2):

$$NDVI = \frac{NIR - RED}{NIR + RED} \qquad (2)$$

Data collecting was carried out 50-100 cm from the foliage. As an interface of GreenSeeker 505 was working, an AgGPS FmX integrated display by Trimble, which collected the coordinate data beside the NDVI values. During the measurement EGNOS DGPS correction signal was used to achieve ca. 15-20 cm accuracy. During the whole measurement, the logging interval was one second. The acquired data was stored in the hardware of the job computer each second. Both the AgGPS FmX and the GreenSeeker 505 were mounted on a tractor. Uniform data collection was provided by the constant speed of a tractor. The raw database file from the jobcomputer was examined and analyzed it in Microsoft Excel™, then for the spatial analyzing, Surfer 11 software was used. To evaluate the data, an NDVI map was created using an interpolation technique. Interpolation is a mathematical approximate method to determine unknown values based on known values. The interpolation of spatial data was carried out using the Nearest Neighbor method.

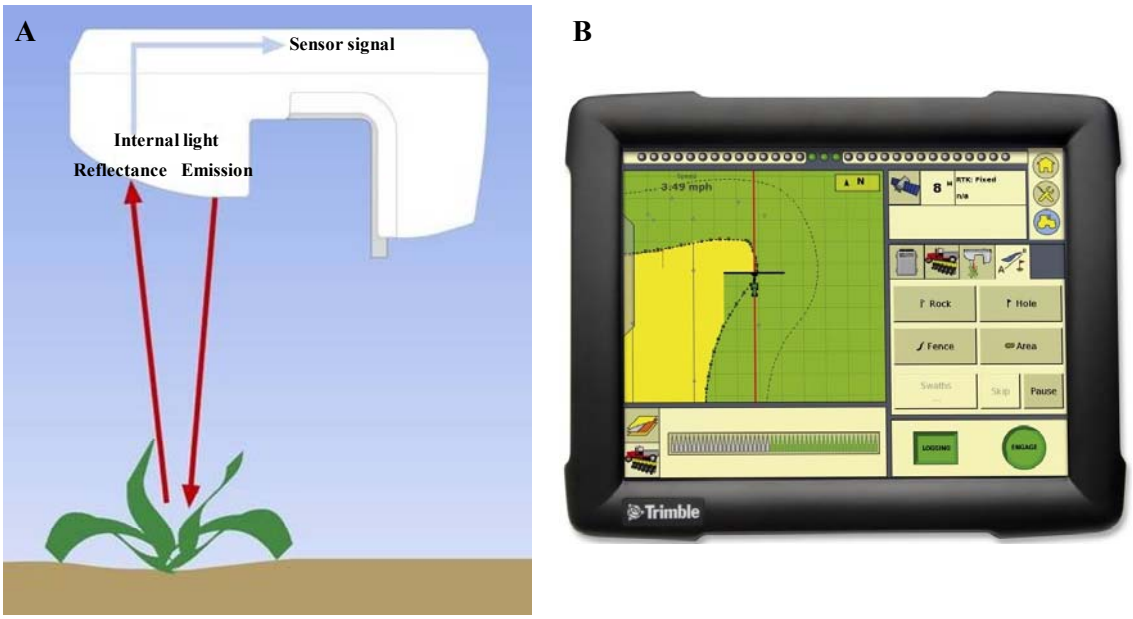

Figure 1. Working principle of GreenSeeker 505 and the AgGPS FmX Integrated Display

Source: A – Crop optics – Australia Pty Ltd.

B – Lessiter Publications and Farm Equipment

To verify the GreenSeeker NDVI map, point sampling was executed by SPAD-502 and Tetracam ADC spectral instruments. SPAD-502 (*Soil Plant Analysis Development*) uses red (at 650 nm peak point) and infrared (at 940 nm peak point) to measure the SPAD value. The instrument is an active remote sensor like the GreenSeeker, with similar electromagnetic sampling bands. The main difference in working principle is, that SPAD measures the absorbance of the emitted lights. SPAD values are between 0-100; lower values indicate lower vegetation activity. 10 trees were chosen in the plot area to determine those SPAD values. The SPAD values were calculated based on 6 replications in the case of each selected tree.

At the time of the other spectral measurements, imagine point surveys were carried out by Tetracam ADC broadband multispectral passive remote sensing camera, its resolution is 1280x1024 pixel. Since the camera is a passive remote device, due to the changing weather conditions, the instruments had to be calibrated. The multispectral surveys could be provided to recognize vigor condition of the whole canopy and the neighboring fruit trees as well and even the spectral properties of one leaf could be known. The camera creates spectral reflectance images in three bands (green – 520-600 nm, red – 650-750 nm and infrared – 750-950 nm). Based on the reflectance values, vegetation indices could be created in PixelWrench2 software environment, which is the main

software of Tetracam ADC. In the basic software, red, near infrared and NDVI images were created. Only one smaller part of each image was exported in TIF format for pixel-based post-processing to avoid interfering effect of the soil, trunk and sky pixels. For further data mining, IDRISI Taiga software by Clark Labs was used. To prepared NDVI images, red and NIR images were combined in this software.

3. Major research results

The collected data by the GreenSeeker 505 were processed and evaluated in Surfer 11 software environment. One week after the first frost in this autumn, the pigment synthesis of leaves began to change. The average middle range (0.566) NDVI values are indicated in Figure 2. During the 30 days, there wasn't further frost, so chlorophyll in the leaves decreased slowly (NDVI=0,509).

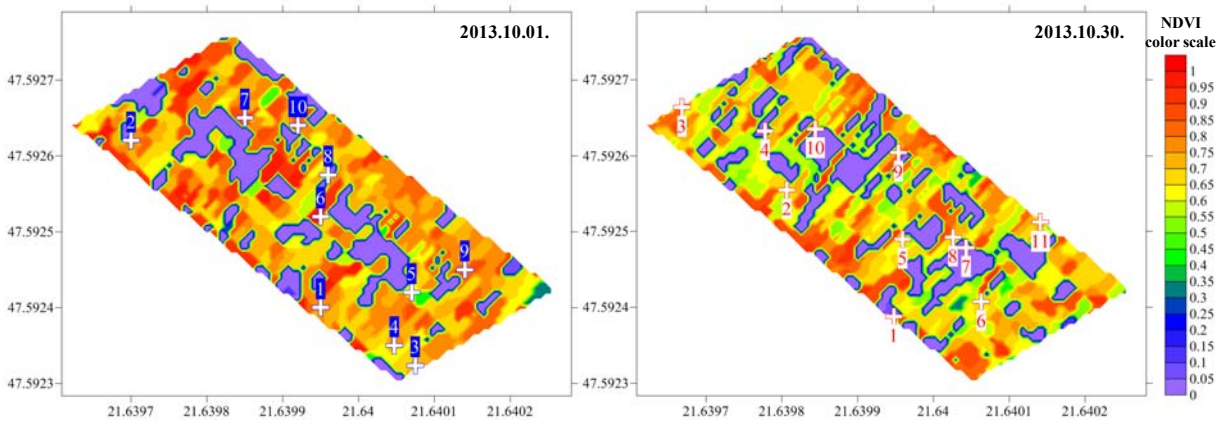

Figure 2. Interpolated GreenSeeker-NDVI map of the investigated area with sampling points of SPAD-502 and Tetracam ADC measurements in Surfer 11 software environment

Due to a microbiological disease (Fire Blight – *Erwinia amylovora*) some apple trees were infected and died in the investigated orchard in the last summer (in the term of July, 2012). The purple areas show, where the trees were died.

GreenSeeker NDVI values and point sampled SPAD values were compared (Figure 3), and it could be detected a strong positive correlation between the investigated variables at the early November (r=0.782) and the late November (0.73) measurements.

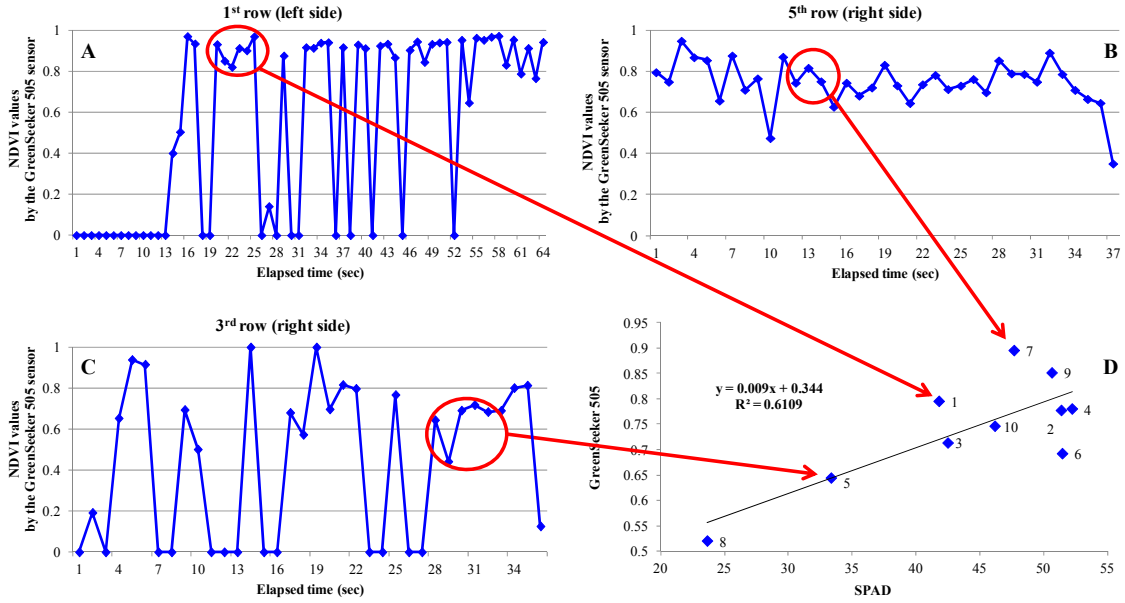

Figure 3. Curve analysis of the course of AgGPS FmX, GreenSeeker 505 (A, B, C), and the correlation between NDVI and SPAD values (D) at 1st November, 2013

In our examinations, multispectral images were evaluated. As a first step, the NDVI values from PixelWrench2 and IDRISI were compared. It could be determined that the NDVI values, which were created in IDRISI, were higher than PW2-NDVI values (Figure 4). The average difference between the two software evaluations was 0.093; nevertheless between the two calculated NDVI values, a close correlation (r=0.96) could be established.

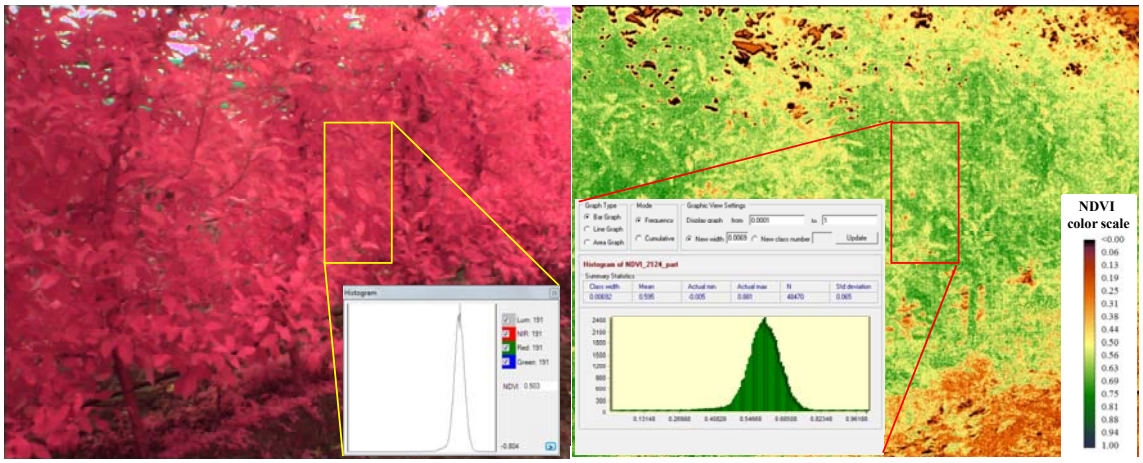

Figure 4. An example of a raw false color image (A) in PixelWrench2 and NDVI color image (B) in IDRIS software environment with the NDVI-histograms of highlighted rectangles.

Comparing the NDVI values by the GreenSeeker and the NDVI values of a given rectangle area by the Tetracam ADC at the two surveys, a high correlation could be detected (r=0.766). Tetracam-NDVI and SPAD values showed even a higher correlation (r=0.856).

6. Conclusions

The intensive apple orchard was surveyed with three remote sensing instruments to investigate the spectral properties of the canopy in the early senescent phenological stage of trees. Combination of the devices, a complex vegetation analysis could be elaborated. The GreenSeeker-GPS system is a useful

tool for mapping vegetation conditions, which is one of the most important elements of the site-specific agriculture and horticulture practice. The multispectral camera was effective to define NDVI values of the full canopy or even of that of one leaf. Point samplings were carried out by the SPAD-502 chlorophyll meter. Based on the result, the used instruments are appropriate to establish the vigor and health condition of the vegetation. Measurement results of the instruments were compared and in each case a high correlation of them was detected ($r>0.7$).

The vegetation analyses are suitable for monitoring the whole plantation, and the vegetation indexes could help to provide the best or most rational horticultural practice. In the future, based on the NDVI values a precision nutrient management, chemical and energy saving spraying system could be elaborated.

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Mapping solution of Interscale Landscape Diversity Modelling Methodology

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A B S T R A C T

Interscale Landscape Diversity Modelling Methodology (INLAND) was set up in order to carry out landscape diversity modelling tasks. The modelling has dual aims: sampling and mapping. In the confines of this paper I introduce the mapping solution, with the description of the modelling needs, and the application of the output results. INLAND methodology defines landscape diversity as the (human/social) perception of spatial heterogeneity. INLAND also intends to model landscape diversity continuously through-out spatial scales. The automated assessment tools of INLAND carry out the modelling tasks relying on Earth Observation (satellite remote sensing) imagery. With the use of sampling tool – objective parameters can be extracted from input data sources. Mapping solution visualises landscape diversity in a map format in order to provide basis for monitoring, and planning tasks – in comfort with the requirements of European Landscape Convention (2000, Florence). Examples of the application of INLAND maps are also introduced along a case study (Rostock region – Mecklenburg-Vorpommern, Germany).

1. Introduction – Challenges of modelling landscape diversity

Landscapes must be defined, assessed and monitored (European Landscape Convention, 2000, Florence. Assessment and monitoring intentions assume objective description of landscapes' manifestation. One of the most global characteristics of landscapes is their diversity. Landscapes are "*a mosaic of heterogeneous land forms*, *vegetation types*, *and land uses*" (Urban et al., 1987) – heterogeneity is even a defining value of landscapes.

What is the difference between heterogeneity and diversity? Landscape, as a phenomenon, is an "*antropo-socio centric*" concept (Mőcsényi, 1968), which means that our approach to landscapes is naturally considered from the viewpoint of our society. Heterogeneity is a pure-natural factor of landscapes, while "*the Landscape is a complex entity, developing in the interaction of nature and society"* (Csemez, 1996; translation by the author). Heterogeneity must be understood/recognised/felt by the society, to let us speak about landscape diversity. This process of understanding is perception. Perception makes difference between heterogeneity and diversity. The term "Landscape Diverstity" (LD) is used in this paper as: perception of spatial structural heterogeneity.

Spatial heterogeneity, thus landscape diversity is a global value of landscapes. However, landscapes have no specific scale: landscape is a cross-scale concept. Spatial heterogeneity and landscape diversity are also phenomena, which are continuous through all scales. *"Spatial heterogeneity is ubiquitous across all scales and forms the fundamental basis of the structure and functioning of landscapes, be they natural or cultural*" (Wu, 2004)

According to the definitions above there are two main challenges of modelling landscape diversity: (1) the modelling methodology must be able to describe landscape diversity through spatial scales; (2) and have to model landscape diversity as the perception as spatial

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heterogeneity. While spatial heterogeneity is a research focus of landscape ecology, there are no parameters of landscape diversity. While the effect of spatial scale is a research focus of GIS (geographic information systems) and Image Information Mining, there are no operative solutions of data mining to handle scale-continuous landscape analysis.

INLAND (Interscale Landscape Diversity Modelling Methodology) introduces two related automated solutions, which handle "cross-scale" and "perception" problems in an integrated way, when modelling Landscape Diversity according to the input data of Multispectral Earth Observation (satellite remote sensing) imagery. These datasets can provide opportunity for mass-data mining in a homogeneous quality and describe land-cover relations of landscapes.

2. Data sources – Earth Observation

Taking landscapes as a perceiver, "*landscape is a cultural construction, expressing itself in images, associations and imaginations*" (Strohmeier, 2007; translation by the author). If targeting the perceivable aspects of landscapes, it is understandable that from the three above, images are the most objectively accessible sources. The most complex, timely and easily gathered images are the optical Remote Sensing (RS) datasets. The most cost-efficient (on longer terms) way of RS imaging is the satellite based RS: Earth Observation (EO). Assessing the statistical power (unit-defining power) of spatial heterogeneity Nicole et al. also point out: „Satellite imagery is likely to be the only way that such a large volume of data can be collected in a practical fashion" (Nicol et al., 2013).

Earth Observation imagery, if observed from the point of cross-scale priority of LD monitoring, can be classified into three main scales according to the spatial resolution - "*Overall, more [landscape] metrics showed consistent scaling relations with changing grain size [/spatial resolution] than with changing extent at both the class and landscape levels*" (Wu, 2004). Low Resolution (LR) imagery (raster size above 40 m) is used for continental, global scale analysis. High Resolution (HR) imagery (raster size 40-5 m) is adequate for regional level information mining. Very High Resolution (VHR) imagery (raster size below 5 m) describes local conditions on the Earth surface. These technical scales of input data are discrete, thus investigators are limited to specific scales of observation. While according to the scale dimensions of Dungan et al. (2002) landscape diversity is a continuous phenomena, the possible sampling scales are suffering from discreteness.

3. Methods

3.1. Subscales

Grain and extent are measures, which are used to describe the spatial scale of an EO image. Grain represents the finest entity in an observation set (spatial resolution, ground size of pixels), while extent is the span of all detected entities (size of acquisition, number of pixels) (Allen et al, 1991). The robust methodology of INLAND intends to give a possible solution for measuring continuous landscape diversity across scales, only with the modification of spatial resolution (degradation of images), without the changing of the extent between the discrete scales.

The concept of INLAND is technically based on the most simple hierarchical (quadtree) (Safavian 1991) balanced image degradation of discrete scaled input EO data, by collapsing the initial image to successively finer resolutions. The quadtree tiling of maps is also a well known coding in cartography. During the looping degradation process an extendable scalogram structure, the structure of subscales is defined *a priori*.

The (multispectral) input image with initial extent, grain and spectral resolution, respectively: (E,G,B), is symmetrically segmented into four (two times two) quarter-tiles, and described with the properties of all included grains into tiles. This description means the aggregation of the information content of the initial grains and the segmentation of the initial extent (e_1,g_1,B). In the next loop, the new segments are tiled up into four again, and described with the properties of all included grains of the initial image. This means again a finer aggregation of the initial grains, and a new, even smaller extent (e_2,g_2,B) (Figure 1/a). It must be pointed out here, that g_2 measured to G is better than g_1 measured to G, while e_2 measured to E is worse, then e_1 measured to E even though that both $g_2=g_1/2$ and $e_2=e_1/2$, because technical (EO) development aims of grain and extent are opposites: decreasing grain and increasing extent. The looping is going on, until $e_x*g_x=E*G'$, where G' is the grain (spatial resolution) of an image, which is from a larger discrete scale (e.g. if the first image was an LR EO image, G' describes already the grains of a HR image). Then the aggregation process is continued with the use of the larger scale image data input (E,G',B) (Figure 1/a). It must be observed, that between the discrete input scales the extent is not changing. The dataset gained this looping way, simulates a continuous "zooming" option with the tiles, and offers a possibility to combine different discrete scaled data along a symmetric fractal. The tiles, described by e_x and g_x are the grains of the "sub"-scales, which originate their information content from a larger discrete scaled input data (Figure 1/b).

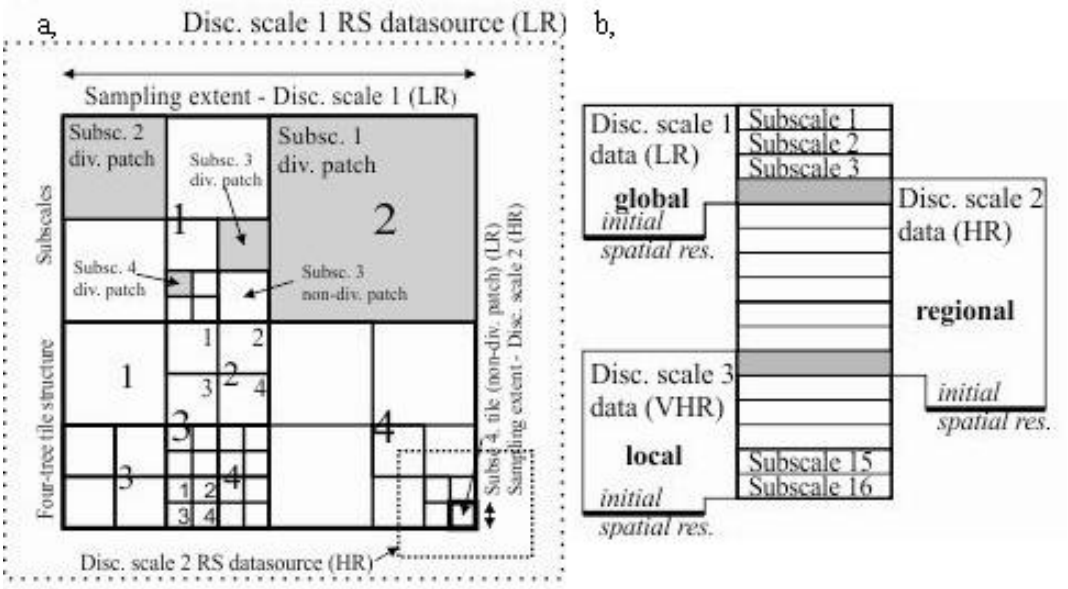

Figure 1. a, Structure of tiling to gain subscale grains; b, Combination of discrete scaled RS data through subscale structure

A similar methodology of image degradation (collapsing the image into successively coarser resolutions) were executed by Woodcock et al. (1987) for selecting the appropriate scale of RS observation to help investigators to choose an appropriate combination of spatial resolution and analysis method. The described process, however, did not include the quadtree aggregation option, causing the pre-definition of degradation scales and the loss of the possibility to combine different discrete scales – the extent of imagery was not assessed).

3.2. Perception resolution – independent parameter of decision making on heterogeneity

If the degraded multispectral image tiles of the quadtree based scalogram are conceived to be grains (pixels, rasters) of subscales, decision making process on diversity corresponds with a loop of raster based image classification processes, where diversity patches are defined. Spatial variance, which is the basis of this classification process, is measured in tiles by the

means and the standard deviation of (spectral) reflectance values of the pixels, which are covered by the tile on the initial input image. The classification leads to a binary decision: across subscales the significantly different tiles (V_x=1) are considered to be diversity patches (and not to be tiled into successively finer grains), while the similar ones (V_x=0) are proceeded to be re-assessed in a larger (with smaller grain size) subscale. This logic is opposite to the well known ECHO image classifier (Landgrebe, 1980), where statistically significantly similar adjacent measurements are classified into aggregate. The INLAND decision making is going on in a loop across every subscale, and uses the following term:

$$\text{if } |A_y - a_y| >= s*d,\ V_x=1;\ \text{else } V_x=0$$

,where:

- V_x is the output value of the pixels of the initial image, covered by the subscale tile;
- x is the index number of the subscale; y is the index number of spectral Band of the initial image;
- A_y is the spectral mean of the input image pixel values of the initial image, which are covered by the containing subscale tile of a smaller subscale (x-1);
- a_y is the spectral mean of the input image pixel values of the initial image, which are covered by the containing subscale tile of the assessed subscale (x);
- s is the standard deviation of the input image pixel values of the initial image, which are covered by the containing subscale tile of the decision making subscale (x);
- d is a multiplicator coefficient (later referred as d-coefficient), which is defined by the user, and which modifies the strictness of decision making.

The output elements of this decision making process are the diversity patches indexed with V_x values in the input image pixels. Diversity patches are the subscale grains (tiles), which differ in their reflectance significantly from the containing grain of a smaller subscale (with coarser resolution). These diversity patches construct a simple scene model during the information mining process. As the decision making is based on the relation of the mean-differences to standard deviation of the tiled pixels, the definition of diversity patches is independent from the global variance of the image. Thus the extraction of diversity patches is also assured from all subscales of combined discrete scale images. Here it must be outlined, that diversity patches are not the outputs of INLAND methodology, they are only used for extracting spatial statistics (sampling tool), and categorical maps of LD (mapping solution).

"*The criteria for defining a patch may be somewhat arbitrary, depending on how much variation will be allowed within a patch*" (Gustafson 1998), or how much is required to define a new patch. "*d*" value (d-coeff) in the expression used for binary decision during the diversity patch definition influences and controls directly how much variation is required to define a diversity patch. The d-coeff is setting the rigidity or strictness of the decision making. In this manner it represents the perceivers ability to understand the landscape – or to observe spatial differences. The d-coefficient is measuring the *perception resolution*, which distinguishes "Dakota Indians" (high perception resolution, small d-coeff values), who recognize even very small differences in the landscape, from "Uptown Infants" (low perception resolution, high d-coeff values), who only think in city–village relations.

As INLAND methodology targets the perceivable spatial heterogeneity (LD), the modelling concept is based on the analysis of the diversity patch structure through subscales in the function of d-coeff (or perception resolution).

4. Mapping solution - keeping the model in raster domain

The sampling solution (published separately – Fülöp et al, 2013) of Interscale Landscape Diversity (INLAND) methodology was set up to measure spatial heterogeneity (define and count diversity patches) in the function of the perception resolution across the subscales of a given discrete scaled image, which is collected from a landscape. This intention assumes, that the scene and accordingly the image) is taken from inside of the boundaries of the functional region of the landscape, which is targeted to be characterized with its LD: there are no landscape boundaries represented on the image. The appearance of such functional landscape boundary was presented with the use of entropy values extracted from polarimetric SAR data on the administrative border of Hungary and Serbia (Fülöp, 2012)

The mapping solution intends to create multi-channelled categorical maps with the use of the methods (subscales, and perception resolution) described above and integrated into the sampling tool. Different channels of the created maps represent different strictness in the decision making process (d-coefficient): the user can observe LD in the function of perception resolution.

As Gustafson (1998) states: "*Raster maps represent boundaries as the interface between cells of different classes* [diversity patches or non-diversity patches of sampling solution] *so that boundaries must conform to the underlying lattice structure. This can have marked effects on the* [vector based] *delineation of patches.*" That is also a reason why diversity patches could have not been used directly for mapping purposes: to keep patch delineation in raster domain. Two other, more important but linked causes were (1) the sampling solution's sensibility for functional landscape borders and (2) the inefficient measurement of neighborhood relations (with the quadtree structure the mean of a given subscale tile is related only to three out of eight neighboring tiles during the decision making comparison of the means). These problems all together mean the sampling solutions exposure to the spatial movement of the sampling image extent.

The INLAND mapping solution is based on a repeated sampling structure, which uses the sampling image extent as a moving window, passed over the landscape scene (Figure 2/a). However, because of the subscale structure (which consists of successively finer subscale tiles) the moving degree of the sampling window had to be spatially considered. While tiles from the first subscale (grain: 64 initial pixels) should be compared to the surrounding tiles which have the same tile size: resulting the movement of the sampling window by 64 initial pixels, tiles from the sixth subscale (grain: 2 initial pixels) require the movement of the sampling window only with 2 initial pixels (subscales and window movement degree on Figure 2/a, b and c).

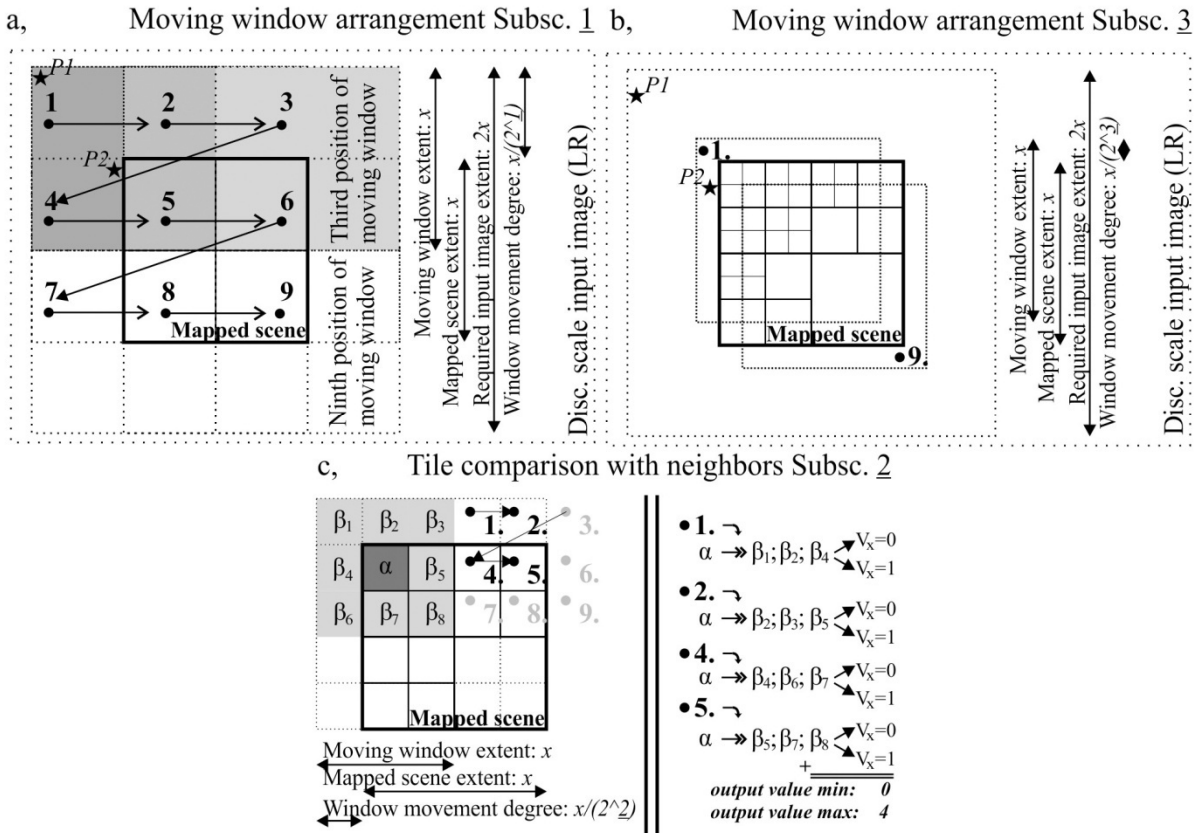

Figure 2. a, Moving window arrangement in subscale 1; b, Moving window arrangement in subscale 3; c, Moving window arrangement in subscale 2 – tile comparison with neighbours – extraction of grain value [0,4].

Therefore the repeated sampling with the moving window was integrated into the quadtree structured decision making process to create categorical maps. While the sampling solution consisted of two different looping processes (looping across subscales and looping across perception resolution) the mapping tool integrates between these two a third one: looping across spatially moved windows. The moving window technique is based on a sampling methodology, which also has a spatial extent. In the case of INLAND mapping solution the sampling image extent is the same as the mapping image extent (128), however the analysis assumes the accessibility of double image extent (256) (Figure 2/a and b).

During the extraction of the INLAND map the MATLAB code runs the sampling method at each d-value and each subscale nine times (Figure 2/a, b and c). Each sampling represents a different state of the moving window, assuring that tiles are compared to all of their eight direct neighbors (Figure 2/c). The movement degree of the tile is the function of the assessed subscale (subscales and window movement degree on Figure 2/a, b and c). At the first subscale this movement measures 64 pixels of the initial image, on the second this value is 32, on the third it is 16 etc. From these nine measurements each assessed tiles participate in four (Figure 2/c). E.g. the first indexed tiles in the first, second, fourth and fifth move of the window, the second indexed tiles in the second, third, fifth and sixth, the third indexed tiles in the fourth, fifth seventh and eighth, the fourth indexed tiles in the fifth, sixth, eighth and ninth movement of the window. Thus each tile can be considered at maximum four times to be a diversity patch at each subscale and perception resolution. In this decision the northern, eastern southern and western neighboring tiles take part twice, while the north-eastern, south-eastern, south-western and north-western tiles only once (Figure 2/c). This weighing represents the edge effect of the tiles originating from the quadtree delineation of the modelled tiles – the last subset of the four neighboring tiles is not connected with the assessed tile along a border line. As the channels of

the output categorical map represent different perception resolution, at each channel the maximum value of the tiles can be four, while the minimum value zero (defining non-diversity patches). As a result of mapping method each tile (α on Figure 2/c) at every d-value and subscale is measured to its neighboring tiles (β on Figure 2/c), and also that is why the mapping solution requires the accessibility of a double image extent as the mapped scene (Figure 2/a). Because of future research needs (see at Outlook), during the mapping process only the first five subscales were used (the output map has four times bigger grain size than the input image).

Viewing globally the whole mapped scene, the categorical map output describes the evenness (composition index) of diversity patches in the function of perception resolution. Evenness refers to the distribution of area among the classes (diversity patches or non-diversity patches). In the study of Riitters at al. (1995) composition indices (such as evenness) have been also spatially referenced, by calculating the index within a moving window that is passed across the map. Galante et al. (2009) also presents IIM use of moving window structure.

The moving window construction was needed because of the rigid neighborhood-handle of quadtree decision making, also not reflecting spatial construction efficiently right out of the borders of the sampling tool (P1 and P2 on Figure 2/a and b). The altering moving degree of the sampling window assumes that closer pixels have greater influence on perceivable LD (differences can be observed more easily between areas, which are more close to each other): the existence of autocorrelation. This can be easily understood when realizing that the initial image pixel just right out of the boundaries of mapping extent influences diversity patch definition at each subscale (P2 on Figure 2/a and b), while an image pixel 64 pixels remote from the mapping extent has impact only at one subscale: at the first one (P1 on Figure 2/a and b). Autocorrelation means in a simple definition: points closer together tend to be more similar than points farther apart (Gustafson, 1998). Thus the natural spatial similarity (decreased differences) of initial image pixels is represented in the INLAND mapping process.

5. INLAND map-products and examples of the map-application

With the use of INLAND mapping solution the landscape diversity maps of Mecklenburg-Vorpommern (MV) (Germany) and Hungary were created. In the confines of this paper the LD map-model of MV, the map-products and the application of these products are introduced in order to illustrate practically the set up of the mapping solution. The Hungarian map will be published when regionally related applied assessments (overlay with the national control plan) are ready.

During the creation of the LD map of MV 32 perception resolution (d-coeff; from 0.1 to 3.6) values were used – thus the map-model consists of 32 Bands – each Band standing for a perception-strength of the perceiver. The total set of these Bands (and the tendencies between them) describe the LD in this region (Figure 3). The resolution of input imagery was 463 m (MODIS), the output resolution of the model is 1852 m (four times bigger). The mapping window-extent was 128 (when shifting 256), thus it is clear, that five subscales were used during the mapping process (128/(2^5)=4). With this mapping extent whole territory of MV was mapped in 17 tiles.

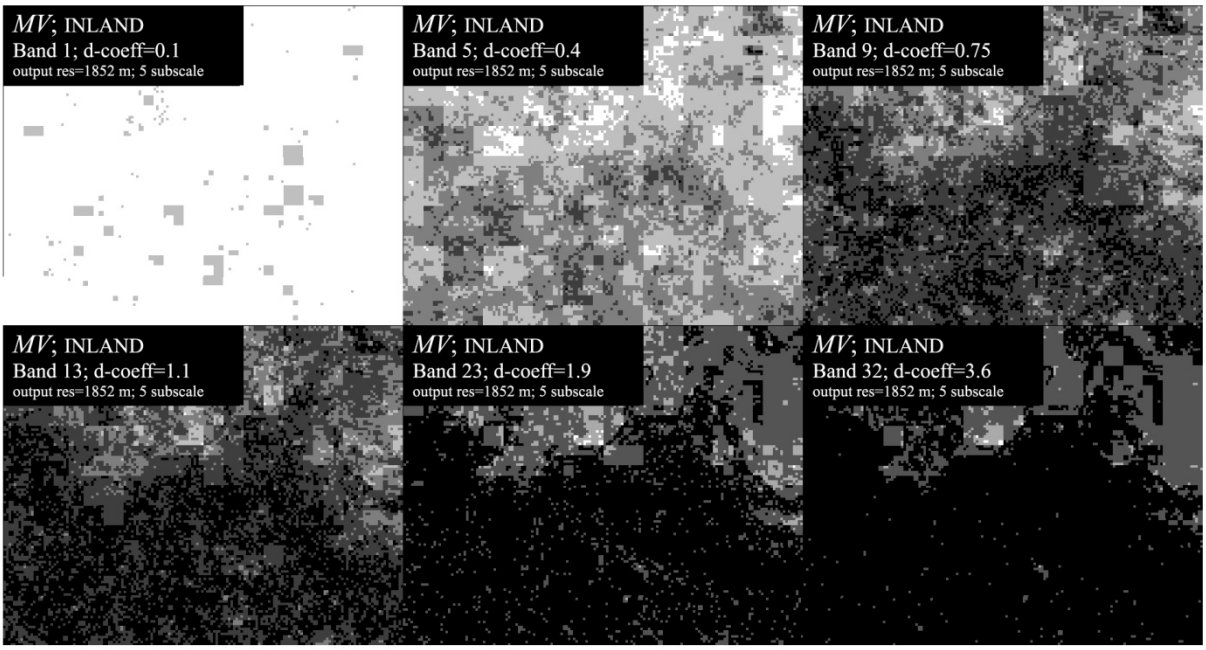

Figure 3. Bands of INLAND map-model of Mecklenburg-Vorpommern (Germany) from 17 mapped scene-tiles (each 128 by 128 pixels). Map-model consists of 32 Bands ~ 32 perception resolution value (d-coeff.) [0.1, 3.6]; 5-subscales were used, resampled from MODIS imagery (463 m); output resolution is 1852 m; pixel values [0,4] – 0 (black) standing for homogeneity, 1 (white) for heterogeneity.

However, the whole set of 32 Bands is very difficult to understand. In order to interpret this map-model, two types of map-products have been created. The first map-product (Figure 4/a) is a grey-scaled image, indicating the d-coeff. threshold, at which value the part of the landscape is turning from diverse to homogeneous (as the perception resolution becomes coarser). The other map-product is an RGB image, each Band (red, green, blue) standing for a perception group (red is the "expert" perception group – d-coeff. values from 0.1 to 0.9 averaged; green is the "medium" perception group – d-coeff. values from 1 to 2.2 values averaged; while blue is the "weak" perception group – d-coeff. values from 2.4 to 3.6 values averaged) (Figure 4/b).

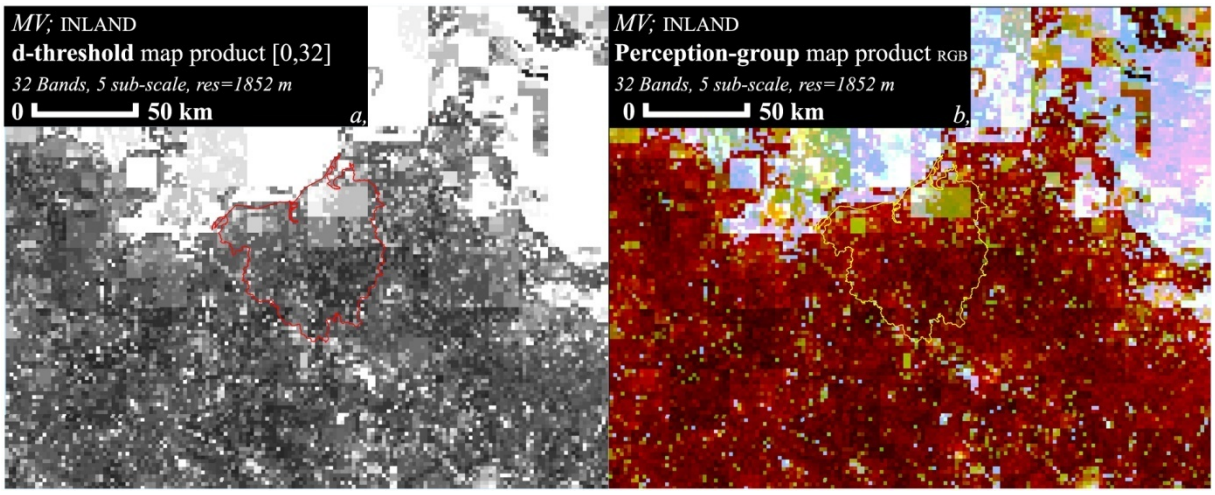

Figure 4. a, d-threshold map-product of INLAND map-model of Mecklenburg-Vorpommern and Rostock Region, pixel values [0,32] standing for by which d-coeff. value area becomes from heterogeneous to homogenous; b, perception-group map-product – R ~ landscape expert d=[0.1, 0.9], G ~ medium perceiver d=[1, 2.2], B ~ weak/children d=[2.4, 3.6].

It must be emphasized, that these maps consider landscape diversity to be a value of its own – not assigning values to different land covers. These map-products were used to analyse the LD related to different land use units, defined in the control-plan of Rostock Region. During the analysis the vector data of the control-plan was overlaid on the raster data of LD map-products. As a result of this analysis, a "regional landscape diversity presentation plan" was prepared, which assigns proposals to control-units of the regional control plan. This presentation plan describes, how the (ecologic, aesthetic, economic) values of landscape diversity could be presented for people, who perceive the landscape. As an example, on Figure 5, the LD assessment of nature-protection areas can be seen, according to the d-threshold values. The colour of the areas shows, how much they can serve the aim to present the value of landscape diversity in nature protection areas. The darker the areas are, the more adequate they are for the demonstration of landscape diversity – since even for visitors with lower perception-resolution the spatial heterogeneity is understandable, recognizable – perceptible.

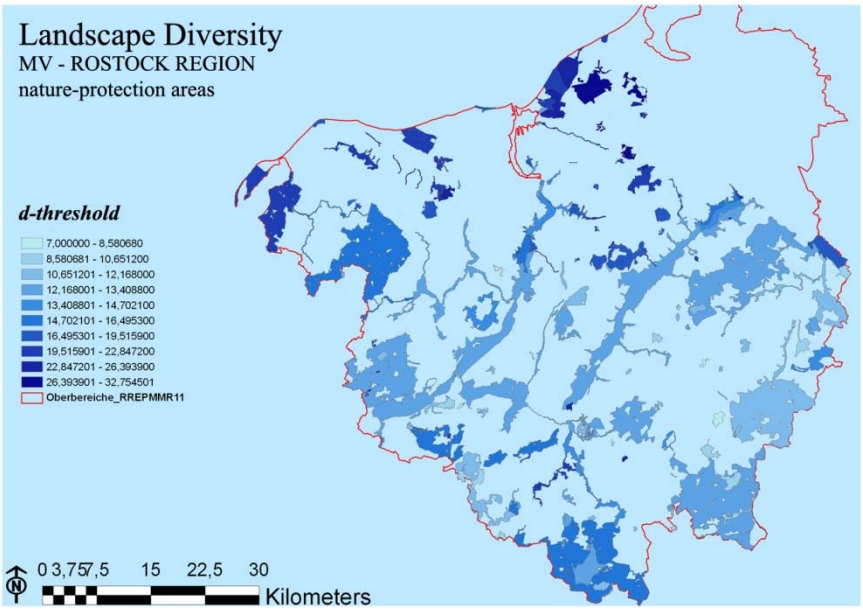

Figure 5. Landscape diversity assessment of nature protection areas in Rostock Region (MV, Germany), with the use of d-threshold map-product of INLAND map-model. Dark blue areas have higher d-threshold , thus in the area LD can be presented for wider group of visitors.

6. Summary

INLAND solutions can model landscape diversity continuously across spatial scales, and in the function of human perception. The automated solutions provide opportunity to utilize Earth Observation imagery, thus besides information mining, the way of data collection can also support the operative monitoring of landscape diversity. As a personal opinion: the greatest value of Hungarian landscapes is their diversity. INLAND provides solutions to take diversity as our national value in order to preserve it and to develop it.

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Operational experienced of an 8.64 kWp grid-connected PV array

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A B S T R A C T

The Department of Agricultural Machinery of the University of Debrecen has a photovoltaic (PV) system. Information's are given about the main operational characteristics and operation experiences. In this research, evaluation of 3 PV modules technologies i.e. monocrystalline PV technology (ST-40), polycrystalline PV technology (KC-120), and amorphous silicon PV technology (DS-40) performed based on points of view energetic in 2011. The produced DC, and AC power, together with the produced energy are as well, and the efficiency can be determined for each used PV technology.

1. Introduction

The Earth receives solar energy (energy from the sun) by way of radiated (light) energy. Refers to quantum theory, light is made up of packets of energy, called photons (tiny particles having no mass), whose energy depends only upon the frequency or color of the light. The energy of visible photons is sufficient to excite electrons, bound into solids, up to higher energy levels where they are relative free to move so that an electrical current can be produce (Nelson, 2003).

Life on Earth is based on solar energy. The outer limit of Earth's atmosphere receives almost a constant amount of radiation of 1352 W/m^2, of which the 23% is absorbed by the atmospheric gases, 26% is reflected, so 51% reaches the Earth's surface in the form of direct or diffuse radiation. In Hungary, the number of sunny hours is 1900-2200 hours per year, the average irradiation intensity is around 1200 Kwh/m^2. (Hagymássy and Fórián, 2009). The Sun emits electromagnetic light in various wavelengths: UV (<400 nm); visible (400-800 nm); infrared (>800 nm). (Rusirawan et al., 2011). Presently, the direct conversion of solar energy into electricity is being accepted as an important form of power generation. This electricity generated by a process known as the photovoltaic effect using photovoltaic (PV)system (cells/modules/panels/array), which are made from semiconductor materials. (Rusirawan and Farkas, 2011)

In Hungary there is a comparable 10 kWp grid-connected PV array system at Szent István University, Gödöllő (Farkas et al., 2008). The PV system in Gödöllő is structured into 3 subsystems (fields). Each subsystem has its own inverter (Farkas et al., 2008).

Vántus (2008) suggested for agricultural enterprises an efficient, environment-friendly solar system.

2. Materials and methods

2.1. The test conditions of the University of Debrecen

There is a demonstration center in the Department of Agricultural-machinery of Educational Research Center where students, teachers and those who interested get an overview of the topic of renewable energy potential and the necessary technological solutions.

The total surface of 8.64 kWp grid-connected PV array system is A=110 m^2.

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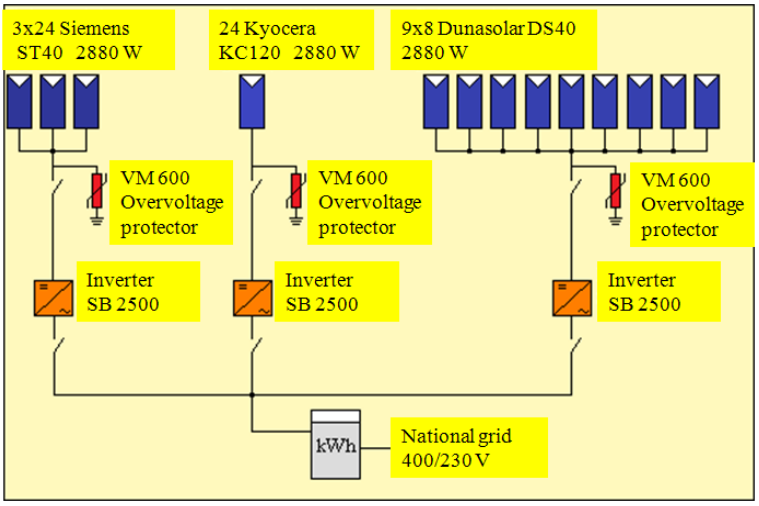

Figure 1. The schematic diagrams of 8.64 kWp grid-connected PV array system

The schematic diagrams of 8.64 kWp grid-connected PV array system can be seen in Figure 1. The PV system in Debrecen is structured into 3 subsystems (fields). The first subsystem has 24 pieces of Kyocera KC 120 W type modules, the second subsystem has 72 pieces of Siemens ST 40W, and the remaining has 72 pieces of Dunasolar DS 40W (Figure 3.). In order to be operable independently of each other three inverter modules (SB 2500) had been installed.

2.2. The inverters

The measured operating and meteorological dates are collected by Sunny Boy Control, produced by the SMA (Figure 2). The Sunny Boy Control has eight analogue and eight digital inputs and eight digital outputs. One of the eight analog inputs is used to measure the air temperature, and one of them measuring the Module temperature.

Figure 2. Sunny Boy (SB 2500) inverters

The recorder can be connected directly to a desktop PC by RS232. Operating and meteorological dates are recorded by MS Excel every 15 minutes.

The power plant is connected to a weather station, which contents a PT 100 type temperature and humidity combined measuring instrument, a CM 11 pyranometer, and a wind speed measuring instrument.

The orientation of the photovoltaic system is nearly to South along with the 30 degrees of fixed inclination angle. Such positioning of the systems means a fairly good yearly optimum value in Hungary concerning to energetic point of view. (Farkas and Seres 2008)

Figure 3. The first subsystem has 24 pieces of Kyocera KC 120 W type modules, the second subsystem has 72 pieces of Siemens ST 40W, and the remaining has 72 pieces of Dunasolar DS 40W modules.

3. Results and discussion

3.1. The energy production in 2011

In 2011, the amount of produced electrical energy is represented by Figure 4 and Figure 5. The energy productions of the subsystems are measured continually and the subsystems are measured separately. As an expected, the produced energy of polycrystalline -Si PV module and monocrystalline -Si PV was higher than amorphous-Si PV module. It is well known that energy analysis is more suitable for energy balance when we design a system, because of this we contribute with the local entrepreneurs helping those designing systems.

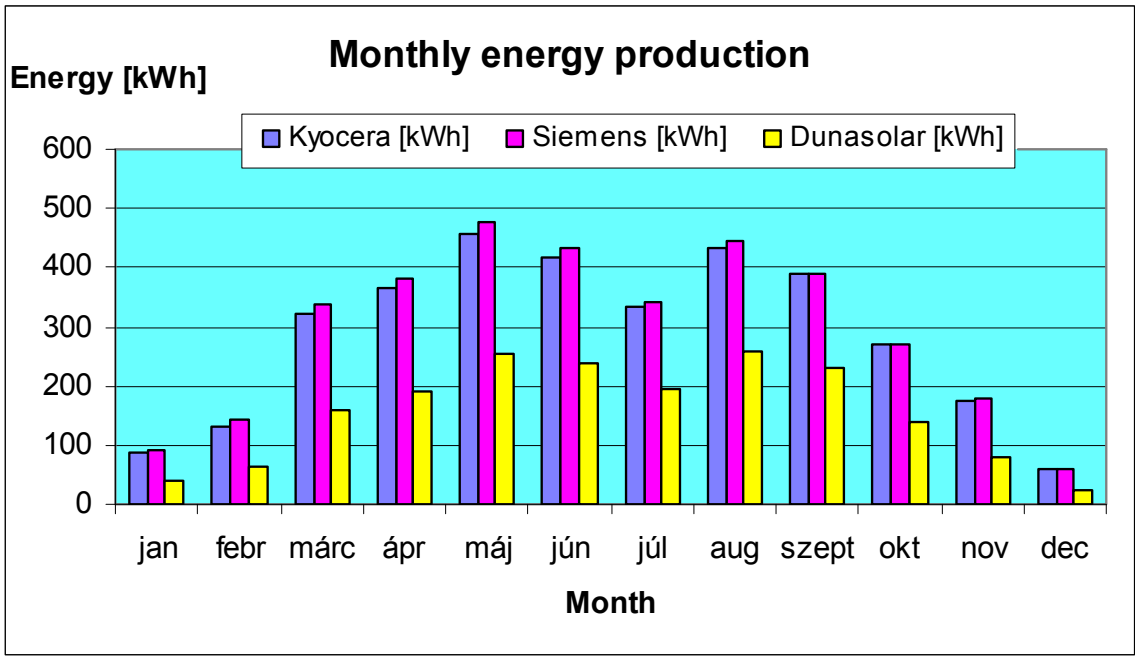

Figure 4. Energy analysis in 2011

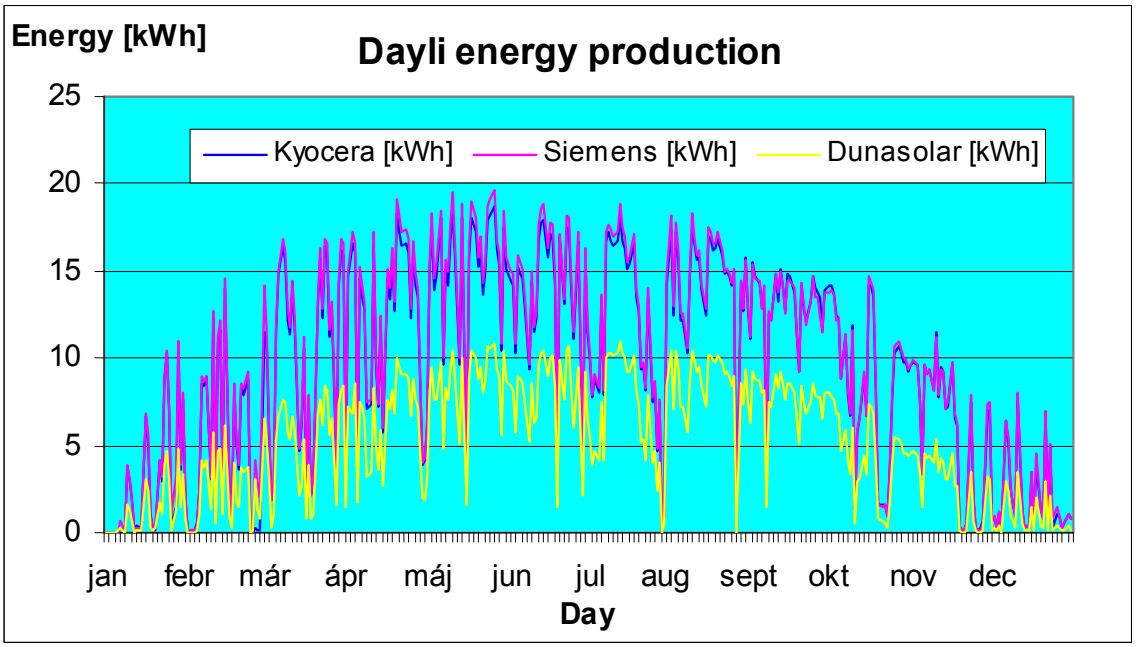

Figure 5. Energy analysis in 2011

3.2. Temperatures and irradiation conditions

The energy of a PV system depends on two major components namely electrical energy and thermal energy (Rusirawan, 2012). While the electricity is generated by photovoltaic effect, the PV cells also get heated due to the thermal energy present in the solar radiation. The air temperature and the temperature of the panels and the global irradiation conditions were measured. In summertime the panel temperature reaches 60-80 degrees in a sunny day. The panel temperatures are in a spring sunny day approximately 30-40 degrees (for example, on the 15th of March 2012). (Figure 6.) It can be concluded that the global irradiation is a major impact feature to influence the amount of energy produced.

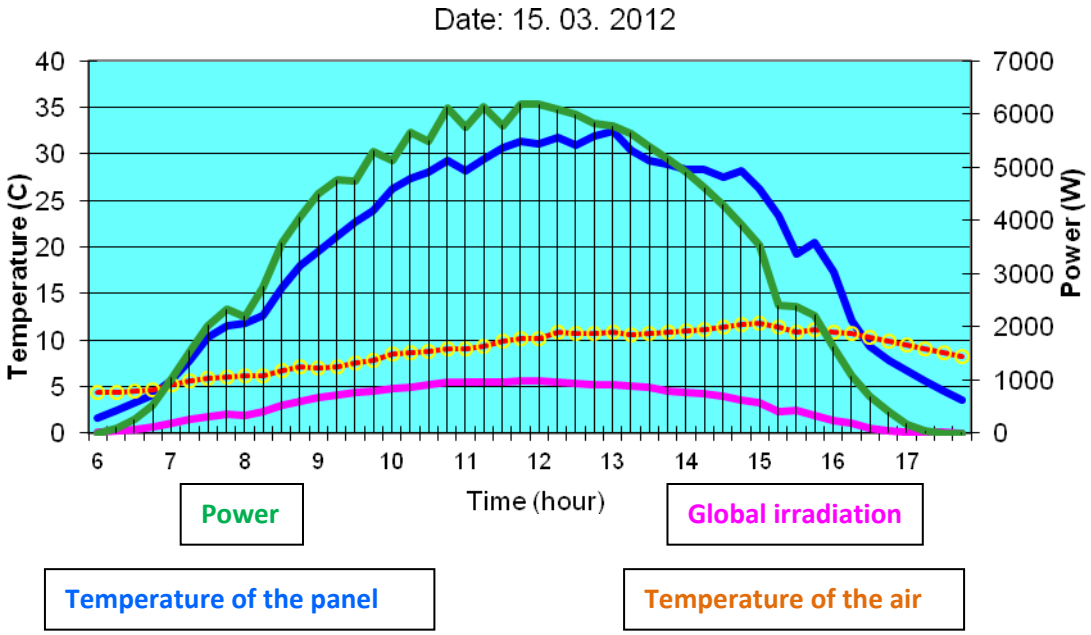

Figure 6. Air temperatures, Temperature of the panels, Irradiation conditions, and Power

3.4. Experiences

The efficiency depends on several parameters (spectral distribution of the incoming light, temperature values, etc.). As the PV system is a multi-component system, the efficiency of the different parts can be calculated and the multiplication of these values provides the system efficiency. In our case not all the part efficiencies are determined, but calculations were carried out for the module efficiency and for the inverter efficiency. According to the suggestion of Farkas and Seres 2008, the cable losses are not taken into the calculations. The time dependence of the efficiency during a month (April, 2012) can be seen in Figure 7.

The energy efficiency of a PV system in general can be defined as the ratio of the output energy of the system to the input energy received on the photovoltaic surface. As an expected, the energy efficiencies of polycrystalline -Si PV module and monocrystalline -Si PV was higher than amorphous-Si PV module. Based on our study, in general it can be concluded that the energy efficiency is lower than theoretical (Figure 7.).

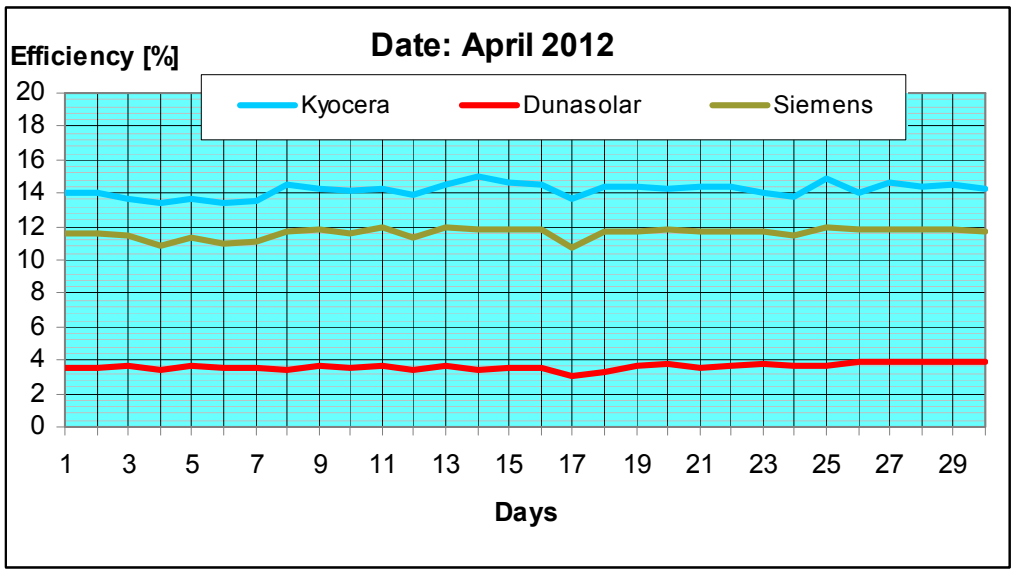

Figure 7. The measured efficiencies

Module Type:

1. Kyocera KC 120W 24 pieces in two rows
Measured efficiency in April: 13-15% (Figure 7.)
The operational experiences: good radiation absorbing ability, aesthetic.

2. Siemens ST 40W 72 pieces in two rows
Measured efficiency in April: 11-12% (Figure 7.)
The experiences of operation: Easy to assemble, low weight (7 kg). Good resistance against environmental affects.

3. Dunasolar DS 40W 72 pieces in four rows
Measured efficiency in April: 3-4% (Figure 7.)
The operational experiences: vulnerable, complex assembly, 2 items were cracked (there were manufacturing defects).

4. Conclusions

The data logging system of a 8.6 kWp grid-connected PV system were discussed in this paper, together with the details of the measured quantities. Based on measurements the distribution of the total energy production was presented together with the distribution of the energy production among the different subsystems in 2011. The energy productions of the subsystems are measured continually. By measuring irradiation and DC and AC power of the system, the efficiency of the two important parts of the system (the PV array and the inverter) were determined. The efficiency of the mono

crystalline module field was calculated around 11…12%, the efficiency of the poly crystalline module field was calculated around 13…15%, while the amorphous module field was 4%.

References

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