CROP DECLARATION AND CONTROL INFORMATION SYSTEM QUALITY EVALUATION

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The aim of this article was to evaluate the quality and effectiveness of Crop Declaration and Control Information System (CDCIS) and to identify the trends of improvement of this system. There are presented results of monographic and empirical of CDCIS quality evaluation according to three of five criteria, identified in standard ISO 9126. To evaluate the quality of this system the following means were created: model of evaluation process; integrated mathematical model; system of criteria and indicators for CDCIS quality evaluation and, also, determined matrixes of these indicators. Using prepared questionnaires 4 experts provided evaluation of importance of CDCIS quality indicators and 16 users provided evaluation of means of these indicators. Using the integrated mathematical model the common index of CDCIS quality it was calculated. The fact that mean of common CDCIS quality index is equal to 0.93 allowed to make conclusion that quality and effectiveness of Crop Declaration and Control Information System is very good, but could be improved by using the recommended measures.

Key words: IS effectiveness, IS quality, model, evaluation.


Introduction

For quite a long time since independence was re-established in Lithuania in 1990, very poor attention has been paid to the development of Agricultural Information Systems. Only in 1998, by the request of the Ministry of Agriculture and Forestry, specialists of the Lithuanian University of Agriculture prepared the concept of development of such information system [6]. In this concept the Agricultural Information System was defined as an open system, with no fixed number of subsystems, meeting requirements of national and the EU legislation and having possibilities to provide necessary information for economical units, state and local authorities in Lithuania and for the EU institutions.

According to the National ACUIS, Lithuania till the beginning of membership in the EU had to develop and implement all necessary subsystems of Agricultural Information System and to test its functioning in practice. Crop Declaration and Control Information System was created and implemented in 1999 as prototype of Parcels Identification System, which was the subsystem of Integrated Administration and Control System. To be sure, that newly created Integrated Administration and Control System would be functioning correctly, at the end of 2002 the evaluation of quality of Crops Declaration and Control Information System was carried out.

The purpose of research – to evaluate the quality of Crops Declaration and Control Information System (CDCIS) by using multi-criteria analysis methods and to determine the ways of this system quality improvement.

To implement this purpose, the following tasks were solved:

- Preliminary analysis of CDCIS;
- Analysis of IS effectiveness evaluation models and methods and estimation of the possibilities to use them for CDCIS quality evaluation;
- Creation of new model for CDCIS quality evaluation;
- Adoption of multi-criteria analysis methods for calculation of the common index of CDCIS quality;
- Creation of system of criteria and indicators for evaluation of CDCIS quality, based on the analysis of scientific publications and requirements of standard ISO/IEC 9126;
- Evaluation of quality of CDCIS by using the created model and summarising results of this research.

The object of research – Crops Declaration and Control Information System.
The methods of research – the monographic, logical analysis, development of questionnaire, observation, expertise, statistical analysis and synthesis.

Preliminary analysis of research object

Crops Declaration and Control Information system (CDCIS) was created and implemented on the base of the Regulation N656 of the Government of the Republic of Lithuanian on 25th May, 1999 and Commissions Regulations, concerning the presentation and processing of data about land usage for agricultural purposes.

The main purpose of creation of CDCIS was to collect data about the land area, used for crops and other purposes in farmers’ farms and agricultural enterprises. This data was used for administration of state support for producers of various kinds of agricultural production and for statistical purposes. Also, there was other purpose of significant importance – the improvement of abilities of institutions, participating in this process, to prepare themselves for administration of the EU direct payments.

From technological point of view the process of data collection and processing included the following steps:

- The economical units had to present filled forms of Crops and Land Use Declarations to agricultural departments of local authorities from May 1st till June 15th.
- The specialists of agricultural departments of local authorities had to perform preliminary check the correctness of the provided data, to enter this data into computers and send it to the central database, which was located in Agribusiness and Rural Development Centre.
- The specialists of Agribusiness and Rural Development Centre had to enter the collected data into the central database and to provide the revision of data identity (not less 20% of presented declaration forms) and to make correction of incorrect data.

The summarised information about number of provided declarations, area of the land, used for crops and other activities had to be presented to the National Paying Agency, to the Ministry of Agriculture and to the other institutions, including Statistical Department. Furthermore, the Agribusiness and Rural Development Centre had to provide list of agricultural units, which declaration forms data had been checked according to the methodology, assigned by the Director of the National Paying Agency, and to present special forms for checking the data, provided in declaration forms of agricultural units, to agricultural departments of local authorities and to National Paying Agency.

Data checking on the spot had to be provided by the staff of agricultural departments of local authorities. The forms with results of revision had to be sent to Agribusiness and Rural Development Centre. Having compared the data, provided in declaration forms of agricultural units and presented in the forms of checking on the spot forms, records in the database were corrected, general amount of support and the sum of support, which had to be provided for each agricultural unit, were calculated. This payment of support had to be provided by National Paying Agency.

The research methods

During latest years various researchers have offered to use the following methods for evaluation of effectiveness of Information Systems: Benefit and Expenses, Value, Hedonic, Praxis, Nolan/Norton & Company, Picot/Reichvald, Sassone/Schwartz, FAOR and Porter/Millar. The expediency and significance of such methods depend on various factors such as description of research object and purposes, aspects of evaluation, possibilities to choose the criteria and indicators for effectiveness evaluation, amount of labour and other inputs to be provided in this evaluation. According to altitude principle the effectiveness of IS can be determined as a difference of benefit from IS usage and expenses of its creation, implementation and exploitation. Evaluation of the benefit can be provided from economical, technical and social viewpoints or their combination. Decrease of labour and financial expenses can be expressed in monetary form, but quality of information processing and working conditions – by qualitative measures. The process of expenses calculation has to take into account not only direct expenses of IS creation, implementation and exploitation, but also indirect expenses, such as rent and exploitation of the office, institution administration, etc.

There is another approach to determination of the effectiveness of information system. This effectiveness can be described as a difference of economical effect (benefit) of enterprise before and after implementation of this system. However, economical effect of enterprise depends on many aspects inside and outside of it, so, identification of the effect, which has been influenced only by implementation of information system, is impossible. Following L. Simanauskas, the effectiveness of information system can be described as a feature of this system, which shows its capability to perform some functions [21]. Information system can be recognized as effective, if it provides all necessary information for decision making, is widely used, meets the requirements of end-users and is functioning very well [21]. Similar view is provided and by P. Keen. He proposes, that IS can be considered as effective one without calculation of the difference between benefit and expenses in the case, when IS benefit has reached some level and expanses do not exceed the defined limits [18].

Taking into account the following facts, that one of main purposes of creation of CDCIS is clear and effective administration of state support for agricultural producers; that data, necessary for administration of support, is not processed by using other IS or manual data processing technologies; and that in the process of creation and implementation of this system the planed financial and other re-
sources are not exceeded, the authors of this paper have come to the conclusion, that calculation of benefit of usage and expenses of creation and implementation of this system have not to be included into process of CDCIS quality evaluation.

Considering the specific features of CDCIS and the main purposes of its creation, the method has been chosen, which in the process of quality evaluation of this system allows taking into account following technical and social aspects:

- Quality of hardware, software and their interrelations;
- Quality of information and its processing technologies;
- Satisfaction of end-users on sufficiency of information and acceptability of usage.

The process of CDCIS quality evaluation, following principles of this model, consists of three stages:

1) Definition of the task of evaluation;
2) Preparation for evaluation;
3) Providing the procedure of evaluation and interpretation of results.

In the first stage, according to the purposes of creation of CDCIS, tasks and primary technical requirements, have to be formulated the IS quality characteristics and possible sub characteristics. These requirements include the following:

1) Creation of IS quality characteristics evaluation criteria system;
2) Estimation of evaluation criteria and indicators importance, according to evaluation purpose;
3) Determination of quality evaluation meanings definitions;
4) Selection of data collection methods.

The second stage of IS quality characteristics evaluation process includes the following tasks:

1) Selection of the indicators, which most precisely reflects researched IS characteristics for each IS quality evaluation criteria;
2) Selection of metrics of these indicators;
3) Definition of rating level of these indicators;
4) Selection of indicators evaluation methods.

Several methods can be used to warrant precise evaluation of each indicator. However, in the process of the evaluation method selection, not only the reliability of the method, but also its exploitation expenses must be considered.

The third stage includes the procedure of IS quality evaluation: the meanings of CDCIS quality indicators are measured and evaluated, the ratings of importance of these indicators are determined, the common CDCIS quality index is calculated and results of CDCIS quality are interpreted.
An integrated mathematical model for calculation of the common index of CDCIS quality

The multi-criteria analysis methods are used to unify the different score of indicators and to calculate the common index of quality. For the purpose of evaluation of IS quality by using such methods, it is necessary not only to establish the indicators, but also to evaluate its importance on common IS quality. It is advisable to base the estimation of the importance of IS quality on expert’s opinion. Scientific works suggest different expert’s opinions estimation methods. The relative weight method, suggested by the Zhang (2000), is used to rank the indicators importance. Different expert k can differently evaluate importance of each indicator i. In the case of this method application, expert or expert’s group use comparison method in points, for example, from 1 to 7 to establish the importance of each indicator rik. To decrease the tendency of expert’s opinion, averages of all estimations z_i are calculated [23]:

\[ z_i = \frac{\sum_{k=1}^{l} r_{ik}}{l}, \]

where: r_{ik} – importance of indicator i evaluated by expert k, \( l \) – number of experts.

The common sum of meanings of indicators importance must be equal to 1, \( \sum_{i=1}^{n} z_i =1 \). To achieve this purpose, the importance of each indicator (Z_i) must be calculated by using the following formula [23]:

\[ Z_i = \frac{z_i}{\sum_{i=1}^{n} z_i}, \]

where: z_i – the average importance of each index i, \( n \) – number of IS quality indicators.

The meanings of evaluated indicators must be generalized in order to compare them. For this purpose the maximal \( x_i^{\text{max}} \) and minimal \( x_i^{\text{min}} \) meanings of each indicator must be identified:

\[ x_i^{\text{max}} = \max \{ x_{ij} \}, \]
\[ x_i^{\text{min}} = \min \{ x_{ij} \}, \]

where: x_{ij} – identified meaning of indicator i in the trial j.

After this had to be identified indicators which have the positive influence on IS quality by increasing of its meaning, and indicators, which have the positive influence on IS quality by decreasing of its meaning. The aggregated meaning of each indicator \( X_i \) can be calculated as difference between the ideal and identified meaning [22]:

\[ X_i = \begin{cases} \frac{x_i - x_i^{\text{min}}}{x_i^{\text{max}} - x_i^{\text{min}}} & \text{, when increasing of meaning has positive influence on IS quality;} \\ \frac{x_i^{\text{max}} - x_i}{x_i^{\text{max}} - x_i^{\text{min}}} & \text{, when decreasing of meaning has positive influence on IS quality.} \end{cases} \]

The common meaning of IS quality index (E) is calculated by the formula:

\[ E = \sum_{i=1}^{n} (Z_i X_i) \]

The calculated common IS quality index had to be in the range \( 0 \leq E \leq 1 \). The high quality of IS may be established in the case, when the meaning of the common IS quality index is closed to 1.

According to the standard ISO/IEC 14598-1:1999(E) generalized IS quality evaluation can be presented in word form, for example, very good, good, satisfactory or bad. For each of these evaluations the ranges of common IS quality index must be identified according to the importance, specific features and evaluation purposes of the evaluated system. The authors of this paper suggest to evaluate the CDCIS quality as very good in the case, when the meaning of common IS quality index is within the range from 0.9 to 1.0, good – when this meaning is within 0.9 - 0.8, satisfactory – when this meaning is within 0.8 - 0.6, and bad - when this meaning is less then 0.6.

If the common IS quality is evaluated as bad, IS does not meet the requirements and have be improved essentially or have be changed to other new system. In the other case, when the common quality of the researched IS is evaluated as very good, good or satisfactory, the conclusion can be made, that IS meets the requirements, can be useful and successfully developed in the future.

Preparation for research of CDCIS quality characteristics

One of the most complex and mostly discussed stages of IS quality evaluation is the creation of the system of the IS quality criteria and its indicators. The common IS quality depend on the used hardware, communication devices, software and interaction of peoples in the course of information processing.

According to the standard ISO/IEC 9126 and specific features of Crop Declaration and Control Information System the system of IS quality evaluation criteria has been selected. To avoid the processing of large amount of not important data, authors have make the conclusion to research only the most important quality criteria presented in the standards ISO/IEC 9126 - 1 and ISO/IEC 9126 – 3: functionality, reliability and acceptability for users. For these three common IS quality characteristics evaluation a detailed IS quality evaluation criteria have been selected.
and the system of the main CDCIS criteria has been created (Table 1).

For evaluation of all these indicators have been selected units of measurement and metrics have been determined.

<table>
<thead>
<tr>
<th>Criteria Description</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Suitability</td>
<td>Information system’s correspondence to hardware requirements</td>
</tr>
<tr>
<td>2 Adequacy</td>
<td>Information system’s correspondence to law certificates</td>
</tr>
<tr>
<td>3 Conformance</td>
<td>Inter-conformance of separate IS parts and conformance with other information systems and state registers</td>
</tr>
<tr>
<td>4 Adaptability</td>
<td>IS possibility to work at not essential changes of conditions</td>
</tr>
<tr>
<td>5 Security</td>
<td>Possibility to secure database from external threats</td>
</tr>
<tr>
<td>6 Reliability</td>
<td>The program meets employee’s requirements for IS reliability</td>
</tr>
<tr>
<td>7 Fault tolerance</td>
<td>The errors’ tolerance in processing of IS information</td>
</tr>
<tr>
<td>8 User satisfaction</td>
<td>IS convenience for using</td>
</tr>
</tbody>
</table>

The estimation of importance of CDCIS quality indicators

To estimate the importance of separate IS quality criteria and indicators for the common IS quality the questionnaire has been performed and CDCIS creators, authorized control specialists and the heads of some institutions has been examined. The specialists have estimated the importance of each indicator for the common IS quality. Estimation is established in seven points scale. The one point estimation is for the indicators with a low influence on common IS quality. Seven points estimation is for the indicators with a large influence on common IS quality. The estimated importance of IS quality indicators and calculated generalized meanings of importance of each indicator are presented in Table 2.

<table>
<thead>
<tr>
<th>Experts</th>
<th>Estimating averages</th>
<th>Modular importance meanings</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1</td>
<td>E2</td>
<td>E3</td>
</tr>
<tr>
<td>1.1</td>
<td>Correspondence of technical means to initial requirements</td>
<td>7</td>
</tr>
<tr>
<td>1.2</td>
<td>Correspondence of software to initial requirements</td>
<td>7</td>
</tr>
<tr>
<td>1.3</td>
<td>Correspondence of computers network to initial requirements</td>
<td>7</td>
</tr>
<tr>
<td>1.4</td>
<td>Quality of IS functioning documentation</td>
<td>7</td>
</tr>
<tr>
<td>2.1</td>
<td>Correspondence of IS to law certificates</td>
<td>6</td>
</tr>
<tr>
<td>3.1</td>
<td>Conformance of separate parts of information system</td>
<td>7</td>
</tr>
<tr>
<td>3.2</td>
<td>IS conformance with other IS and State registers</td>
<td>5</td>
</tr>
<tr>
<td>4.1</td>
<td>Adaptability of operating system</td>
<td>6</td>
</tr>
<tr>
<td>4.2</td>
<td>Adaptability of data input software</td>
<td>7</td>
</tr>
<tr>
<td>5.1</td>
<td>Data protection by infrastructure means</td>
<td>7</td>
</tr>
<tr>
<td>5.2</td>
<td>Data protection by administrative means</td>
<td>6</td>
</tr>
<tr>
<td>5.3</td>
<td>Data protection by software and hardware means</td>
<td>7</td>
</tr>
<tr>
<td>6.1</td>
<td>Computer hardware reliability</td>
<td>6</td>
</tr>
<tr>
<td>6.2</td>
<td>Reliability of databases management systems</td>
<td>7</td>
</tr>
<tr>
<td>6.3</td>
<td>Reliability of relation means</td>
<td>7</td>
</tr>
<tr>
<td>6.4</td>
<td>Reliability of data input software</td>
<td>6</td>
</tr>
<tr>
<td>7.1</td>
<td>Tolerance of initial data errors in electronic storage</td>
<td>7</td>
</tr>
<tr>
<td>7.2</td>
<td>Tolerance of data errors in central database</td>
<td>7</td>
</tr>
<tr>
<td>8.1</td>
<td>Convenience of data input software</td>
<td>5</td>
</tr>
<tr>
<td>8.2</td>
<td>Simplicity of data referral</td>
<td>6</td>
</tr>
<tr>
<td>Total:</td>
<td>1,00</td>
<td></td>
</tr>
</tbody>
</table>

Evaluation of the meanings of CDCIS quality indicators

In the course of analysis of this system the decision was made to invite for evaluation of meanings of CDCIS quality indicators users of this system – persons, who record the initial data to computers storage and use the collected data for their day-to-day work. Sixteen of thirty specialists working in agricultural departments of local authorities have answered the questionnaire. Having processed and summarized the questionnaire data the following results are received:

1. Suitability
   1.1. The hardware corresponds to the initial requirements and is evaluated at the score very good. The hardware fully corresponds to initial requirements and ensures functionality of CDCIS.
1.2. The software corresponds to the initial requirements and is evaluated at the score very good. The operating system, database management system, computers network management software and application software fully correspond to the initial requirements.

1.3. The computer network corresponds to the initial requirements and is evaluated at the score very good. The computer network and its telecommunication components, which connect local network with other networks, fully correspond to the initial requirements and warrant the 100 Mbps speed for local network and 11 Mbps speed for Internet connections.

1.4. CDCIS functionfing documentation corresponds to the initial requirements and is evaluated at the score good. The suggestions of CDCIS users are registered and the works of CDCIS improvement are documented.

2. Adequacy

2.1. The information system adequacy is evaluated at the score very good. The amount of collected data and formulated reports corresponds to the requirements.

3. Conformance

3.1. Inter-conformance of separate parts of information system is evaluated at the score very good. The applied hardware and software warrant full interaction between CDCIS and its separate parts.

3.2. Conformance of information system with other information systems and State registers is evaluated at the score good – no direct data from the Farmers Farms and from Territorial Administrative Units, Inhabited Localities and Streets of the Republic of Lithuania state registers is revise.

4. Adaptability

4.1. The adaptability of operating system is evaluated at the score very good. Operating system is fully adapted.

4.2. The adaptability of data input software is evaluated at the score very good. All respondents assume, that data input software is adapted for their needs and does not required improvement.

5. Security

5.1. Data security by using means of infrastructure is evaluated at the score very good. All required means of infrastructure are used for data security.

5.2. Data security by using administrative means is evaluated at the score very good. All required administrative means are used for data security.

5.3. Data security by using hardware and software means is evaluated at the score very good. All required hardware and software means are used for data security.

6. Reliability

6.1. Computer hardware reliability is evaluated at the score very good. The computer hardware meets all reliability requirements.

6.2. Database management system reliability is evaluated at the score very good. Database management system meets all reliability requirements.

6.3. The reliability of relation means is evaluated at the score very good. The relation means meets all reliability requirements.

6.4. The reliability of data input software is evaluated at the score very good. All respondents assume, that there are no software errors, which affect data losses or damages.

7. Fault tolerance

7.1. The fault tolerance of collected initial data is evaluated at the score enough. 80% of respondents assume, that there are no logical data errors, 15.3% of respondents assume, that there are logical data errors and 6.7% of respondents have not answered this question.

7.2. The correctness of data in central database is evaluated at the score very good. The logical revise of data and no direct revise by using state registers eliminate the possibility to present the incorrect data to central database.

8. User satisfaction

8.1. The convenience of data input software is evaluated at the score enough. 80% of respondents assume, that data input programme is convenient for use, 20% of respondents assume, that this programme is partially convenient, and there are no respondents with negative answers.

8.2. The simplicity of data translating is evaluated at the score very good. The users can use all means of data translating to central database.

Five points scaled rating levels for evaluating of each indicator have been established: 5 – very good; 4 – good; 3 – satisfactory; 2 - not satisfactory; 1 – bad. The calculated modular meanings of each IS quality indicator and common CDCIS quality index are presented in Table 3.

Table 3. Evaluating of CDCIS quality indicators

<table>
<thead>
<tr>
<th>№</th>
<th>IS quality indicators</th>
<th>Importance of indicators (Z)</th>
<th>Evaluating of indicators</th>
<th>Levels of indicators ratings</th>
<th>Modular importance of indicators (X)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Correspondence of technical means to initial requirements</td>
<td>0.058</td>
<td>Very good</td>
<td>5</td>
<td>1.00</td>
</tr>
<tr>
<td>1.2</td>
<td>Correspondence of software to initial requirements</td>
<td>0.054</td>
<td>Very good</td>
<td>5</td>
<td>1.00</td>
</tr>
<tr>
<td>1.3</td>
<td>Correspondence of computers network to initial requirements</td>
<td>0.054</td>
<td>Very good</td>
<td>5</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Conclusions and suggestions

The performed research allows to make the following conclusions and suggestions:

1. According to the viewpoint, that the information system can be accepted as effective if it can perform some functions, the Crop Declaration and Control Information System effectiveness can be determined only by evaluation of its quality without calculations of its economical advantages and expanses.

2. For the purpose to avoid the necessity to process less important data, the quality of Crop Declaration and Control Information System are researched by using only three criteria from the standard ISO/IEC 9126 – 3 – functionality, reliability and user satisfaction.

3. Researched quality of CDCIS can be evaluated as very good in the case, when the value of the common CDCIS quality index is within the range from 0.9 to 1.0; evaluation good can be used, when this value is within 0.8 - 0.9; evaluation satisfactory can be used, when this value is within 0.6 - 0.8 and not satisfactory, when this value is less than 0.6.

4. Crop Declaration and Control Information System can be recognized as effective, because the established value of the common quality index of this system is 0.93 and the properties of this system can be evaluated as very good.

5. The used model for evaluating of Crop Declaration and Control Information System quality indicators makes it possible to determine the works, the processing of which should increase the following quality indicators:
   - Establishing the possibility to write the data from municipality computers to central database online;
   - Establishing online revise of input data by comparing with the data of Farmers Farms and of the Territorial Administrative Units, Inhabited Localities and Streets of the Republic of Lithuanian state registers and also providing the possibility to use data of these registers for formation of record of CDCIS databases.

   • Improving the data input software of document form „Crops“ to computer storage, including logical revise of input data.

References