# Information system as used to monitor sowing, care and harvesting on agricultural lands

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**Abstract.** Active digital transformation of Russian agriculture, especially of precision agriculture, accounts for the relevance of the present research. The developed reference information systems and software products that automate processes in this area are independent and most often do not cover the full cycle of obtaining agricultural products. Integrated use of methods for designing and developing a software product allowed creating an information system used to monitor agricultural plants growth. The present research describes the functionality of the developed system, and lists user categories and user interface prototypes.

## 1 Introduction

Agriculture has a long history of being regarded as unattractive industry for investors due to the long production cycle which is subject to natural risks and, accordingly, large yield losses at any production stage (growing, harvesting or storage), to difficulties/impossibility of automating biological processes and to the lack of progress associated with increasing productivity and introducing innovations [1]. In this regard, information systems had limited use, mostly in managing finances and supporting commercial transactions [2, 3].

Over time, active implementation of digital technologies in Russian agriculture showed new trends. In 2021, Mikhail Mishustin, approved the strategic direction for digital transformation of the agro-industrial complex and fisheries. In 2022, creation of a scientific center for introducing technologies in agriculture was approved; moreover, purchase of software for large agricultural companies is actively financed. In 2023, state information systems are created in seed and grain production, and a digital register of agricultural land is launched. [4, 5]. In general, over the past five years, significant changes in Russian agriculture were due to active implementation of software solutions for assessing and modeling crops development, precision farming and other types of agricultural work with the help of stream data processing, automatic control, weather data analysis, data visualization, forecasting, etc. [1, 6, 7].

Software systems development is mainly aimed at digitalizing large agricultural organizations. Notably, in 2016-2021 in Russia, the sown area increased from 76.6 million to 77.8 million ha, and in farms, this area increased by 3 million ha, reaching 25 million

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[https://tass.ru/ekonomika/14636281]. Changes in indicators fully justify development of information systems aimed at monitoring processes for small organizations without significant sources of funding.

Thus, the research *aims* to create a complex that provides monitoring for sowing, care and harvesting on farms. The set goal requires the following tasks: determining the categories of system users and the system structure, developing algorithms for the system to function and createing a prototype of the software product.

The *theoretical significance* of the research lies in the systematized theoretical framework of sowing, caring for and harvesting crops depending on external conditions, and in adapting it to be used in digital ecosystems of agricultural organizations. The *practical significance* lies in using the obtained results to maintain processes in agricultural organizations in order to reduce growing, care and harvesting costs.

## 2 Materials and methods

Developing an information system required studying all the aspects of the problem area: identifying the qualitative and quantitative characteristics of key objects and their interaction features and establishing external factors influencing the implemented processes. Structural analysis, synthesis, statistical analysis, grouping and abstraction were used for this purpose [8, 9].

The comprehensive methods for developing the information system were as follows:

- object-oriented modeling for creating a conceptual model of the system;
- information modeling for creating a logical data model that allows automatic collection, storage and processing of data without loss or excessive duplication;
- object-oriented programming for creating program code as a set of interacting objects [10, 11].

## 3 Results

The aforementioned research methods allowed developing the client-server structure of the information system which includes the following *links*:

1. *The client part* as a mobile application or web-based interface, allowing the user (depending on access level) to create and edit digital twins of land plots, to manage the location and level of care of agricultural crops, and to collect reference information about the current state of land plots;
2. *A link of sensors* that collect and send data on the current state of the land plot, for example, sensors for humidity, salinity, temperature, and light;
3. *A database* that stores and provides access to the following data: users and associated land plots, information on crops (growth and watering periods, periods for applying fertilizers, care timing, etc.), information on planted crops in the relevant areas (date and place, variety), background information, and data from sensors;
4. *Application server* that stores the business logic of the entire system, meaning that all the algorithms that calculate the timing of watering, fertilizing, care and harvesting are implemented with the help of programming tools at the specified link.

Table 1 shows the main screens of the mobile application that ensures functioning of the information system.

**Table 1.** Mobile application screens and their functionality description.

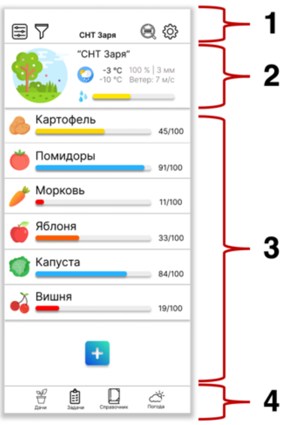
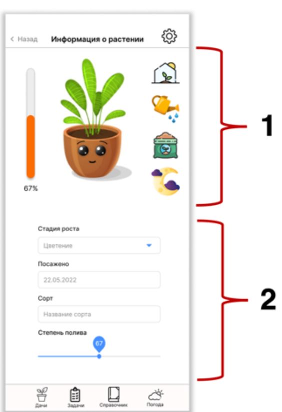
| **Screen image** | **Screen area numbe r** | **Description** |
|---|---|---|
| *Screen describing the current state of the land plot* | | |
|   | 1 | Panel for joint search and filtering of planted crops on a selected plot and for customizing the technical information (temperature, humidity, etc.) displayed |
| | 2 | Panel with the plot description: name (user configurable), current plant state (based on completed tasks for watering, fertilizing, care and cleaning), current environmental state (weather conditions, soil conditions) |
| | 3 | Panel of current tasks which are listed based on planted crops – adding a new crop or another variety automatically determines future tasks. Changes in the progress scale are based on current weather conditions and on farming works |
| | 4 | Pinned functional panel for navigating the application: selection of plots assigned to a specific user, a list of tasks to complete on the selected plot, reference books on crops available in the application, and weather conditions help center |
| *Screen describing the current state of the selected plant on the land plot* | | |
|   | 1 | Panel with a graphic interpretation of the plant state – its overall progress on the left, icons showing what needs to be done on the right. The example shows that plant is in a greenhouse, requires watering and fertilization, and also shows weather conditions |
| | 2 | Panel describing the selected task to complete. The example shows the growth stage, timing of planting and transition to another stage, as well as a scale for watering level change (either manually or based on sensor data or weather conditions) |
| *Screen showing current environmental conditions* | | |
|   | 1 | Calendar panel |
| | 2 | Panel with weather conditions and soil conditions for a selected date based on the information received from sensors or from open sources for the region. In addition, the data can be adjusted based on readings from sensors located in nearby areas |
| | 3 | Panel of additional information about external conditions affecting the plot (user configurable). The example shows the lunar calendar |

Table 1 demonstrates some of the application screens where functionality is available depending on the user's role in the system. The following roles are available:

1. *System administrator* has access to the database; manages system security settings; carries out data archiving; manages the functionality of and creates new user categories.
2. *Administrators* moderate users; update reference content on agricultural crops; update, add or delete tasks associated with plant categories; add, update, or remove sensor categories and associated functionality; interact with users. This is a team of specialists whose functionality is divided into segments, meaning the administrator associated with sensors does not manage the help content and therefore does not have access to this segment. Each new administrator in a segment can only be added by an acting administrator from this segment.
3. *Agronomist* is a user with the ability to create digital twins of land plots with crops, to receive reports on the progress and quality of work performed, to generate statistics on various indicators, to control the operation of sensors, and to control workers or unmanned equipment.
4. *Worker*: a user who carries out work directly in the field, i.e. performs watering, fertilizing, harvesting, etc. Moreover, if a system of unmanned equipment or any robotic system is installed on the farm, the worker configures it and monitors the indicators automatically received by the system. If tasks are performed manually, the worker independently enters the necessary data on the results into the system.

Several basic algorithms for the system functioning in terms of farming can be presented in view of the information above. When an *Agronomist* registers in the system, they gain access to reference resources on agricultural crops and are able to create digital twins of land plots linked to a map.

Based on the received geolocation information, the application determines the climate and soil composition to adjust tasks based on external conditions.

The *Agronomist* correlates the digital twins with the crops that will be grown on the land (selects the type and variety) and sets the planting date. From this moment, the system considers the plot sown and sets *a work calendar* until harvesting, based on the crop characteristics and adjusted daily to external conditions. For improving the indicators, sensors are installed on the land plot, which automatically generate a dataset at specified intervals to make corrections of the work being carried out.

The task list is available to the *Agronomist* and to the assigned *Worker* users associated with specified plots. Notification systems are created for *Workers* regarding the need to carry out certain work. If a task is missed, a report is created for the *Agronomist*, and the work calendar is adjusted.

# 4 Discussion

The main directions of agricultural digitalization are precision agriculture and livestock farming [4]. Russian researchers proved that in terms of the former, fields are partially digitized, and differentiated sowing, weed spraying, fertilization, and analysis for diseases are carried out [4, 5]. The results of the present research correspond to the listed areas and allow consolidating them within a single software platform, which allows obtaining complete analytical data that qualitatively influences forecasts and determining factors that positively and negatively affect agricultural production [1, 6, 12].

The developed information system corresponds to modern trends of digitalizing business processes in various organizations and enterprises [7, 10, 13]. The resulting user interface is intuitive and does not require additional specialized training for users performing work on the farm. Notably, the resulting software product is of interest to specialists receiving agricultural education [4, 14].

## 5 Conclusion

Information systems based on farm management technologies optimize indicators such as: fertilizers use; plant protection products; costs for sowing and harvesting. This is achieved through the automation of manual labor, which significantly reduces production costs and increases productivity. Digitalizing the agricultural sector is crucial for innovative development of the global and local economy.

The results obtained determine a systematic approach to digital transformation of agriculture. The developed software product will allow controlling the full cycle of crop production using devices for transmitting data on the current environmental state, using universal algorithms for processing data from these devices and suggesting control actions to improve or maintain the necessary conditions of the observed object. The resulting system can be integrated into an ecosystem including a unified network that exchanges and manages data that allows maximum automation of agriculture.

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