Expected Programming of Efficiency of Sugar Beet with Application of GIS Technology

G.E. Omarova, M.N. Sennikov, E.O. Omarov and Zh. E. Kolbachaeva

Faculty of Water Resources, Environment and Construction, Taraz State University named after M.Kh. Dulan, Taraz, Kazakhstan

Submitted: Oct 14, 2013; Accepted: Nov 19, 2013; Published: Nov 23, 2013

Abstract: Features of climatic conditions of the southern region of Kazakhstan strongly influence formation of superficial water resources and all microclimate of the region. It is necessary to make for reduction of complex monitoring and the analysis short and long-term forecasting on the basis of GIS DB. In this regard productivity indicators were received on: potential productivity, climatic security of productivity, really possible productivity and productivity in production.

Key words: Forecasting · Database · Monitoring · GIS · Moisture contents · Limitation · Agroecosystem · Drainage · Contour · Culture · Erodibility

INTRODUCTION

The lands located in an arid zone with high-energy resources and low natural moisture; require carrying out a complex of meliorative actions for cultivation of crops. Therefore at the end of the XX century in all regions of the southern Kazakhstan has the big development, irrigated agriculture which occupied about 2.4 million hectares, from them 1.5 million hectares were located in the territory of the South and southeast regions of the republic.

Important factor of a choice of the main directions of ameliorative impact on land grounds is in particular in case of irrigation the climate [1].

Complex monitoring and the analysis of economic activity of the person and influence it allows to allocate the following directions which are possible at the decision for environment and definition is short - and long-term expected indicators on the basis of a database of the geographical information systems (GIS) - echo-economic justifications of criterion of an assessment and the forecast of all its components in the conditions of concrete economic activity of the studied region. Owing to climatic features of various regions of the republic to 90% of a drain of superficial sources it falls on the spring period. Superficial water resources are distributed on the territory extremely unevenly and hesitate by years and in a year, causing uneven security of various regions and branches of economy [2].

Now water supply is carried out (85% of security) at the expense of superficial water sources, other part at the expense of underground and sewage. Deficiency of water resources leads to reduction of water consumption of meliorative lands in the republic. At rational use of water resources of Kazakhstan it is possible to irrigate to 5 million hectares of lands that more than twice covers needs of irrigated lands. In this regard the most actual and necessary is the solution of a question on forecasting of a choice of resource-saving technologies of an irrigation with use of a database of geographical information systems (GIS DB), thus it is necessary to consider the adopted resolutions and rules on regulation of water resources at the basin agreement and the decision executive bodies of the republic. They include collecting,
storage, transformation and various ways of display of existential information on geographical and geological and other properties of environment. GIS cover all spatial levels, from global to municipal, integrating the most various information - cartographical, space, statistical, materials of field researches, etc. Forecasting and stockpile management of water resources depending on a year of water security demands multiple-factor security and the analysis of the studied region which allow to receive expected indicators on creation of plans, coordination of schedules, adoption of important decisions on use of water resources.

To expect an essence of expected programming of a crop of crops to a set of accidents of the nature, to find a way out of those unexpected difficulties for the farmer, which are connected with nature whims.

Applied aspects of modeling of efficiency of agro ecosystems in the present’s time are reduced to development of methods of programming of a crop generally on the generalized soil and climatic indicators [3-4]. Prime stage of programming is definition of level of a crop counting on which has to be under construction all agrotechnology. To prove our approach to the solution of this, tasks we will give some systematization of levels of the crops, representing development of the known scheme of authors [7, 8].

According to offered classification the following categories of crops differ:

- The potential crop (PC) - a crop which can be received in ideal soil climatic conditions and HEADLIGHTS limited only by arrival;
- Climatic provided crop (KU) - a crop depending only on action of these or those meteorological factors;
- The really possible crop (RPC) - a crop which can be received on a concrete field taking into account its real fertility;
- Crop in production (unitary enterprise) - the actual crop that usually has been a little underestimated in comparison with TWO-owing to a non-optimal agrotechnology and losses at cleaning.

As well as any classification, such scheme is conditional, however it well reflects real sequence of the restrictions imposed for a crop by external factors.

According to definition [8] for calculation of PU it is possible to use dependence

\[ Y_{pc} = \frac{R_f \sum Q_f}{100q} \]  

Here:

- \( Y_{pc} \) - Potential crop of absolutely dry biomass (t/hectare);
- \( Q_f \) - Summary arrival of HEADLIGHTS for the vegetative period;
- \( q \) - Caloric content of unit of dry organic substance (17 10^kZh);
- RF - Coefficient of use of HEADLIGHTS crops answering to ideal soil climatic conditions (%).

Transition from a crop of absolutely dry biomass of \( Y \) by a crop of useful production of \( Y \) is carried out on a formula [8].

\[ y = \frac{100Y}{(100 - a_b)y} \]  

where - standard humidity of useful production (%),

The sum of parts of the relation of useful production to a collateral biomass in the general crop (for example if the relation of weight of a useful crop to the mass of collateral production makes 1:1.2 that =2,2).

Climatic provided crop of \( Y_c \) (t/hectare) usually is less potential and it can be calculated, using a ratio [8].

\[ y = R_M Y_{ib} \]  

where \( R_M \) - the dimensionless coefficient reflecting limitation of a crop by these or those meteorological factors (\( R_M \) 1).

In particular, when such limiting meteorological factor is moisture, equalities (3) take a form

\[ Y_{ry} = \frac{\sum E_e}{\sum E_0} Y_{ry} \]  

where \( E_e \) and \( E_0 \) respectively total evaporation and an evaporability from crops during vegetation.

Considering physical sense of sizes and, we receive the following approximate:

\[ Y_{sy} = \frac{W_c - W_s + \sum f}{2.4 \sum R_6} Y_{sy} \]  

Here: \( W_c \) and \( W_s \) respectively initial and final moisture contents in the soil (mm),

- Precipitation during vegetation (mm)
- Total during vegetation radiation balance (kJ/cm²).
Sometimes at Ku's calculation instead of (3) use the empirical ratios, which directly are not including the size YPU. For example, at Ku's limited moisture security often I determine by a formula

\[ Y_{ky} = \frac{10 \sum W}{R_w}, \]  

(6)

where \(-\sum W\)- resources of efficiency of moisture during vegetation (mm);

\( R_w\)- water consumption coefficient.

Good coincidence to real data gives also calculation of YKU for a so-called hydrothermal indicator (GTP).

According to definition [9],

\[ \Gamma \Pi = \frac{T \sum W}{8.6 \sum R_\sigma}, \]  

(7)

Where: \( T \)- duration of the period of vegetation (decade);

\( \sum W \) and \( \sum R_\sigma \)- resources of productivity of moisture (mm) and summary during vegetation radiation balance (kJ/cm²).

Between GTP and a limiting crop exist a ratio.

\[ Y_k = 2.2 \Gamma \Pi - 1.0, \]  

(8)

The last theoretical level - really possible crop of UDVU (t/hectare) - can be as a first approximation found, proceeding from a ratio:

\[ y_{10v} = y_0 + \frac{B - B_0}{100} y_{ky}, \]  

(9)

Here:

UKU - Climatic provided crop (t/hectare) calculated one way or another;

\( V \)- Site class of a concrete field (%);

\( B_0 \)- Site class of most poorly cultivated fields of the region (%);

\( U_0 \)- An average crop, which can be received on fields with point site class.

The main objective of programming of crops at the present stage is finishing of a production crop to level really possible. However because of annual fluctuations of limiting meteorological factors climatic provided and with it agrees and really possible crop will change year by year.

Application of this technology of programming of productivity of field cultures in the conditions of irrigated agriculture of Zhambyl area is the most actual in the analysis of productivity of the sugar beet, as a result dominating use of this culture in irrigated agroecosystems of this region and layout of plants on processing of this culture in the territory of Zhambyl area.

Potential, or the greatest possible crop (UNITARY ENTERPRISE) of sugar beet can define by means of a mathematical model of productional process and crop formation. For its approximate assessment use a formula.

\[ y_{1by} = 10^4 \eta K_m \sum Q \rho \]  

(10)

where - Occupation efficiency of HEADLIGHTS (efficiency of HEADLIGHTS);

\( K_m \)- Coefficient economic efficiency of a crop, or \( K_{s pivotal} \):

- summary for the vegetative period arrival of HEADLIGHTS, kcal/cm²;

- Caloric content of a biomass, kcal/kg.

In a zone of cultivation of this sugar beet arrival of HEADLIGHTS during vegetation makes 26-34 kcal/cm² or 2.6-3.4 billion kcal/hectare. Caloric content of a root crop is equal on the average 4450 kcal/kg In the general biomass on 1c root crops 0.4 c of leaves with footstalk are necessary. At this \( K_m=0.714 \) (1:1.4 parts) when calculation conduct on a dry biomass of root crops and \( K_m=3.57 \) (0.714:20%*100%) - for a crop of the root crops containing 20% it is absolute solid. Using a formula (1) count a crop of root crops which it is possible to program in case of arrival 34 kcal/cm² of HEADLIGHTS, assimilation by its plants for 4% and caloric contents of one root crop of 4450 kcal/kg

\[ y_{pc} = 10^4 \cdot 4\% \cdot 3.57 \cdot \frac{34\text{kcal/cm}^2}{4450\text{kcal/kg}} = 109 \text{l/c h}, \]  

(11)

In the conditions of an optimum soil food and moisture security leaves of sugar beet acquire 1.5-2 times more solar radiation in comparison with average conditions ands the biomass gain on the fertilized soils is 2-3 times higher, than on averages on fertility.

In case of low security of plants with elements of a power and moisture the area of leaves appears no more than 10-15 thousand sq.m/hectare. In this case crops absorb only insignificant part of energy of HEADLIGHTS. Crops as though automatically regulate
the optical properties and energetic balances bringing into accord quantity of energy absorbed by plants with availability of available water. If during this period fall out besiege, growth of plants amplifies and the area of leaves reaches optimum value. Here the law of the regular system at the plants which entity consists that they continuously receive information from an external environment comes into effect, processing it on the basis of what strengthen or decelerate processes occurring in an organism. The knowledge and the accounting of these properties of plants will allow the agronomist correctly, depending on developing weather conditions, to approach to selection of cultures in a crop rotation and to select such complex of agrotechnical receptions which will reduce the negative influence of a factor limiting a crop.

Further proceeding from given a possible crop of sugar beet depending on arrival of HEADLIGHTS, from moisture security of crops, from the contents in the soil of easily hydrolyzed nitrogen, phosphorus, potassium; it is possible to solve problems with application of GIS of technologies with the best use of a cultivated area and an assessment of quality of lands on their suitability of use under crops of sugar beet.

Statement and the solution of a task on the best use of the cultivated lands under crops of crops probably is based on the analysis of the agricultural cultures given programming. Initial information in developed technology considers the following indicators: land relief and its derivative characteristics (biases, watersheds), drainage of the territory and extent of its moistening: capacity of a soil profile; soil type; the maintenance of a humus in the soil; acidity of the soil; depth of ground waters; contour; culture of lands; erosive danger; erodibility degree; granulometric structure; carbonate; extent of salinization; indicators of HEADLIGHTS and etc.

The part from these indicators is applied with use of visual cartographical data, on the basis of GIS. Another is set in the form of tabular data.

By means of the specialized, a part applied software of GIS this problem is solved as follows:

- According to the initial card (or to a picture) the electronic card of studied uniform sites is created.
- The base of attributive these sites and the design file are created. The binding of attributive data to the chosen sites is made.

The table contains all attributive data of each site. It includes all data on the areas, perimeters and to suitability indicators on different factors (to a bias, the power of a soil profile, type of the soil, the maintenance of an organism in the soil, acidity of the soil and etc.) each site.

- The database necessary for multiple-factor classification is created.

The table [aptness classification] contains all standard data for classification by each factor. This table is fundamental for classification.

The table [aptness classification weight] contains the weight (importance) of each factor for classification.

The table [aptness lookup table] contains the list of compliance of each type of lands on suitability for a concrete type of crops to a graphic layer displayed on EK.

The table [aptness map] keeps results of classification.

- Performance of classifications. As a result of performance of classifications in the table [aptness map] the list of compliance of each site to different type of suitability of lands remains [11, 12].

Proceeding from the analysis of efficiency of sugar beet using indicators of HEADLIGHTS, moisture security, the maintenance of nutritious elements of the soil and application of GIS of technology of an assessment of quality of lands on their suitability of use under crops. Will probably count efficiency of sugar beet cultivated in the future for the set site that will allow to calculate profit on a predicted crop, comparing with the analysis of expenses for cultivation, GIS of technology allow to analyze profitability of cultivation of sugar beet for a certain site (Table 1).

Table 1: Predicted structures of crops, productivity and gross collection of crops on Zhambyl area (2009-2015 yy.)

<table>
<thead>
<tr>
<th>Cultures</th>
<th>Cultivated area, one thousand hectares</th>
<th>Productivity, c/hectare</th>
<th>Gross collection, one million tg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn</td>
<td>8.5</td>
<td>40</td>
<td>0.043</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vegetables</td>
<td>17.2</td>
<td>300</td>
<td>0.602</td>
</tr>
<tr>
<td>Long-term herbs</td>
<td>52.1</td>
<td>85</td>
<td>0.495</td>
</tr>
<tr>
<td>Corn on a silo</td>
<td>4.7</td>
<td>350</td>
<td>0.165</td>
</tr>
<tr>
<td>Annual herbs</td>
<td>2.6</td>
<td>300</td>
<td>0.091</td>
</tr>
</tbody>
</table>

753
Sugar beet is one subsidized crops today since during formation of our state a rupture of existing communications between the states (concerning regulation of water resources) both outdated methods and technologies of cultivation and an irrigation of crops (sugar beet and other leading crops) demand radical restructuring further. Obtaining expected data on the basis of multiple-factor monitoring it is possible only by application of innovative technologies of an irrigation since the choice and justification on the basis of GIS-of technologies will allow to make forecasts on short and the long-term periods of research and to coordinate to ways and technology of its cultivation.

REFERENCES