Abstract

The stable development of regional economics requires research and analysis based on the set of management scenarios. Implementation of the latter can be achieved by building stable development models. They will allow us to select the best scenarios taking into account the mentality of our country and implement forecast of region stable development.

The problems of building research and analysis models for the effective planning of region stable development based on situation self-development scenario and control impact on it is considered in the paper.

In weakly structured organizational systems the need of making decision in course of control process appears. Situation development laws and patterns are described in qualitative manner. In situations where dynamics of their development is not subject of any patterns experts and analytics take part. They use their own experience and intuition when making decisions.

Keywords: Region Stable Development, Goals Tree, Local Goal, Global Goal, Region Development Model

Introduction

The important stage of creation, development and implementation of organizational systems is pre-design analysis and modeling. Development of modern large-scale complex systems has stimulated keen interest to modeling methodology.

When analyzing complex organizational systems the set of goals and factors to be achieved by the system can be formulated.

Information technology for selection of optimal set of system goals and operation modes consists of the several phases:

Structuring system goal means that main or global goal of system operation is selected. This is assigned a zero level and the latter is decomposed by sub-goals.[1]

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>C0</td>
<td>Region’s sustainable development</td>
</tr>
<tr>
<td>C1</td>
<td>Social indicator</td>
</tr>
<tr>
<td>C11</td>
<td>Struggle against poverty (%)</td>
</tr>
<tr>
<td>C12</td>
<td>Demographic dynamics (%)</td>
</tr>
<tr>
<td>C13</td>
<td>Support of education, personnel preparation and society’s awareness (%)</td>
</tr>
<tr>
<td>C14</td>
<td>Health protection of population (%)</td>
</tr>
<tr>
<td>C15</td>
<td>Support of population’s sustainable development (%)</td>
</tr>
<tr>
<td>C111</td>
<td>Growth rate of population’s employment (%)</td>
</tr>
<tr>
<td>C112</td>
<td>Ratio of average wage of men and women (%)</td>
</tr>
<tr>
<td>C113</td>
<td>Population living under poverty threshold (%)</td>
</tr>
<tr>
<td>C114</td>
<td>Ratio of incomes of rich and poor</td>
</tr>
<tr>
<td>C121</td>
<td>Population’s growth rate (%)</td>
</tr>
<tr>
<td>C122</td>
<td>Population’s migration rate (%)</td>
</tr>
<tr>
<td>C1211</td>
<td>Population’s density (%)</td>
</tr>
<tr>
<td>C1221</td>
<td>Growth of birth rate (%)</td>
</tr>
</tbody>
</table>

* Prof. Dr., Faculty of Technical Science, Georgian Technical University, Tbilisi, Georgia. E-mail: zur_gas@gtu.ge

** Prof. Dr., Faculty of Informatics and Control Systems, Georgian Technical University, Tbilisi, Georgia. E-mail: mziakiknadze@gmail.com

*** Ph.D, Georgian Technical University, Tbilisi, Georgia. E-mail: zviad_jan@gtu.ge
### C11: Growth rate of school age population (%)
- C111: Growth rate of quantity of graders (%)
- C112: Growth of quantity of pupils of secondary school (%)
- C113: Ratio of educated people among old (%)
- C114: Population with 5-class education (%)
- C115: Average quantity of school classes
- C116: Number of girls per 100 boys in secondary school
- C117: Number of women per 100 men in service field
- C118: Ratio of national income per capita (%)
- C119: Ratio of population living without clean drinking water
- C1110: Ratio of population living without sewerage (%)
- C1111: Ratio of population living in environment with contaminated, hazardous air (%)
- C1112: Death rate per 1000 newborns (%)
- C1113: Population’s average life expectancy

### C12: Growth of quantity of graders (%)
- C121: Ratio of national income per capita (%)
- C122: Average quantity of school classes
- C123: Number of girls per 100 boys in secondary school
- C124: Number of women per 100 men in service field
- C125: Ratio of national income per capita (%)
- C126: Ratio of population living without clean drinking water
- C127: Ratio of population living without sewerage (%)
- C128: Death rate per 1000 newborns (%)
- C129: Population’s average life expectancy

### C13: Growth of quantity of pupils of secondary school (%)
- C131: Ratio of national income per capita (%)
- C132: Average quantity of school classes
- C133: Number of girls per 100 boys in secondary school
- C134: Number of women per 100 men in service field
- C135: Ratio of national income per capita (%)
- C136: Ratio of population living without clean drinking water
- C137: Ratio of population living without sewerage (%)
- C138: Death rate per 1000 newborns (%)
- C139: Population’s average life expectancy

### C14: Ratio of educated people among old (%)
- C141: Ratio of population living without clean drinking water
- C142: Ratio of population living without sewerage (%)
- C143: Death rate per 1000 newborns (%)
- C144: Population’s average life expectancy

### C15: Population’s average life expectancy
- C151: Growth rate of urban population (%)
- C152: Ratio of urban population (%)
- C153: Ratio of rural population (%)
- C154: Entrepreneurship (%)
- C155: Export ratio (%)
- C156: Fuel consumption per capita (%)
- C157: Ratio of urban population per national income (%)
- C158: Expenses on building of cheap housing (%)
- C159: Expenses on public transport (%)
- C1510: Infrastructural expenses per capita (%)
- C1511: Marginal population and area (m²/quantity)
- C1512: Ratio of residential area per capita (m²)
- C1513: Marginal population and area (m²/quantity)
- C1514: Ratio of deceased because of different natural disasters (%)

### C2: Economic Indicator
- C21: Economic development (%)
- C22: Change of demands
- C23: Ratio of shortening of natural resources (%)
- C24: Investment ratio (%)
- C25: Energy consumption per capita
- C26: Financial mechanisms and resources (%)
- C27: Internal support for development (%)
- C28: External support for development (%)
- C29: Ratio of debts per domestic product (%)
- C210: Debt services (% according to debt)
- C211: Ratio of gross domestic product per capita
- C212: Adjusted gross domestic product per capita (%)
- C213: Export ratio of gross domestic product (%)
- C214: Additional financing for sustainable development (%)

### C3: Ecological Indicator
- C31: Water resources (%)
- C32: Terrestrial resources (%)
- C33: Other natural resources (%)
- C34: Atmosphere
- C35: Waste (ton per year)
- C311: Protection of resources and quality of fresh water (%)
- C3111: Annual water expenses (ton)
- C3112: Reserves of ground waters (m²)
- C3113: Concentration of excrements in reserves of fresh water (100ml)

### C4: Ecological Indicator
- C41: Ratio of domestic product per environment protection (%)
- C42: Ecologic taxation and subsidies (%)

---

The Fig. 2 depicts the tree for the above goals and sub-goals:

![Goals and sub-goals tree](image)

Assigning weights to system goals. Ranking of goals occurs by evaluation of each of them through numerical values – their “weights”. Experts or expert group make this evaluation and assignment. This evaluation has subjective character. The goal is described by text sentences and can contain numerical indices. The method is known as hierarchical analysis method.
Interaction of goals to determine if how important is the goal (to introduce tree’s nodes weights) is evaluated and in accordance with the expert evaluation points are introduced. The interaction strengths of goals $C_i$ and $C_j$ are evaluated by linguistic formulas and are expressed numerically in the interval $[1-10]$.

For each fragment of the goal tree (starting from the zero one) a quadratic matrix $R=\begin{pmatrix} r_{ij} \end{pmatrix}$ is created.

The matrix columns correspond to tree’s nodes. In the upper entry of the he right column the weight of the root node (for the global goal $C_0$ the weight is $W_0=1$) is given. At the intersection of the row $C_i$ and column $C_j$ the value $r_{ij}$ is determined, this value is equal to 1 if $C_i = C_j$; if $C_i$ is more important than $C_j$ then $b_{ij}$ is determined, otherwise - the value $1/b_{ij}$.

Let us select a two-level fragments (from top to bottom) that consist of root node and all nodes that are incident to it. The fragment that contains the tree’s root node is assigned the zero rank. The lower level’s nodes of this fragment represent the root level for the first rank nodes.

The goal tree’s fragment $(C_0, C_1, C_2, C_3, C_4)$ has the zero rank. The goal tree’s fragments $(C_1, C_{12}, C_{13}, C_{14}, C_{15})$, $(C_2, C_{21}, C_{22}, C_{23})$, $(C_3, C_{31}, C_{32}, C_{33}, C_{34}, C_{35})$, etc. have the first rank.

In the example under consideration the equation system relevant to zero fragment has the form (1):

$$
\begin{align*}
    w_1 &= \frac{1}{4} (w_1 + 3w_2 + 3w_3 + 3w_4) \\
    1) \\
    w_2 &= \frac{1}{4} \left( \frac{1}{3} w_1 + w_2 + 3w_3 + 3w_4 \right) \\
    w_3 &= \frac{1}{4} \left( 3w_1 + \frac{1}{3} w_2 + 3w_3 + 3w_4 \right) \\
    w_4 &= 1 - \left( w_1 + w_2 + w_3 + w_4 \right)
\end{align*}
$$

As a result of solving this system we obtain the weights of goals $C_1, C_2, C_3, C_4$.

Such kind of equation systems are formed for other fragments. By solving equations systems for the first rank fragment $(C_1, C_{12}, C_{13}, C_{14}, C_{15})$, etc. the weights of goals $C_{11}, C_{12}, C_{13}, C_{14}, C_{15}$ is obtained.

$$
\begin{align*}
    W_{11} &= \frac{1}{5} \left( 3W_{11} + 3W_{12} + 3W_{13} + 3W_{14} \right) \\
    W_{12} &= \frac{1}{5} \left( \frac{1}{3} W_{11} + 3W_{12} + 3W_{13} + 3W_{14} \right) \\
    2) \\
    W_{13} &= \frac{1}{5} \left( \frac{1}{3} W_{11} + \frac{1}{3} W_{12} + \frac{1}{3} W_{13} + 3W_{14} \right) \\
    W_{14} &= \frac{1}{5} \left( \frac{1}{3} W_{11} + \frac{1}{3} W_{12} + \frac{1}{3} W_{13} + W_{14} \right) \\
    W_{15} &= 1 - (W_{11} + W_{12} + W_{13} + W_{14})
\end{align*}
$$

Minimization of system local goals. Since the amount of simple goals and factors can be very large, it is necessary to carry out numerical evaluation and ranking of the most important goals and factors in order to select the most effective goals and factors.

To build the cognitive map of local goals interdependency the fact that the table’s rows and columns correspond to local goals. As a result of analysis and agreement with experts the cognitive map, which has the form for given fragments, was obtained (fig.3). The numerical indices - reachability degrees of global $(C_0)$ and local $(C_j)$ goals - were introduced. They have the following form for the above-considered zero rank tree’s fragments (2):

$$
(C_j) = \sum_{i=1}^{N} \left( a_{ij} + a_{2i} + a_{3i} + a_{4i} \right) W_j
= (a_{0j} + a_{1j} + a_{2j} + a_{4j}) W_j + (a_{1j} + a_{2j} + a_{4j}) W_j + (a_{1j} + a_{2j} + a_{4j}) W_j + (a_{1j} + a_{2j} + a_{4j}) W_j = 3.5101
$$

The computations gave the result: $J(C_0) = 3.501$.

The reachability degree for the subsets of goals (taken into account their interdependency) is expressed by the formula:

$$
J(C^*) = J(c_{j1}) + \ldots + J(c_{jk})
$$

$J(C^*)$ is the maximum acceptable reachability degree and is denoted as $\Delta$. In the considered case its value is 0.2101.

Let us form the minimization problem: $C^* \in C$ must be found so that the following conditions would be fulfilled simultaneously:

$$
(3) \quad J(C^*) \leq \Delta \\
|C^*| = \max
$$

The result of minimization for the local goals is $E=\{b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8\}$.
References


Gubko, M. V. (2002). Games Theory in organizational systems control. Moscow, CYNTET.


