

System dynamics model of the Croatia with inbuilt war situation 1953 - 2033

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Abstract

The Computer Simulation Model of the Socio-Economic and Ecological System of the "CROATIA"-SEESC had been developed in accordance with the System Dynamics Approach. It is a continuous model and at the same time discrete digital model because it is presented as a system of non-linear differential equations and it is presented as a system of difference equations (System Dynamics DYNAMO-software program-package) and its "DT" (length of intervening time = computation interval) is chosen in full accordance with the Sampling Theorem (Shannon and Kotelnikov). In this paper the authors have presented the principles of the application possibilities of the System Dynamics Modeling Approach on the Socio-Economical and Ecological Systems of Croatia. Further, they have conducted elementary observations on the Socio-Economic and Ecological Systems of CROATIA-SEESC, their four regional parts (CMZSR, CSOSR, CNWACRSR and CDACSR), the Space and Environment Sector-SES of the CDACSR, and the high aggregated structural models of the SES, ecological model of the CDACSR, and rudimentary global model of the SEESC. The developed model covers period from years 1953 to 2033, with inbuilt war situation (1990-1995).

Keywords: *System dynamic, economic system, ecology, modeling, simulation.*

1. The socio-economic and ecological system of "Croatia"-SEESC

The Socio-Economic and Ecological System of "CROATIA"-SEESC is presented as an entity consisting of:

I - The four Socio-Economic and Ecological Sub-Regions-SEESR: 1. -CROATIAN-MID-ZAGREB SUB-REGION-"CMZSR"; 2. -CROATIAN-SLAVONIAN-OSIJEK SUB-REGION-"CSOSR"; 3. -CROATIAN-NORTH-WEST ADRIATIC COAST-RIJEKA SUB-REGION-"CNWACRSR" and 4. -CROATIAN-DALMATIAN SUB-REGION-"CDACSR" (Figure 1.).

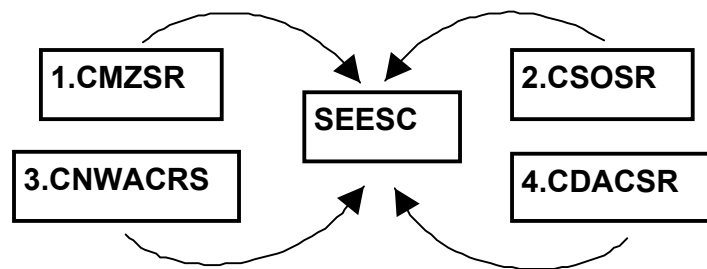


Figure 1. Model of “CROATIA”-SEESC

The SEESC is analyzed as a “whole” consisting of the four sub-regional parts: CMZSR, CSOSR, CNWACRSR and CDACSR. These sub-systems communicate with their relevant environment that consists of 1. -CROATIA without CMZSR, ... (CSOSR, CNWACRS and CDACSR without CROATIA), 2. -Former Yugoslavia (without Croatia), 3. -Mediterranean (without former Yugoslavia) and 4. The rest of the world (the remaining developed countries, except those of the Mediterranean) (*Figure 2.*)

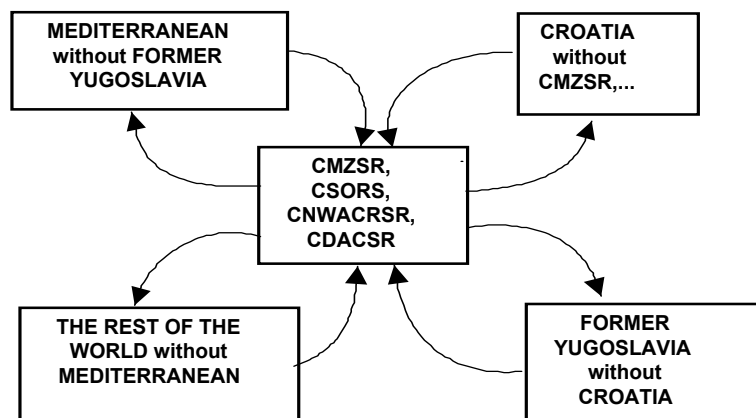


Figure 2. The rudimentary and analogous flow-communication between the regional sub-systems of the SEESC.

II. - Each has seven relevant sectors: 1. -Population, 2. -Economic activities, 3. - Social activities (social and national income), 4. -Internal space, environment and pollution, 5. -Economic output (social and welfare activities), 6. -Socio-economic development policy and 7. -External relevant environment (*Figure 3.*)

The SEESC as a social and ecological “overall” context, comprising of the territory outlined by the Adriatic aquatorium and the continental area, which, within the national context, is defined as the area of the Republic of Croatia. At the same time,

SEESC is part of the Mediterranean Regional Socio-Economic Ecological System and the Rest of the World-Socio-Economic Ecological System at the same time. It's relevant territory; i.e. the "continental, maritime and aerial space" is the ones communicating with their relevant environment.

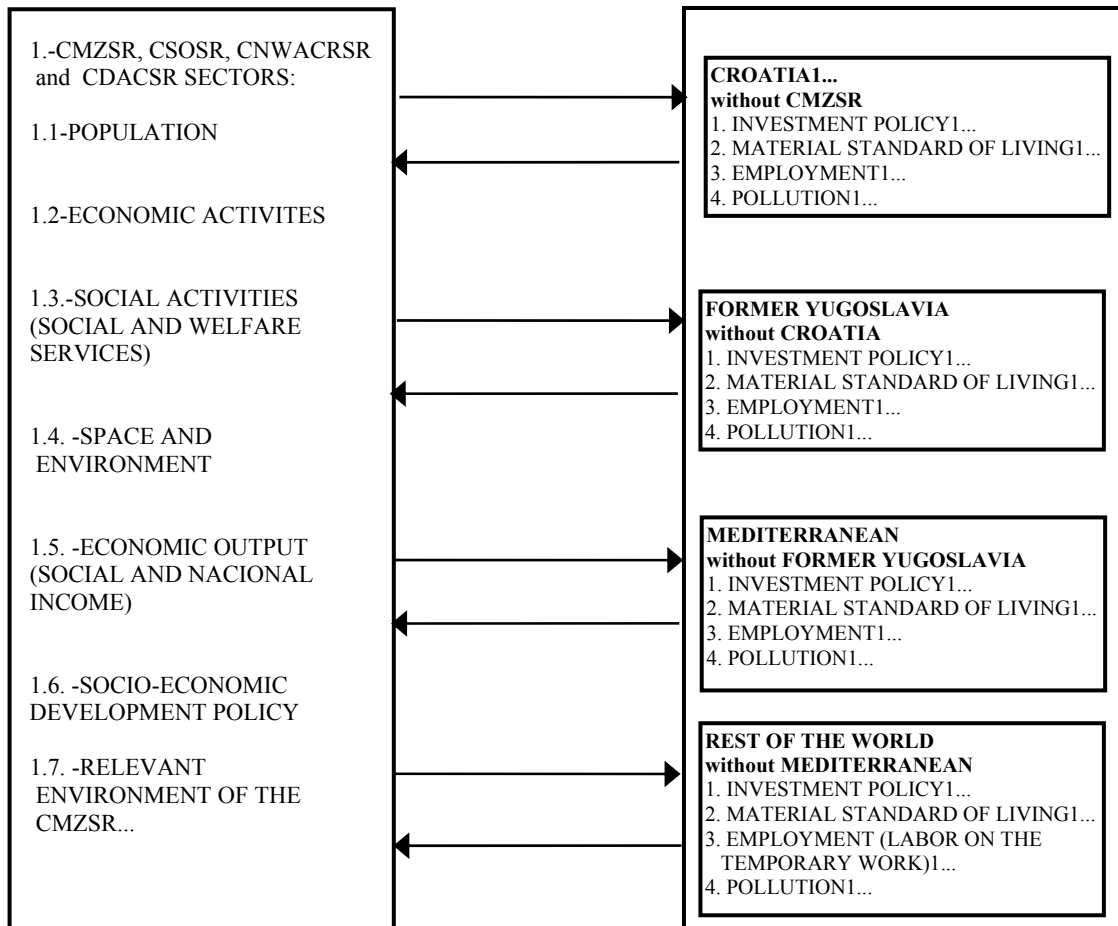


Figure 3. The High Level Aggregation Organization System of the SEESC and its analogous regional sub-systems-CMZSR, CSOSR, CNWACRSR and CDACSR.

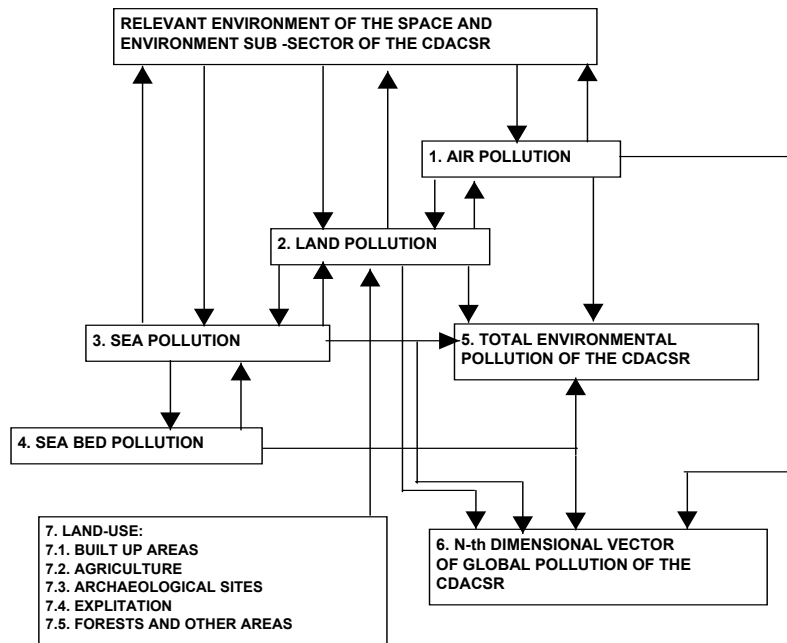


Figure 4. The Regional Space and Environmental Sectors of the CDACSR high aggregated model.

2. Space and the environment sector of the CDACSR

The SEESC is composed of the four sub-regions and only two of them have maritime space: CNWACRSR and CDACSR. At least one material, energy or information flow, which is particularly important for the behavior dynamics of a complex organization system SEESC or its four sub-regional systems are circulating through communication channels. As a rule, many material and information flows circulate through communication channels such as: population, funds, goods and services, flows of agreed information, political information, cultural, scientific, technological information flows, pollution flows, etc.

In this paper, the authors have presented in more detail only one of the more relevant sectors: The SPACE and ENVIRONMENT SECTOR-SES of the CDACSR (CNWACRSR, CMZSR and CSOSR have analogous models). The SES of the CDACSR is being desegregated: 1. -AIR POLLUTION; 2. -LAND POLLUTION; 3. -SEA POLLUTION; 4. -SEA BED POLLUTION; 5. -TOTAL ENVIRONMENTAL POLLUTION OF THE CDACSR; 6. -N-th DIMENSIONAL VECTOR OF GLOBAL POLLUTION OF THE CDACSR; and 7. -LAND-USE (*Figure 4*).

3. High-aggregated structural model of the SEESC-Croatia

It is true that any regional or global regional SEESC is naturally an “open loop” problem and cannot be “resolved” mathematically, meaning that we might have to “close” global SEES by introducing relevant feedback loops, or cause-consequences links, between SEESC and its “relevant” environment, namely: CDACSR (and CMZSR, CSOSR and CNWACSRs, as well). Their relevant environments are: SEESC (without CDACSR, ...CMZSR, CSOSR and CNWACSRs, as well), FORMER YUGOSLAVIA without CROATIA, MEDITERRANEAN without FORMER YUGOSLAVIA and THE REST OF THE WORLD without MEDITERRANEAN COUNTRIES (*Figure 5.*).

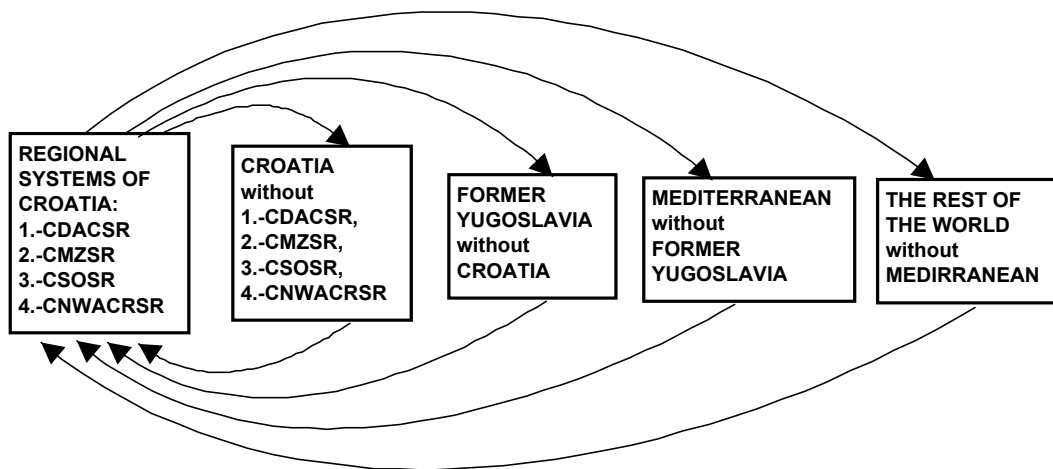


Figure 5. High-aggregated structural model of the SEESC.

4. High-aggregated structural ecological sub-sector model of the CDACSR

The “global” Space and Environment Sector Model of the SEESC-Socio Economic and Ecological System of Croatia is presented as the “simple sum” of the four regional Space and Environment Sector-SES models.

The high-aggregated structural ecological sub-sector model of the CDACSR consists of the four levels of pollution (AA1=AIR AREA, LA1=LAND AREA, SA1=SEA AREA and SBA1=SEABED AREA). Between them, there are flows of pollution: RP11-radioactive particles, HM12-heavy metals, BC12-biological cells, BM12-unexploded bombs and mines and other weapons). This means that the “global” Ecological Sub-Sector Model of the CDACSR is built by the four parallel modules: RP11, HM12, BC12, BM12 (*Figure 6.*).

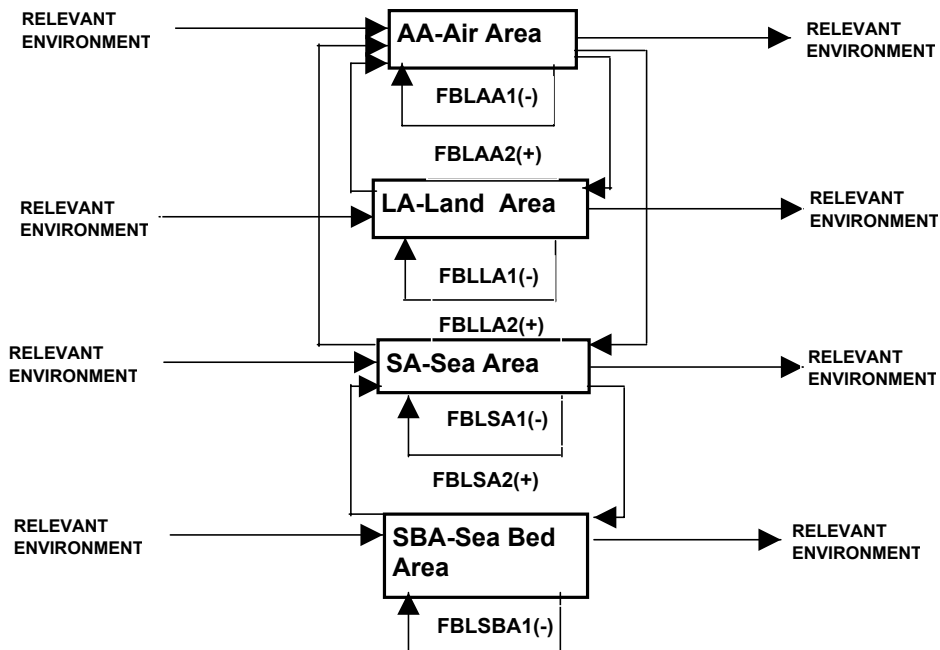


Figure 6. High-aggregated structural ecological sub-sector model of the CDACSR.

In an analogous sense, the “global” Ecological Sub-Sector Model of the SEESC is built as the “simple sum” of the four regional ecological sub-models of the CDACSR, CMZSR, CSOSR and CNWACRS.

5. “Global” model of the SEESC

Seen analogously, or from the same point of view, the “global” Economic and Ecological Model of the SEESC is built as the “simple sum” of the four regional economic and ecological sub-models of the CDACSR, CMZSR, CSOSR and CNWACRS (*Figure 7.*).

The first version of the System –Dynamics Computer Simulation Model of the Socio-Economic Ecological System of “CROATIA”-SEESC1 was made eight years ago (The initiator was the Economic Institute of Zagreb, Croatia). The SEESC1 was continually improved and updated during the eight-year period and today we have the SEESC8 version. This last version is of a higher order, non-linear, stochastic, very complex and relatively simple-modular in the software sense (DYNAMO, POWERSIM, and QBASIC-SYSDYNS software). It is installed in the System Dynamics Laboratory at our Maritime Faculty - University of Split, Croatia. Our students continuously practice on current SEESC versions or with their sub-systems alone. Our Science Research Team has used it for the making scientific prognosis and for post-analysis development of the SEESC during the long-term period (1953-2033).

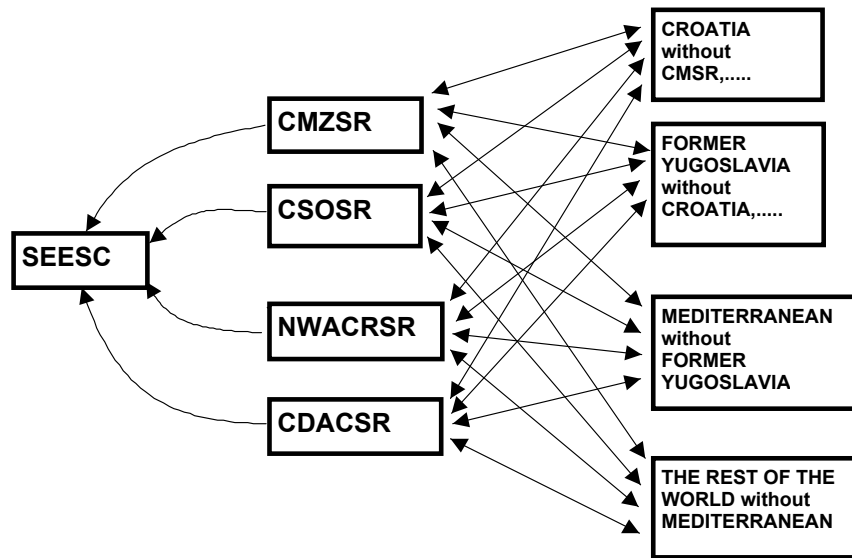


Figure 7. Rudimentary model of the global Economic and Ecological System of Croatia-SEESC.

6. About the system dynamics “before war -war and post war” modeling of the Croatia (1953 – 2033)

In accordance with the “bW-W-pW” hard time period of the Croatian history, exactly: 1953 – 2033, authors finished out a lot of really simulation scenarios (1988, 1998, 2006) and they have been very content with results of those simulation modeling experiments. Some dynamic behaviors of relevant social and economical variables of the Social System of Croatia Model SEESC have been performed in this paper without some plentiful printed comments.

There are:

- MZS1= material standard of living of CMZSR (dollars/person-year)
- MZS2= material standard of living of CSOSR (dollars/person-year)
- MZS3= material standard of living of CNWACRSR (dollars/person-year)
- MZS4= material standard of living of CDACRSR (dollars/person-year)
- MZSH = material standard of living of Croatia (dollars/person-year)
- MZSO = material standard of living of ex Yugoslavia (dollars/person-year)
- MZSI = material standard of living of the rest of the World (dollars/person-year)

Development of Croatian regions by the case of the own finance funds + “fresh” investment (1007-2001: 13.3 e9 USA\$) in time period from 1997 – 2001.

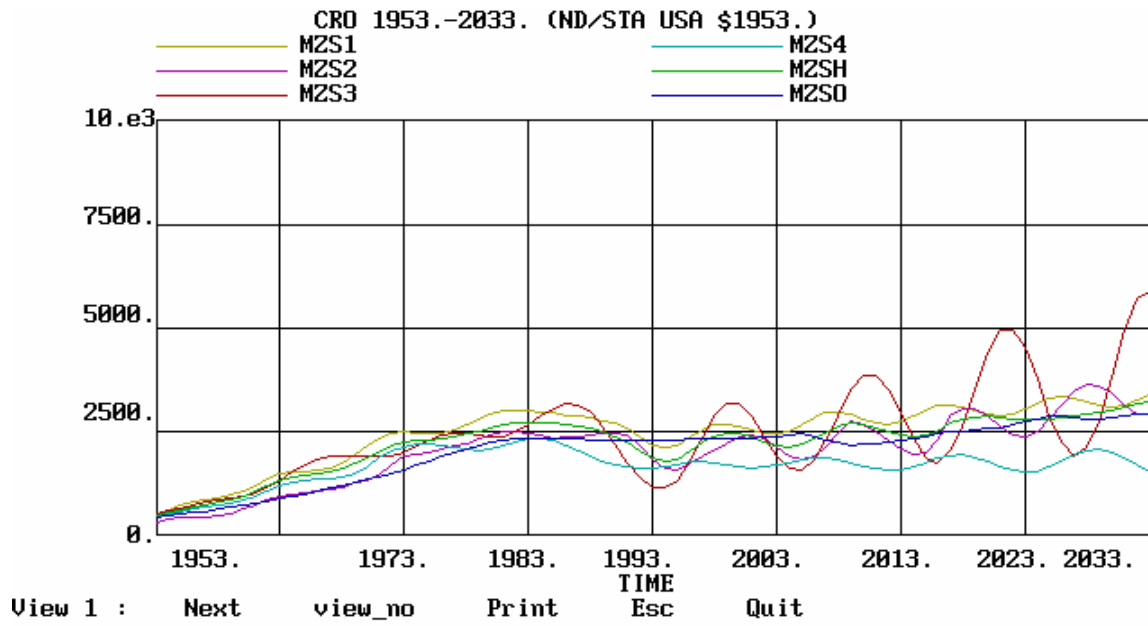


Figure 8. Scenario – 0 development of the Croatia by its own strength.

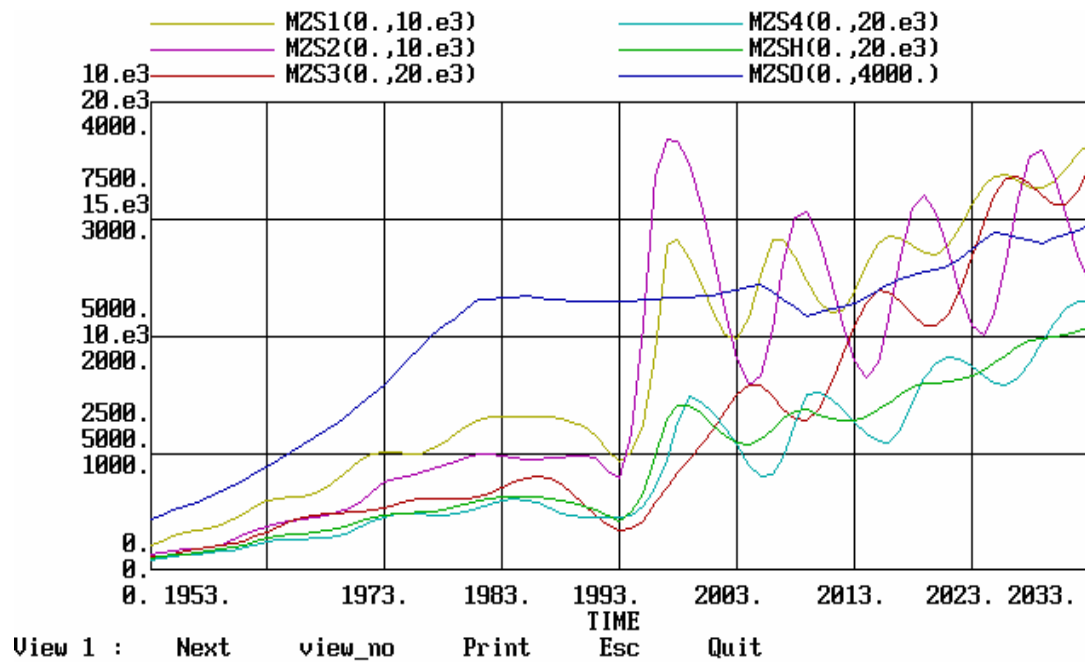


Figure 9. Scenario – 1 Development of Croatia in combination of its own strength and fresh investment (13.5mld USA \$).

7. Conclusion

In the accordance with this paper on System Dynamics Computer Simulation Modeling of the SEESC in the period of 1953 until 2033 with inbuilt war period (1990 – 1995) and our simulation experiences with it, as well as with the simulation of different media models (Natural, Technical and Organization Systems), it is possible deduct a lot of conclusions about SEESC stability, feasibility, adaptability, structure flexibility, feedback loop with relevant environment of the SEESC, prewar and war period. In the war period the special dynamics of relevant variable was observed cause of population frustration, decrease of material standard, sharp decrease of national income, street protest, local national fights and the and war.

It is possible to present the Socio-Economic Ecological System of Croatia as a “whole” that has four regional socio-economic ecological sub-systems on the System Dynamics Approach. Every one of them could be presented as a set of several subsystems, sectors and sub-sectors. Between them and their “relevant environment” as well as internally, there are flowed a great deal of the different material and information flows. Further, the SEESC-model is very suitable for continual upgrading and improving. It is highly applicable and adaptable to the computer modeling of any other regional analogous system.

Analyzing figure 9 and 10 it is possible to notice that fresh investment in time period from 1997 – 2001 can cause high growth rate of living material standard, but also high variable oscillations.

We are truly pleased with our practical experience with the System Dynamics Modeling Approach of the SEESC (especially the SEESC8 model), because the results of our computer simulation and the results of real events, in the SEESC, were within the expert-tolerable deviation values throughout the past period of 46 years of development.

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