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DEVELOPMENT OF METHODS AND TECHNOLOGIES OF INFORMATICS FOR PROCESS MODELING AND MANAGEMENT

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This book consists of papers describing applications of informatics in process modeling and management and in environmental engineering. Problems presented in the papers concern development of methods supporting process management, development of calculation methods for process modeling and development of technologies of informatics for solving some problems of environmental engineering. In several papers results of the research projects supported by the Polish Ministry of Science and Higher Education are presented.

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CHAPTER 1

Process management and management tools

INTEGRATED URBAN AND PERI-URBAN MODELLING THE STUTTGART CASE STUDY*

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Abstract: *In this paper the author focuses on the application of the AWARE methodology to urban and peri-urban areas. With such methodology, stakeholders should be able to test various strategies and to adapt their planning strategy to the most recent long term projections. The core of these tools should be a fully integrated, low-order, parameter efficient simulation model based on sound existing physically based, distributed models which portray the behaviour of the different natural subsystems in the peri-urban areas (catchment in Great Stuttgart Region). These tools should also be able to deal with soft (e.g. land use restrictions) and hard (e.g. technical infrastructure) decision measures.*

Keywords: Integrated approach, urban, peri-urban areas, low-order model.

1. Introduction

Sustainable management of natural resources requires a new way of thinking with respect to safeguarding economic development in a restricted biosphere (Miklewska, 1995, 2004, 2005a, 2005b). We are lacking a sound integrated analytical approach to cope with the complexity and the inherent uncertainty of the natural system at the mesoscale (Samaniego, 2003; Samaniego and Bárdossy, 2005). Consequently, it is imperative to promote research activities focusing at filling these gaps as well to develop tools which should allow stakeholders and decision makers to meet the often contradicting challenges of integrated water resources and land-use planning without compromising natural resources of future generations.

With such tools, stakeholders should be able to test various strategies and to adapt their planning strategy to the most recent long term projections. The core of these tools should be a fully integrated, low-order, parameter efficient simulation model based on sound existing physically based, distributed models which portray the behaviour of the different natural subsystems in the peri-urban areas (catchment

* Project of the State Committee for Scientific Research (KBN) No PBZ-KBN-086/P04/2003, BMBF Project of the German Federal Ministry Education and Research entitled "Integrated catchment management and risk- based resource allocation in urban and peri-urban areas" and Inner University Grant of the Agricultural University in Szczecin No BW/HE/03/03.

in the Great Stuttgart Region - GSR). These tools should also be able to deal with soft (e.g. land use restrictions) and hard (e.g. technical infrastructure) decision measures (Samaniego and Treuner, 2004a, 2004b). The predictions of this simplified, but robust, integrated model (Samaniego and Bárdossy, 2004) should deal within a holistic framework with at least three of the following topics, namely: the economic and demographic development of a region, land and crop management, environmental processes and restrictions, land use/cover changes, as well as with the water budget at the catchment scale and the impact and management of natural hazards (e.g. hydrological extremes).

The experience gained in this pilot BMBF project is aimed to guide the Research Team into the preparation of a follow-up project within the EU-FP7, which should implement these tools into a Decision Support System (DSS) to be tested in different catchments in Europe (e.g. Szczecin, Poznań, Leipzig, Stuttgart), especially on the peri-urban areas.

2. Peri-urban areas

While there is still no consensus on the definition of peri-urban interface, it appears to be characterized by: (1) a "patchwork structure" in terms of functions, values, strategies of occupation of the territory, or appropriation and transformation of natural resources; (2) a dynamic pattern with a wide range of transformation and flows (people, goods, income, capital, natural resources such as water, energy, and building materials); (3) the new economic opportunities it provides to peri-urban dwellers such as land speculation, or informal activities linked to mineral extraction, etc. This ''patchwork'' structure applies to the type of land-use occupation that ranges from urban infrastructure to strictly rural and agricultural uses. Thus, land-use changes combine different processes: conversion from non-urban (rural and/or natural) to urban activities; loss of farmland; and development of special infrastructure, due to appropriation of land and changes in property rights. The future of numerous rural areas is increasingly functionally interlinked with urban development as is obvious in the densely populated areas (eg. peri-urban zones) undergoing considerable urbanization pressure. It is also relevant for more sparsely populated rural areas, under less visible urban influence. The project shall further explore relations between urban and rural areas in terms of exchange processes, institutional links and interdependencies. These relations are of special interest on the background of the diverse structure of the EU territory and the neighbouring countries. They have developed substantially but differently within Europe in accordance to the diversity of spatial contexts.

The peri-urban agricultural space means several things to the urban center:

- space for production of agricultural products and (to a lesser degree) space for location of small agricultural industries,
- space for extracting labor force,

- space for installations of enterprises related to the secondary and tertiary sectors (industries, department stores, wholesale parks etc),
- residential sites for the urban population,
- space for relaxation and recreation of the urban population,
- space for installing vital functions of the urban center such as airports, water supply plants, sewage treatment plants, refineries, etc,
- space for ecological reproduction and environmental equilibrium.

Reciprocally, the urban center relates to the peri-urban agricultural space by providing:

- a big market for agricultural products,
- a sizeable employment market,
- a large market for land demands,
- unfailing source for population afflux,
- a pattern for life, work, consumption and socio-economic organization.

Ducrot et al., (2004) articulate land and water dynamics with urbanization in a MAS (Multi-Agent System) to examine the connections among the hydrological process, land-use changes, and urbanization.

3. Study area

The nature of this BMBF project is purely investigative and its scope is limited to the Greater Stuttgart Region (GSR) which covers an area of approximately 3600 km^2 with an estimated total population of 2.66 million inhabitants in 2004.

The GSR comprises the City of Stuttgart (capital of the state of Baden-Württemberg) and the surrounding five counties with a total of 179 local authorities. It is the hub of economic, scientific, and political life in Southwest Germany and the center of a flourishing economy with its own elected assembly and administrative structure (Verband Region Stuttgart). The economic activities are based on: services (43,3%), commerce (13,2%), industry (37,7%), construction (5,2%) and agriculture (0,6%). The Stuttgart Region is home to many major global players, including: DaimlerChrysler, Porsche, Robert Bosch, IBM, HP and many highly successful medium-size companies ("hidden champions"): e.g. Kärcher, Dürr, Schuler, Eberspächer and Beru. In 2003 the regional economy generated a GDP of 88 billion Euro.

Eurostat figures show the Stuttgart Region to be Europe's leading high technology area. Stuttgart Region has an excellent research infrastructure, including many leading universities and institutes working at the cutting edge of new technologies (e.g. Universities of Stuttgart and Hohenheim, to the international Stuttgart Institute of Management and Technology, nine universities of applied sciences, several Fraunhofer and Max-Planck Gesellschaft research institutes). Enterprises here invest more in R&D than anywhere else in the country, accounting for 10 percent of total expenditure by German industry. The R&D expenditures by regional industry amount to more than 5 % of GDP, whereas 88% of total expenditures in R&D come from the private sector (figures for 2003). The R&D expenditures by high-tech companies have influenced the establishment of numerous research institutes. Start-ups and young technology-led businesses are grouped in close proximity at a number of technology parks and business incubation centers.

At the beginning of this century, Stuttgart Region Economic Development Corporation (Wirtschaftsförderung Region Stuttgart GmbH - WRS) started supporting cluster management activities in order to foster innovation and economic development within the region by establishing Regional Competence and Innovation Centers. These integrated networks include 18 municipalities, more than 350 of its companies (mostly SMEs), and nearly 60 university institutes and research facilities. Currently 14 centers are focusing on well-defined fields - from fuel cell technologies to customer care and from internet-based services to solar power. The main objectives of these Regional Competence and Innovation Centers are to provide assistance and advice on market entry, to network regional expertise and innovation by organizing dialogues even between competitors and to stimulate collaborative projects.

Clusters offer greater access to labor, suppliers, specialist firms, local markets and knowledge. They can facilitate innovation and provide for a cumulative causation, where over time the advantages become self-reinforcing. An example of this type of network is Stuttgart. It is necessary to develop regional spatial plans which offer an integrated response to the critical dimensions of polycentric areas: economy, environment, settlement and mobility. Measures aimed at creating a common identity and positive image for the polycentric area as a whole (including those interstitial areas between the main centers) are seen to be valuable. The case of Stuttgart is a good example.

The most recent effort to organize balanced city region development and to better coordinate the local development efforts of fast growing peri-urban governments is taking place in the Stuttgart Region. A newly established inter-communal authority is trying to moderate between Stuttgart, the wealthy local governments surrounding the city and the various regional public authorities (Verband Region Stuttgart). Since its establishment, the Stuttgart model has become an often praised model for city region governance in Germany, mainly because the regional assembly is a democratically elected regional body.

The GSR has endured rapid land use transitions from cropland or grassland to built-up area or industrial usages from 1960 to 1993 (in some places this transition is up to 1.5% per year). Among the principal driving forces behind these land use changes there are:

1. A steady technological and industrial development during the last decades: GSR is among the top ten richest regions of the European Union (GDP expressed in

purchasing power standard, Eurostat 1996), and has a relatively low unemployment rate of 6.9% (Statistisches Landesamt Baden-Württemberg, Stuttgart, 2006).

2. The excellent transportation infrastructure available in the region: The transportation infrastructure has contributed to improve the accessibility from anywhere in the countryside to all urban centres and vice versa. This fact together with the high income per capita of the region's inhabitants has modified the commuting behaviour of a large part of the population. This behavioural change is one of the reasons of the steady growth of car ownership in the region since 1974, at an average rate of 2.5% per year, whose absolute value rose up to 0.529 car/inhabitant in 1997 (SLA). As a direct consequence of that is the rapid growth of floor space per capita in the past decades. This indicator increased in average from less than 15 m^2/inh in 1950 to more than 38 m^2/inh in 1997 (BBR 2000). In general, the demand for urban space, which includes transportation, commerce, and manufacturing, has grown 71% from its value in 1974, whilst the population has increased merely 11% in the same period.
3. The population growth: This growth, especially its immigration component, originated due to its high income per capita and very good living conditions.

As a result, this study area offers an excellent opportunity to investigate the effects of anthropogenic (e.g. land use/cover) changes on the natural system in general and the water cycle in particular. The frequency of high flows, the magnitude of peak events, and the total discharge in winter have increased. Conversely, the total discharge in summer has decreased. Consequences are a higher risk for flooding in winter and water shortage in summer. Other consequences are the reduction of biodiversity due to the fragmentation of landscapes and the deterioration of the air and water quality due to industrial and CO_2 emissions.

BMBF project assumes for agriculture a central position in future scenarios building for GSR and emphasizes the fundamental importance of agricultural land use, in addition to the production of raw materials and forestry, for "ensuring the natural bases of existence on a sustainable level". It is precisely in respect of soil conservation that agriculture plays a key role. This derives from the fact that along with forestry, agriculture represents the "most important use of open space" and farms "over half the region's open space". These peri-urban areas in need of protection have to be maintained/developed in such a way "that they will be able to perform their production functions, their social and recreational function for the population in the future as well".

In particular, the idea is for areas needing to be protected for agriculture and soil conservation:

- to contribute to home-grown production and to the supply of healthy foodstuffs,
- to help maintain the natural bases of existence such as soil, water, air and biodiversity of indigenous fauna and flora, and
- to be tended as a cultural landscape and thus secured for recreation.

The soil serves as:

- a site for the production of foodstuffs and raw materials,
- a filter and compensating body in the water cycle,
- a habitat for indigenous fauna and flora,
- a site for ground monuments, and finally
- a place of recreation for the population.

The main problems in the agriculturally favorable zones are the severe shortage of land and the resultant high land prices. Leasing land is basically the only chance farms have of expanding to a certain degree. Although existing farms have a relatively good livelihood, it is scarcely possible for new farms to establish owing to the high leasing costs. What is more, as residential building increases so the conflict about any odor and noise emissions intensifies.

Historically, residential development has been a corollary of the natural setting and topography, which means that now there is usually a high concentration of inhabitants and a predominance of land cultivation in agriculturally favorable zones. There is also increasingly keen competition for land from industry, housing, transport and large infrastructures. The trend in these zones is for livestock farming to decline, since the residents in the densely populated area reject intensive stock rearing and the resultant odor emissions.

4. AWARE methodology

Current research points out that an iterative analysis and planning approach with emphasis on the system's uncertainty rather than on deterministic knowledge is the appropriate choice (Pahl-Wostl, 1995, 2002a, 2002b, 2004). It is worth noting that this challenge is not restricted to the water sector, but rather than that, it is inherent to many other aspects of environmental management (Young, 1998; Embrechts, 2004a, 2004b; Miklewska, 2005a, 2005b). In order to address these existing limitations and shortcomings, this BMBF project aims to accomplish two general objectives.

First, it is devoted to develop a systematic approach aiming at a holistic model of an "adequate" complexity that mimics the dynamics of the dominating processes of both the natural and the socio-economic subsystems. Put differently, it should become a surrogate of the actual system with respect to some characteristics of interest. This holistic model will constitute the core of a Decision Support System (DSS) that is to be delivered at the end of the project. This holistic model is composed of a set of coupled low-order, Dominant Mode (DM) sub-models derived from simulations of existing physically-based models calibrated on the study area (Figure 1).

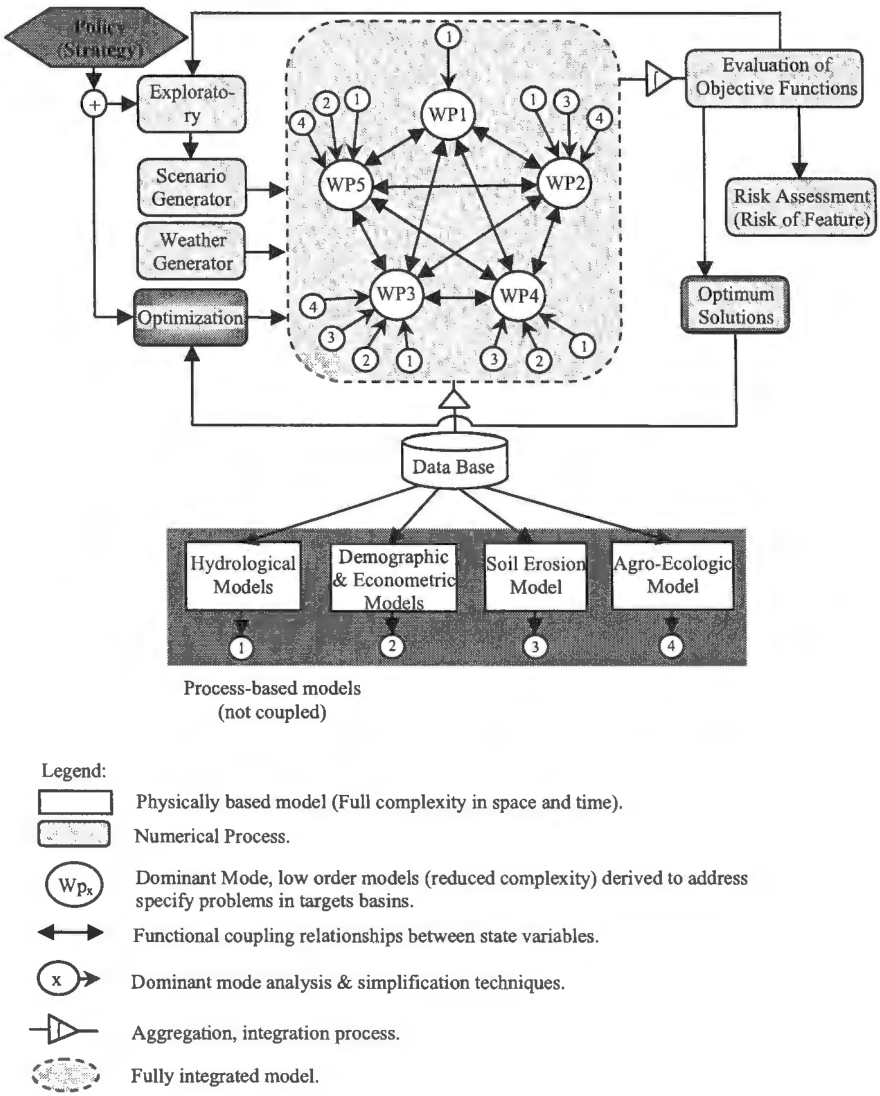

Figure 1. Spatial Decision Support System of AWARE Project (AWARE 2005). Schematic description of the main components and processes of a low-order, dominant mode integrated model composed of five main work packages. WP1: Hydrological extremes, WP2: Long term water balance and quality; WP3: Water-driven land use, crop management and ecosystems; WP4: Soil degradation and erosion; WP5: Livelihood and water management.

Each DM sub-model will be calibrated, validated, and coupled in GSR area (Samaniego, 2003; Samaniego et al., 2004, 2005). Coupling at a lower level of complexity will ensure that the holistic model will still be able to exploit the synergy effects among various processes of the system while reducing substantially the computing time of a simulation.

In general, the functional relationships of the DM sub-models should be parsimonious and efficient, their explicit formulation, however, could vary; for instance: fuzzy-rule based (Bárdossy et al., 2002, 2005), or data-based mechanistic models (Samaniego et al., 2004; Young, 1998), or data relationships based on a nearest neighbors technique (Bárdossy et al., 2005).

It should be emphasized that it is not enough that these DM models coexist in different computer environments, but rather than that, it is absolutely essential that they interact among themselves during every simulation interval in space and time, as shown in figure 1. This constitutes a fundamental feature of the integration approach followed in this project.

The flow of information among sub-models, which describes the dynamics of the interacting processes, will be accomplished by the DPSIR (Miklewski, 2001) (Drivers-Pressures-States-Impacts- Response - framework) schematically depicted in Figure 2, and described more in detail in Table 1.

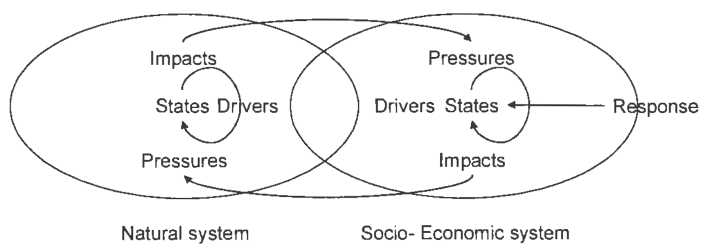

Figure 2. Interaction between natural and socio-economic systems in the DPSIR-framework.

The second general objective of this project is to develop an exploratory modelling tool within the DSS aiming to quantify the risk of failure that is inherent to any development strategy (i.e. a plan of action) proposed by the stakeholders and/or decision makers (Pahl-Wostl, 2002b).

By doing so, water resource managers will be able to fully address the uncertainty that characterizes the system, and simultaneously, find a robust strategy (i.e. one having a low risk of failure given a large ensemble of scenarios evaluated according several predefined objectives).

Here, a scenario is defined as a feasible set of parameters that fully define both the starting conditions and the evolution of the system.

The distribution function of each parameter will be estimated by Monte Carlo simulations. In order to assess the risk of failure associated with a given strategy, the proposed DSS will stress-test it with a large number of automatically generated scenarios or realizations and then compare it with an optimal strategy, which is obtained assuming a completely deterministic behavior of the system.

The assessment of system sensitivity against climate variability and climate change, land use/land cover change (Samaniego, 2003; Hundecha et al., 2004) should yield the identification of the critical paths in the system.

Table 1. "**D**rivers, **P**ressures, **S**tate, **I**mpact, **R**esponses" (DPSIR) Framework for Changes of Land Use and Land Cover

D – Driving forces	Socio-economic drivers	Transport development Population change Change in GDP Expansion in tourism Agriculture and forestry World commodity prices	Climate change Water stress, floods, drought
	Policy drivers	Regional development Transport policy Energy policy Agriculture and forestry Environmental protection Other macro policies	
P -Pressures	Land use changes	Urbanization Land abandonment Agricultural intensification Afforestation/deforestation Overgrazing Extraction of minerals Engineering/Construction schemes	
S - State		Land cover change footprint Change in water resources	
I - Impact	Land use/land cover change impacts	Landscape degradation Habitat loss/disturbance Biodiversity loss Damage to soil Damage to water resources Habitat restoration Biodiversity gain Groundwater contamination	
R - Responses		Greening CAP Water Framework Directive Species/Habitats Directive Nitrate Directive Waste Water Directive Biodiversity Strategy Local Sustainable Development Strategy Integrated Water Resource Management System BMBF project	

Source: Project AWARE

The quantification of the uncertainty is another focus of the project. The main emphasis here is to identify whether these uncertainties and to which extend influence the decisions taken

The advantages of the selected approach regarding other integrated modelling approaches are:

- To produce a substantial improvement of the computational speed for a whole simulation period (5 years, 10 years, 20 years) in a way that risk assessment becomes feasible.
- To ease the upgrading of DSS algorithms when advancement in process based-full complexity models occurs.
- To allow stakeholders and water resource managers to use a "surrogate reality" to carry out experiments aiming at learning and drawing conclusions from the behavior of the system. This knowledge can, in turn, be used to improve current planning activities and/or to develop better adjusted versions of the DSS.
- To allow to explore a wide range of plausible paths to the future (or scenarios) that may occur under a given development strategy.
- To assist to find ways to cope with the system's uncertainty rather than ignoring it.
- To minimize the risk of failure of a strategy by considering simultaneously the mitigation of natural hazards and the reduction of the system's vulnerability.

5. Preliminary results of the BMBF project

The GSR in Southwest Germany covers an area of some 3,600 km^2 and has a population of 2.6 million. Although it is densely populated with 727 inhabitants per square kilometer, the region does have a high proportion of open spaces due to its polycentric residential structure and the concentration of the population in the river valleys and along hubs of development.

The percentage of agricultural land in the total surface area of the Stuttgart Region decreased from 49% in 1989 to 47% in 2001. A 2% decrease may seem relatively small, but no other land use has shown a decline approximate to that clear drop. Reforestation schemes, residential and transport developments have hit agricultural land first and foremost.

Table 2. Surface area structure in the Great Stuttgart Region comparing 1989 and 2001.

	1989	2001
Total surface area	365 444 ha	365 390 ha
Residential and transport area	72 163 ha	77 449 ha
Agricultural area	180 555 ha	170 841 ha
Wooded area	106 767 ha	111 295 ha
Other	5 959 ha	5 805 ha

Source: Baden Württemberg Statistics Office

There is an extremely diverse agricultural use of land in the Stuttgart Region. Apart from traditional use of arable land and permanent grassland, other important sectors include horticulture (vegetables, ornamental plants and strawberries), viticulture and fruit-growing. The spatial distribution of the main types of use in the GSR primarily reflects the soil conditions and topography. The GSRR is a wine region. The spatial distribution of the vineyards is likewise explained by the topography of the region. The viticulture is concentrated along the Neckar and Rems valleys. In 1996, the GSR produced 23.6% of the fruit yield in Baden-Württemberg, making it the leader in the federal state. The fruits produced are apples, pears, sour cherries and shrub berries. Just as with the vineyards, most of the land occupied by orchards is to be found along the region's rivers.

When we consider the change in the number of farms over the last few years and the associated change in the farm size structure, the structural transformation in the region becomes quite obvious. The number of farms in the GSR fell by 33% from 1991 to 2003, with the average farm size going up from 12 hectares to 18 hectares over the same period. The percentage of holdings farming an area in excess of 50 hectares has more than tripled, and the absolute number of farms with an area of agricultural land of > 50 hectares has more than doubled. Yet smallholdings still predominate in the region: 58% of all agricultural holdings farm an area of under ten hectares.

Table 3. Farm size structure in the Great Stuttgart Region 1991- 2003.

	1991	2003	Change in %
< 10 ha	7 194	4 348	- 39,56
10 – 20 ha	1 841	1 046	- 43,18
20 – 50 ha	1 911	1 314	- 31,24
> 50 ha	339	776	+ 128,91
Total farms	11 285	7 484	- 33,68

Source: Baden-Württemberg Statistics Office, Agricultural Structure Survey 2003

Since 1991, there has been more or less no change in the ratio of farms as main livelihood to farms as sideline in the GSR, and in 2003 it was 37.2% to 62.8%. The only major exception is the urban district of Stuttgart. Although the ratio here has not changed *per se*, the proportion is exactly the reverse: 62.5% of the farms operate as a main source of income, only 37.5% of them as a sideline. In the course of structural transformation, main livelihood farms and farms as sideline have been equally affected by the general recession in farming. For instance, since 1991 there has been a 39.1% decrease in main livelihood farms and a 39.6% decrease in farms as sideline. There is a clear difference between these two types of farm, though, in terms of their farm size. Apart from intensive permanent culture cultivation, as one finds especially in the urban district of Stuttgart, a particularly large area is required to be able to farm an agricultural holding as the main source of income.

The GSR with its polycentric residential and economic structure holds out both exceptional opportunities and potential conflict for the farms based there. A main feature of the regional structure is the large number of medium-order centers around the federal state capital of Stuttgart that form an important basis for a balanced economic, social and cultural situation. Since the 1960s, these medium centers and their immediate surroundings have been faced with high increases in population, a consequence of people's greater mobility and the attendant suburbanization process. This has exerted a growing residential development pressure on farms. The concomitant non-agricultural demand for space also played no small part in the rapid implementation of land consolidation schemes in the 1960s and '70s.

The suburbanization process, however, also entails conflicts for agriculture that are only indirectly associated with land take. It is not uncommon for the demands of an increasingly urban population to collide with the needs of a future-oriented agricultural company. To make the farm sustainable but at the same time, with livestock farming, adapt the rearing process to the stipulations of animal protection legislation, the farms are generally forced to adopt modernizing or expansion measures. Such projects frequently meet with a critical response from residents. They fear odour emissions, an adverse effect on their leisure facilities or on the characteristic landscape. But alongside these areas of conflict between agriculture and a growing population, the Stuttgart Region's polycentric residential and economic structure also offers opportunities for farms. It enables many smaller farms to be still run today as a sideline, which means that they carry on contributing to home-grown production and to the supply of healthy foodstuffs and raw materials. Two aspects play a major part in this:

- The numerous medium-order centers in the region give farmers the chance to earn their main income outside agriculture, in spatial proximity to their own farm, which is run as a sideline.
- The polycentric residential structure offers farms run as main source of income or sideline the special opportunity of having a sales outlet on their doorstep. Direct marketing in the shape of ex-farm sales or the weekly market enables farmers to achieve significantly larger profit margins by cutting out intermediate trade.

The BMBF project breaks the region's areas down by varying suitability for cultivation. The "high-grade areas with predominantly very good or good suitability for cultivation" are primarily located in the conurbation; the link between residential development and suitability for cultivation is therefore clearly recognizable in the region.

It is precisely in the densely populated area that there is tough competition for free space, which is reflected in high land prices. The upshot of this is that in zones with conditions that are favourable to cultivation agricultural areas are particularly endangered: loss of resources through building development, coherent agricultural areas fragmented by roads, and contamination from airborne pollutants are the main threats to which agriculture is exposed here. Furthermore, there are conflicting interests in the conurbation between intensive agriculture, which is forced to gear itself up to increasing production, and the population's demand for attractive recreational areas near where they live, stimulating unspoilt zones as a habitat for indigenous fauna and flora, natural stretches of water, and a supply of unpolluted ground water. Despite this, the conurbation also offers farms locational benefits, for instance the opportunity for "direct marketing". Farmers can cut out intermediate trade through local ex-farm sales and in this way achieve manifestly larger profit margins. In addition, the conurbation offers a comparatively diverse "supply of non-agricultural employment". The income generated outside agriculture enables not only the farms to enjoy greater operational flexibility but also smaller farm holdings to be run as a sideline.

Although the average farm size in the region is continually rising, with a simultaneous overall decrease in the number of farms, the change in the farm size in the centre of the conurbation is taking place more slowly than in the rest of the region, owing to the special conditions for agriculture referred to above. The specific sales outlet conditions, the supply of non-agricultural jobs and the favourable conditions in the conurbation for cultivating special crops, provide even the smaller farming units with an exceptionally good livelihood.

Overall, it can be assumed that in the agriculturally favourable zones increasingly large farming units will continue to be concentrated in the hands of fewer and fewer farmers. Even though the small-scale structure, especially based on sideline farms, has managed to survive for a very long time in the conurbation, development in the agriculturally favourable zones will aim at further raising productivity and endeavouring less to find a second income, as is the case in agriculturally disadvantaged zones.

The focus of the conflict for the scarce resource that is land in the Stuttgart Region is the fertile, intensively farmed Filder area south of Stuttgart. This is where the Stuttgart-Munich motorway is to be found, as are Stuttgart Airport and the new exhibition centre currently being built. Practically every infrastructure scheme in this zone results in arable land being converted into residential and transport space and thus lost to agriculture. The BMBF research team is currently working on measures for the future of agriculture in this area.

Decision making, in Great Stuttgart Region, should be based on reliable, robust and unbiased estimators; therefore the sub-models have to be simplified under consideration of the previously identified dominating processes (Young, 1998). The simplification of a sub-model (soft-computing) to the necessary degree of parsimony, which is the need of a fully coupled integrated model, requires advanced stochastic and fuzzy approaches, but *nolens volens* increases the uncertainty and simultaneously reduces the accuracy on the spatial and temporal scale (Zehe et al., 2004). This uncertainty has to be quantified in order to make the reliability of the DSS-simulation apparent to the end-user (i.e. a stakeholder will have as a final result of the DSS an estimate of the probability of failure of a given strategy during a predetermined planning period).

6. Conclusions

Central in the project is the idea to bring together the expertise and software tools of 5 research groups in Germany and Poland to develop a first version of a fully integrated, low-order, parameter efficient simulation model and to test robust strategies for the future development of the GSR.

The main objective of this research project is to develop a Decision Support System (DSS) that will allow stakeholders to meet the often contradicting challenges of integrated land use and water resources planning and river basin management in The Great Stuttgart Region area without compromising natural resources of future generations. This DSS will enable planers to execute the following tasks: 1) to perform exploratory modeling in order to find robust strategies for future development, 2) to perform failure risk assessment of a given strategy taking into account the intrinsic model uncertainty, and 3) to carry out multi-objective optimization. With such a tool, stakeholders can test various strategies for integrated land use and water management and adapt their planning strategy to the most recent long term projections. The core of the DSS will be a fully integrated, low-order, parameter efficient simulation model based on sound existing physically based, distributed models which portray the behavior of the different natural subsystems. The predictions of this simplified, but robust, integrated model will deal with economic and demographic development, land use and climate changes as well as the impact and management of hydrological extremes which will be assessed taking into account the experience and feedback from both stakeholders and potential users of this DSS. This project also aims to bring together relevant local institutions dealing with natural resources management so that coordinated actions will be launch in the future. Based on the results of this project, local, regional, and federal authorities will be able to prepare policy guidelines and bylaws that will increase the likelihood of improving the quality of life of the population while preserving natural ecosystems.

The experience gained in this pilot BMBF project is aimed to guide the Research Team into the preparation of a follow-up project within the EU-FP7, which should implement these tools into a Decision Support System (DSS) to be tested in different catchments in Europe (e.g. Szczecin, Poznań, Leipzig, Stuttgart), especially on the peri-urban areas.

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DEVELOPMENT OF METHODS AND TECHNOLOGIES OF INFORMATICS FOR PROCESS MODELING AND MANAGEMENT

The purpose of this publication is to popularize application of informatics in process modeling and management and in environmental engineering. The papers published are thematically selected from the works presented during the conference '*Multi-accessible Computer Systems*' organized by the Systems Research Institute and the University of Technology and Agriculture in Bydgoszcz for several years already in Ciechocinek. Problems presented in the papers concern: development of quality and quantity methods supporting the process management, development of quantity methods for process modeling and simulation, development of technologies of informatics for solving problems of environmental engineering. In several papers results of research projects supported by the Polish Ministry of Science and Higher Education are presented.

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