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UNCERTAINTY of HYDROLOGIC EVENTS under DAKOTA'S CHANGING CONDITIONS: RESEARCH PLAN

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Work on the proposal

will be organized by dividing the entire team in temporary groups; every member will consider participation in one or more groups from the initial list of topics to begin with:

*concepts of the uncertainty for modeling the watershed & describing the time spatial variability of water cycle & budget for regional hydrologic study;
*concepts of the risk assessment & the interaction with the economy;
*remote sensed data use;
*scale & influence of drainage & irrigation on GW regime & hydrology (wetlands, lakes, land use) in Missouri River valley & the pothole areas;
*types & scales of regionalization of the physical & human environment;
*concept & design of simulation models;
*cartographic presentation & simplified educational by interactive modeling of the hydrological events in the landscape conditions of the state of South Dakota.

Abstract

The widespread flooding across South Dakota (SD) in 2011 has spurred a new look at the institutional, regulatory, & mathematical models used to manage the Upper Missouri River Basin. A SD EPSCoR planning grant was awarded to a group of local, national & international researchers. The team worked a strategy & plan to develop conceptual & mathematical models to understand & describe the uncertainty of hydrological events (HE) across SD. The plan brings together a variety of disciplines, & allows for the development of an artificial intelligence approach to analyze the interaction of HE, engineering installations & social systems in a SD setting. The researchers are organized in groups to consider: concepts of uncertainty for modeling the watershed & describing the time spatial variability of water cycle & budget for regional hydrologic study (remotely sensed data use, scale & influence of drainage & irrigation on GW regime & hydrology of wetlands & lakes in the Missouri River valley & Prairie Pothole areas); (2) concepts of risk assessment & interaction with the economy (types & scales of regionalization of the physical & human environment); concept & design of interactive simulation models (cartographic presentation & simplified educational modeling) of the HE in the landscape conditions of the state of SD. SD's economy depends greatly on natural conditions & events, & SD will benefit from improved evaluation of the risk associated with HE & improved reliability of information pertaining to irrigation & drainage, water management, & crop insurance.

Research tasks, Data & Maps

The climate & land use change, as marked-driven agriculture practices have very significant impact on hydrology. The model's development will consider the changing climate, the market conditions & hydrological respond to those changes for the state of South Dakota.

The new approach of using the complex of models will be placed and tested for the changing climate, land use & market conditions of state of South Dakota, & also the life style changes in the state (recreational & conservational).

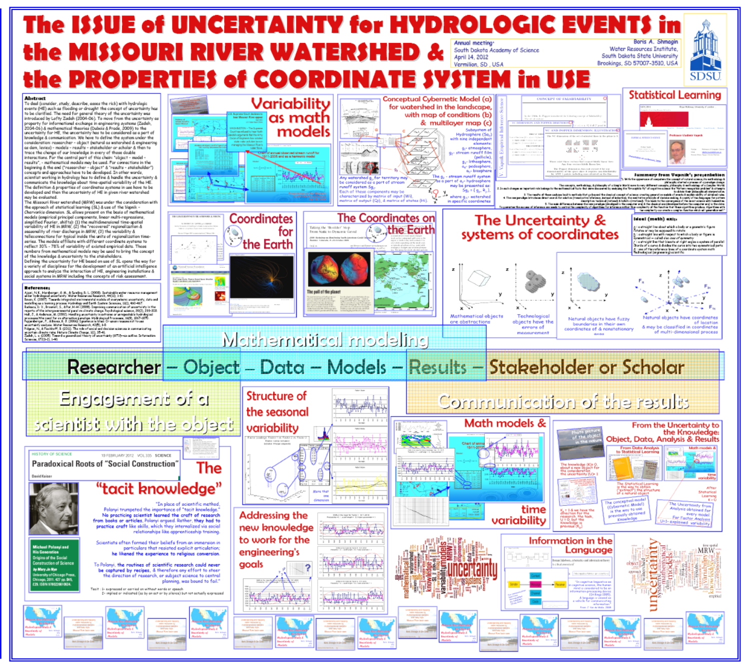
The main focus of research is bringing the new modeling concept & approach for the study of regional variability & changes in hydrology including streamflows, wetlands, potholes, groundwater levels (GWL). Verification of the developed models will be done using: 1- USGS observations of river discharge & GWL, 2- data about soil moisture & GWL from NASA-GISS, & 3- geological & hydrogeological maps & GWL observations from the state of SD Geological Survey at the USD. Special attention will be given to the use of remote sensing that reflects the conditions on the ground using the satellite imagery. Two spatial scales of hydrological processes will be studied: the state of SD & surrounding areas (neighboring parts of Missouri watershed), & several subregions within the state. The dynamics of water cycling & HE occurrence will be modeled with consideration of the forward & feedback connections to the economic process dynamics in SD. Initially annual & monthly data will be used, & more detailed time steps are in consideration. A variety of simulation models will be created to bring the results to education, state & local governments, consulting companies & project developers.

Data analysis & Maps review (Web based maps); Modeling

New mathematical approaches:

* to analyze the uncertainty of extreme hydrological events, because conventional modeling approaches failed to adequately forecast the hydrologic extreme of the 2011 Missouri River flood.
* to develop conceptual & mathematical models to understand & describe the uncertainty of hydrological events from the artificial intelligence standpoint. The mathematics in use will be about distributed system interactions, statistical learning & cellular automata. The statistical learning with use of Vapnik-Chervonenkis dimension will provide the uncertainty evaluation, & other mathematical methods will help to understand & apply the results of statistical findings.

Significant part in the complex of models will be specially developed for community use simplified simulation models & they may serve for the wide outreach, targeted at decision making in communities, state & local government, agriculture & other manufactures & consulting industries, & also for the education of all levels & application by environmental researchers whose objects based on (or connected with) the better understanding of the hydrological events.



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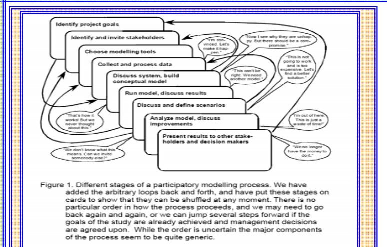
Mathematical modeling

Researcher – Object – Data – Models – Results – Stakeholder or Scholar

Engagement scientist with the object



From Voinov A. (2010)

Communication of the results

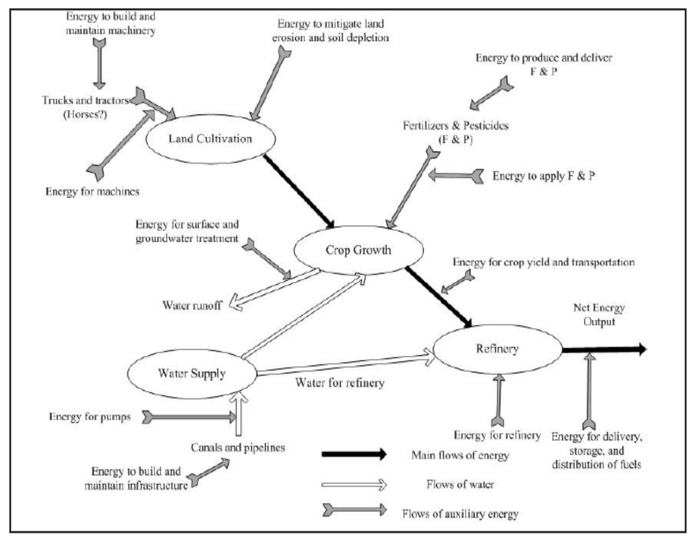


Figure 1. The life cycle of energy from biomass production.

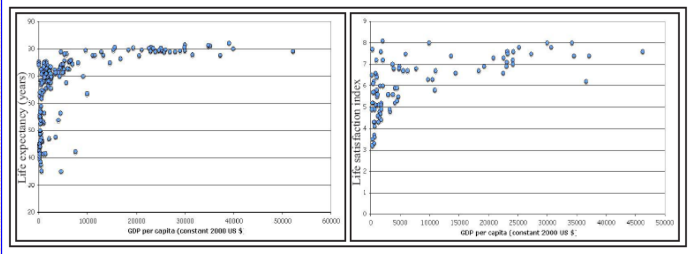


Figure 3. Relationship between gross domestic product per capita and life quality indices calculated for 97 countries.

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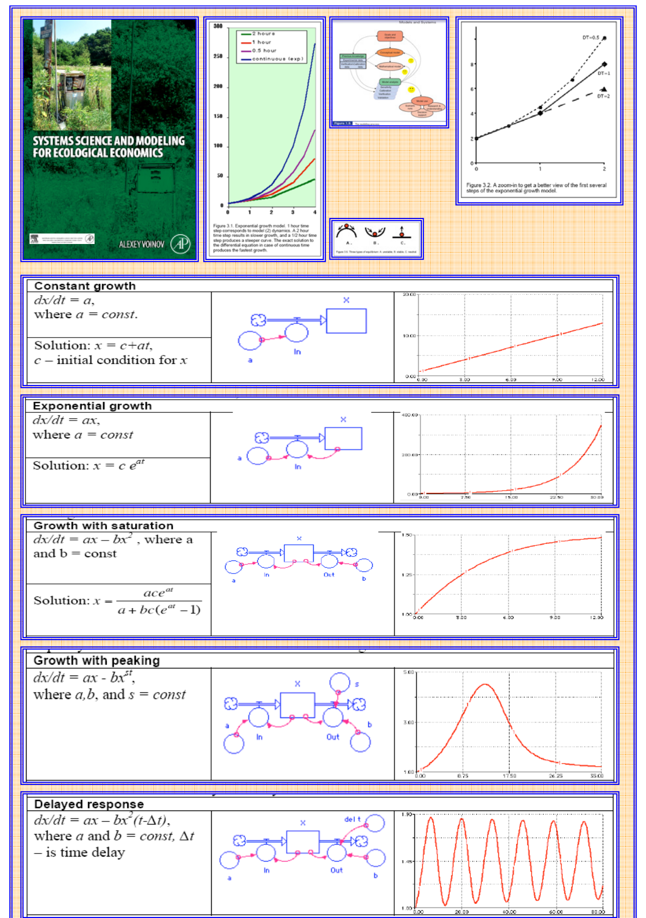

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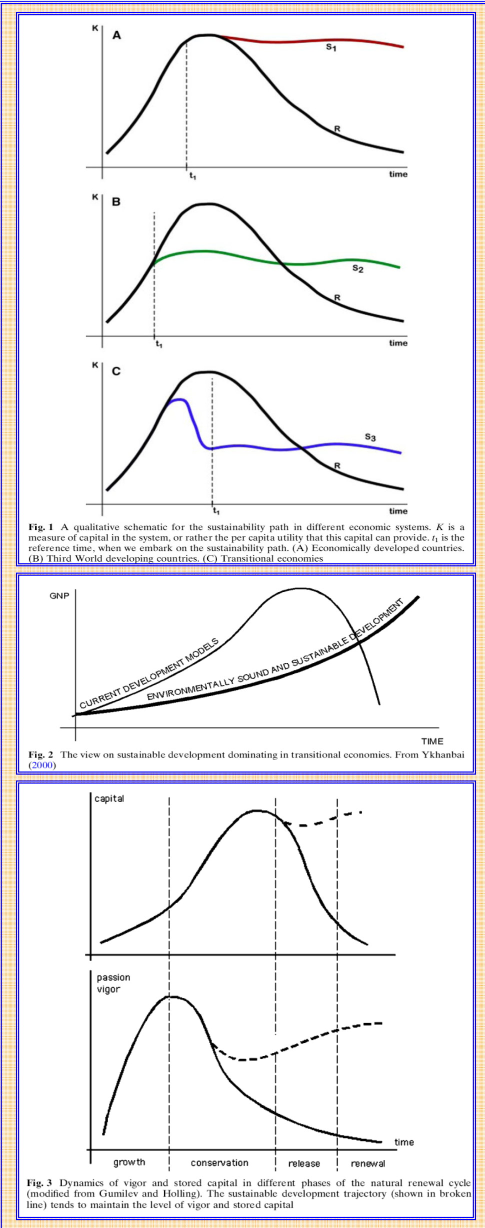

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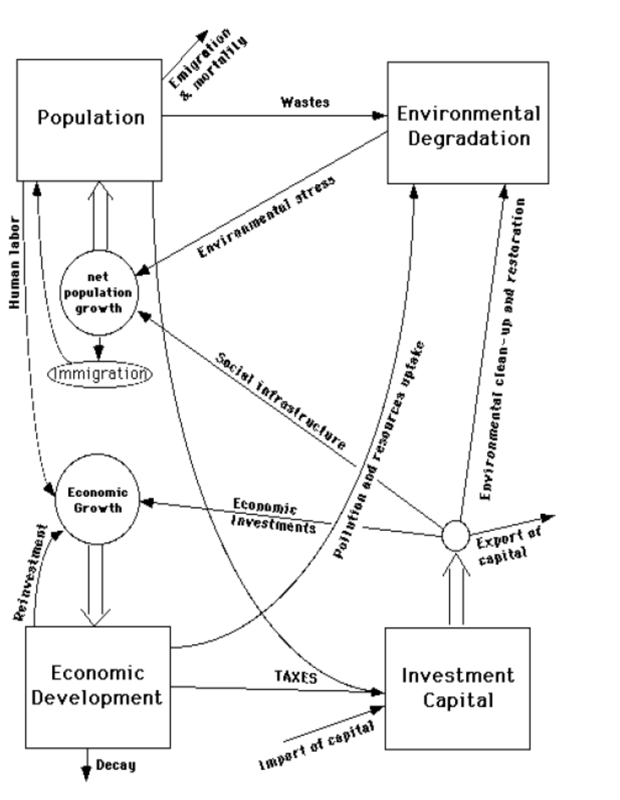
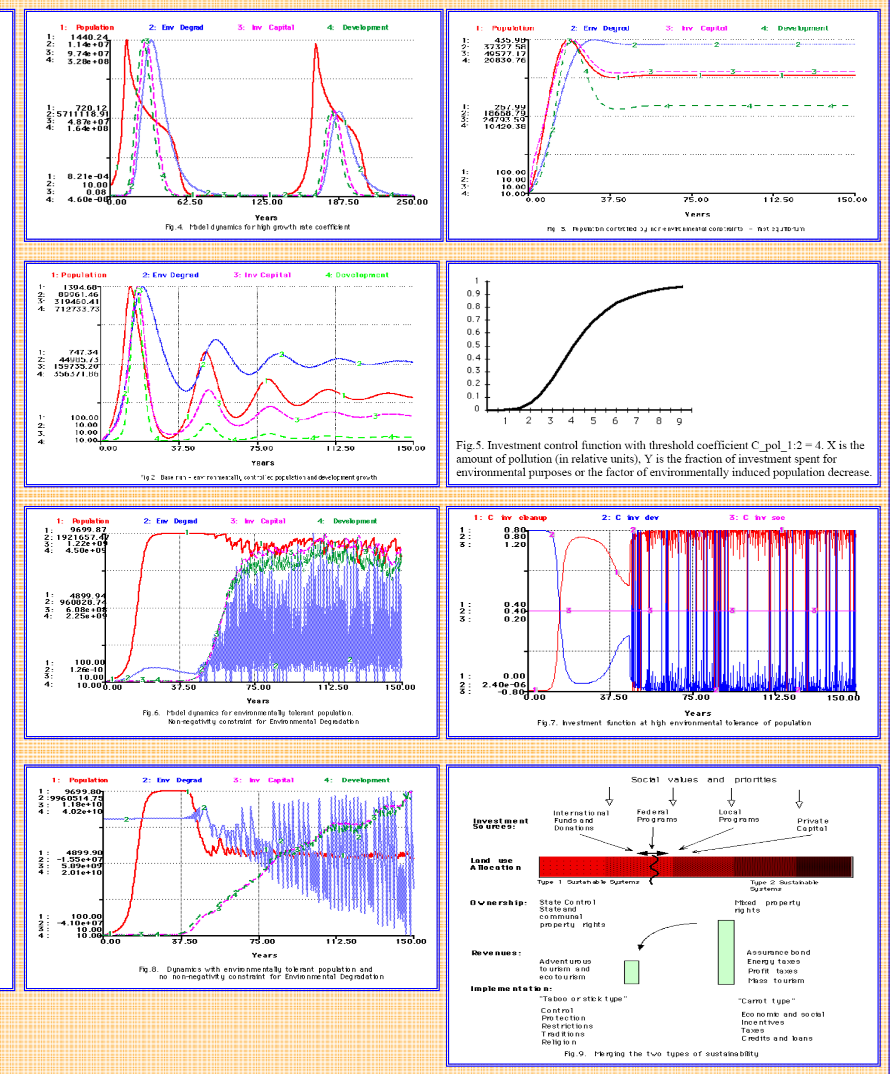


Fig.1. Conceptual model

For population we will have:
dP/dt = P_growth - P_decrease, where population growth
P_growth = (1-P/Car_cap)*net_p_growth*(P+Immigration),
and population decrease **P_decrease = C_pop_dec*F_EP_factor*P**.



From Voinov A. (1994)