Modelling and Simulation in E-Learning for Sustainable Agricultural Development in Ethiopia

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ABSTRACT
The paper presents an integrative concept of modelling and simulation for information and communication technology (ICT) supported or better said, electronic learning. The simulation models support education and training to enhance sustainable agriculture and rural environmental development in Ethiopia. More particularly, the model construction serves for application of technological innovation in human resource development so that agricultural extension services at a grass root level may reach farmers effectively. Thereby two main integration aspects will be emphasised: Firstly, the focus on modelling and simulation contents in horizontal width and vertical depth and secondly, the integration of the knowledge gained into organization like the scientific research community, the education and training such as universities and service entities that implement on the daily work of decision makers in agriculture and agriculturalists.

1. INTRODUCTION

Recently, promoting E-Learning for sustainable development particularly in rural and agricultural development has become one of the most debated issues on educational innovations in developing countries. The innovation is supposed to give immense opportunities to countries where agriculture is a dominant sector as well as the main basis to the well-being of the society living in that part of the world. This emanates from a general agreement on leveraging the use of information and communication technology (ICT) in the learning and teaching process. Nevertheless, ICT-supported education or E-Learning, as ostensibly promising as its candid merits excels, requires extensive research through construction of models and simulating the scenarios as well as piloting realistic schemes before dwelling upon white elephant projects improbable to suite rural environment and thereof fail too short imprinting negative impact on subsequent tasks.

Modelling and simulation built on various scenarios reveal and demonstrate land use strategies and environmental protection ensuring sustainable development in very descriptive manner. By and large, modelling and simulation tools are means to explore, comprehend, learn and communicate complex ideas, especially in distributed learning and work environments.

Thus, a working group at the Department of Computer Science - Hamburg university has initiated a collaborative project “Modelling and Simulation in E-Learning” with the Institute of Development Research (IDR) of the Addis Ababa University (AAU), in cooperation with the Ethiopian Agricultural Research Organisation (EARO) and the Forum for Social Studies (FSS) to implement these new technologies in Ethiopia effectively and efficiently.

To this end, this article highlights the concept of modelling and simulation of integrative internet-base learning and gives a birds-eye view on training, education and research and development in rural and environmental development in Ethiopia. Methods used are based on abstraction from prior findings and experience attained, assumptions deduced from realities and scenarios. Moreover, focus on integration of technology, organisation and society and their integrating into the human resource development are discussed. At last, the levels of integration and at last the concluding remarks follow, respectively.

2. IMPACT OF TECHNOLOGY, ORGANISATION AND SOCIETY

There are multitudes of factors which directly or indirectly influence the realisation of an ICT-supported education and training for sustainable rural development. These factors range from sets of technological inputs to the organisations supporting education and the learning society. The degree of the impact these factors depend on in either the level of the socio-economic and/or the technological development of a country under study, though.

2. 2. Technological Infrastructures

The most discussed technological infrastructure that shall be applied in education is the ICT supporting learning and teaching. Since the concept ICT is more general, in our context, we mean different educational technologies used for the

processing, delivering and realising learning materials. Choice of education technology for E-Learning relay on the type education and learner under question. It may mean access to Internet for online learners (synchronized or asynchronized mode of communication). On the other hand it could be the traditional mass media (newspapers, radio and TV) for distance learners, etc.

More often, the technological infrastructure is pre-assumed to be a missing element in developing countries in general and in Ethiopia in particular to enhance E-Learning. And yet, the agricultural sector is not only deprived of this infrastructure, but also lack of able-bodied human resource. Ethiopia, and specifically the rural development are highly muffled by impoverished technological use and trained manpower.

Meanwhile, however, Ethiopia proclaims to have a full Internet access nation-wide. Surprisingly enough, Ethiopia launched SchoolNet for all 604 secondary schools the country possesses facilitated by the V-SAT communication network. Moreover, the Ethiopia ICT-Development Authority, in cooperation with various Ministries has plunged itself in promoting WoredaNet, an E-Government project as well as AgriNet for agricultural sector, HealthNet for healthcare and telemedicine (Beyene, 2005).

Nonetheless, as the degree of diffusion of the ICT technology to rural area is quite limited, equally with high computer illiteracy, efficient utilization of this technology broadly is hardly possible. In order to tackle these problems, this article suggests building models on the requirement and application technological infrastructure to agricultural and environmental development.

2. 2. Educational Organisations

Institutions engaged in human resource development in Ethiopia are immense, ranging from the Ministry of Education, to each and every other ministries like Ministries of Agriculture, Health, Capacity Building, etc. public, private or NGOs. Ministry of Education is the prime responsible for the issuing policies, setting the curricula, accrediting a single or a group of field of studies or education institutions.

The educational organisations are highly hierarchically structured, inefficient and rigid. Thus, many criticize the educational organisations as responsible for existing pitiable education system, i.e. poor quality, less accessible, and skewed equity, etc. especially towards contribution to the well-being of the majority of the rural population. In this vein a synthesis of the indigenous culture with the foreign [innovation] and defining all curricular materials in congruent with:

- Current performance problems and future needs and plans in training/education
- Continuous evaluation mechanism integrated in the accreditation system
- Acceptance depends on the benefits or returns and goal to attain. All participants in all phases may critically assess this sooner or later.

Besides a model of participatory shall be introduced availing unified and mass-based as well as self-paced learning/teaching system.

2. 3. Learning Society

The learning society are target groups consisting of all who are legible to a particular education or training irrespective their age, sex, prior knowledge, geographical location, etc. Thus, factors like learners' language(s), socio-cultural, psychological, the prior knowledge (in form of indigenous knowledge), etc, are complex phenomena of require to be dealt systematically at time of planning and disseminating the education program, especially a sustainable rural and environmental one.

The learning society (actual and potential) in this case can be categorized into:

- The researchers and students of the MSc/MA PhD, Post PhD
- The Extension service employees who are serving as a connecting thread between the academic institutions and the farmers-end users.
- The farmers themselves who shall at last implement the methods developed and tested to be viable.

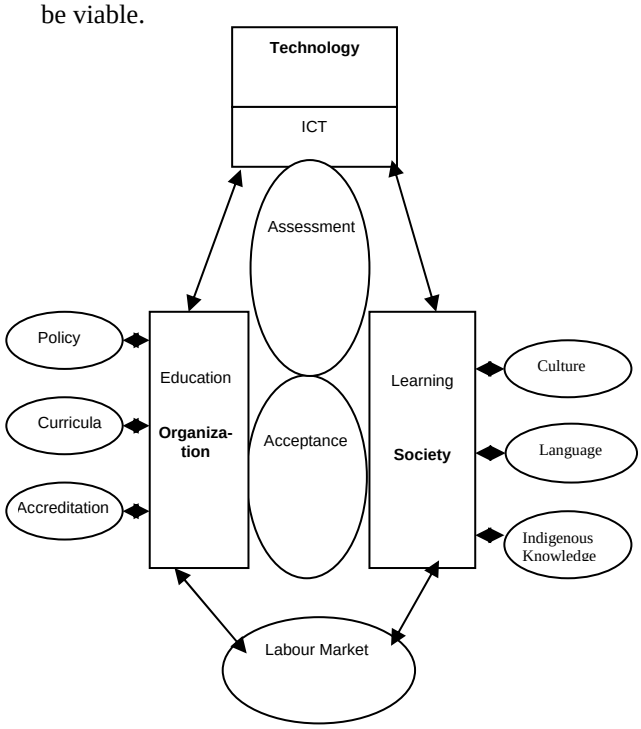

Fig.1: The Integration of Influencing factors to E-Learning

The over all factors impacting on enhancing E-Learning for rural and environmental development can be roughly sketched as depicted in the diagram. The main components, designed in a triangular form, surrounding with various attributes are subject to investigation, i.e., building models and exemplified by a series of simulations. Empirically,

all factors are integrated i.e., interconnected individually or conglomerated elements, influencing the whole process. Finally, the effect of influence will be verified by the rate of degree of acceptance. Modelling and simulations is, thus, quite vital not only to identify the impacts and degree of influence, but also to choose the type of education system itself (say, online or blended or face-to-face) in consideration to learners needs.

3. Levels of integration

Integration of specific simulation models of E-Learning environment into Ethiopian agricultural system requires identifying the area of possible fields of application. This paragraph overviews the thematic scope as well as the technological and organisational integration aspects.

3. 1. Thematic scope of integration

Ethiopia is the second highly populated Sub-Sahara African countries with over 85% of agricultural population living under sever poverty. Environmental degradation resulted in failure to produce sufficient food not only for urban society but even for the farmers themselves.

Cognizant of the urgent need to address the wide array of capacity constraints that hindered the performance of socio-economic development in general and the rural and environmental development in particular, policy makers, researchers and donors designed various programs with regard to human resource development specifically for rural areas innovation enhanced as well as supported by new technology, i.e. ICT. Few prevalent measures in this regard are provisioning training for large-scale agricultural extension service cadres alongside with national institutional reform-known by Civil Service Reform Program. This capacity building efforts is sought to build a fair, transparent, efficient, effective, and ethical civil service primarily by focusing on strengthening core technocratic systems within the public sector (McPherson and Nunes, 2004). The WoredaNet and the AgriNet are other measures to augment communication and thereby facilitate education and research.

Other topic equally vital is the Food Security or Safety Network program, which influences agriculture and rural development at large. Droughts occur too often and food security in all its dimensions could not be sustained. Irrigation would have to be introduced in a significant way for a sustainable attainment of food security at the national level.

Agricultural innovation to alleviate poverty and achieve food security is a social process involving many actors and needs to take full account of social dimensions – referring to the motivations, attitudes, behaviour and beliefs not only of farmers but also of scientists and policymakers. Using the example of an international partnership programme, we show how the research and development capacities of resource-poor farmers can be strengthened and agricultural services can support them. It is based on the realisation that farmers, on their own initiative and using local resources, are innovating, that their innovations can provide a focus to examine development opportunities and research needs, and that recognition of this local creativity is a prerequisite for genuine partnership in research and development (Bayer and Waters-Baye, 2005)."

Various activities like environmental protection, soil and water conservation, terracing and afforestation shall be purposefully modelled and simulated to carry out research to support education and training.

3. 2. Organisational integration

Organisational integration focuses on the conditions concerning infrastructure and education system in Ethiopia. Hence, key application elements are.

***Organizational development*:** This encompasses the structure of workflow and service system, inside or inter-organisational for the e-Learning material-production during a continuous improvement process in supplementary publishing house or other central production.

Personnel development: Through training ranging from learners to e-learning course authors (stage I A) as well as to Life and Tele-Coaches (stage I b), to e-learning material publishers (stage II), and to editor-in-chief and knowledge manager for educational institutions and the affiliated networks (stage III). Details in Bergstedt et al. 2003.

***Didactics*:** Altering the paradigm of the instruction didactics and knowledge-orientated for the paradigm of the constructivism and action-orientated e-Learning materials in line with the context of a complete learning process; and

***Learning technology*:** Establishing learning and co-operation appropriate Intranets/Extranets among educational institutions furnished with multimedia terminals so as to establishing a creation, distribution and communication environment for the production, revision and distribution of e-Learning materials

3. 3. Technological integration

The technical part is regarded as one part beside other factors. Due to the problems in infrastructure and the financial constraints, there is no need to develop new scientific methods. However, there is a strong need to integrate existing technologies effectively, efficiently and sustainable.

The modelling and the e-learning aspects rely on software technology that is well known and on concepts that are proved. The technical solution will be based on a combination of techniques that are listed here without longer explanation:

Flexible model access will be reached by modular hierarchical modelling in connection with a model server concept. In a modular model-bank, different phenomena are specified as black-box-

models, which can be assembled to more complex hierarchical models. Doing so, the models are sizable in respect to the educational task they have to fulfil. These model-components together with the possibility to build hierarchical models are offered by a web-based software environment. Thus, modelling know-how is centralized on a model-server, where access is free to users of all classes under the condition they fulfil or the role they have.

***Different roles and groups of users**:* The users of the model-base and learning environment have to be provided with different roles and rights to manage this flexibility. There are at least the five types of users:

- External: possess browser-based access to firm scenario interfaces.
- Students: with a right or possibility to change parameter values to explore the range of model dynamics.
- Authors: eligible to access the content on the server within the editorially not secured range.
- Researchers: entitled to access to the model on the server within the editorially not secured range
- Editors: have access to all information with the empowerment to activate private content for a larger group of users.

The integration and/or linkage of simulation and e-Learning must be realized: Due to various reasons most applications fail to differentiation between knowledge base and model base accesses. Thus, this aspect has to be mirrored by the systems structure (Wittmann 2003).

A reliable technical infrastructure must be developed: The reliability of the system is precondition of its usage. Therefore the technical solution must guarantee accessibility on a solid level.

The content must be reviewed by a controlled editorial process to guarantee the quality of the content (for texts as well as for models!)

Feedback mechanisms between authors, model developers, editorial board, and learners guarantee acceptance and a continuous improvement of the content. Known communication mechanisms can be used on the basis of forums and chats as well as valuation systems.

4. APPLICATION FIELDS AND STAKEHOLDERS

Simulation of praxis-relevant scenarios seems to be the best alternative way to start with catchy realty associated with shortage of agricultural manpower development. Application fields for simulation and modelling in E-Learning are as immense as the availability of capacity to realise. It is quite commendable to indulge with the possible area of application, possible project(s) and potential stakeholders.

4.1 Application Objectives

The prime goal of the application under study is to attain and facilitate the preparation of a learning and research model in cooperation with leading national education and research centres that examines natural resources of systems and model instruments that are available in form of existing projects and/or case studies (internal and external), expert knowledge in the context of the MSc/PhD and post-doctoral programs from the involved network of partners. The experience gained shall definitely enhance self-sufficiency and maintain sustainability. Two main integration aspects, which are described in the following:

Firstly, the content of the system must be simple and open. Therefore, we intend to build up and model knowledge base from high scientific level down to the level of practical skill for the agricultural development planner and extension service workers at a grass root level. If up-to-date knowledge is kept posted by scientists, tested in university courses by students, and prepared that the users can illustrate to use it, we hope that a long-lasting process of the knowledge exchange on the basis of the model construction box can be initiated and developed.

Secondly, the production of the models and their integration in teaching/training and daily professional experience must be accepted and promoted by the organizations implementing the results. To materialize this fully, the activity must be relevant for:

- The researchers: Model description and specification document current research results in publishable quality and are reviewed and acknowledged by the scientific community.
- The learners: models promote the understanding of the learning content and the engagement with a guiding system to attain the desired goal, i.e., recognized qualifications (or covered credit hours, etc.)
- The filed or extension service workers: the model treats practical topics and the experiments are pre-defined in such a way that their results supply practice-relevant data, which also help in actual decision making.

To fulfil these demands, there is a need to further integration concerning:

- modelling and simulation contents in horizontal width
- modelling and simulation contents in vertical depth and
- the organizational integration

The effective integration of partners on all levels offers a sound organisational platform to implement the initial prototype. The model development and application can be, hence, aggregated into three distinct levels (layers):

- the process level,
- the ecological system level and
- the catchments area level.

The model simulates a set of tasks based on the similarities and differences of the findings of the project partners. This comparison promises valuable suggestions for the arrangement of similar projects, not only on the international and national (in this case Ethiopian) level, but also within the national framework.

Thereby each simulation process assists researchers and agricultural extension services experts to boost their knowledge (learning by doing). At last the mechanisms aggregated to instruments of tools will be demonstrated and implemented to enhance integrated rural and environmental development. This steady process, not only increases knowledge of to the scientific pool, but it assists practically the betterment of the society at large.

4. 2. Work packages to Realisation

To achieve the desired goal, it needs to go through the following procedures as well as elaborated tasks to throw light on these work packages:

a) A qualification system for modelling and simulation know-how has to be established within the participating organisations. This implies a multiplication effect to learning and researching activities, where know-how and infrastructure for the following phases of tasks could be granted.

b) The preparation of the country-specific requirements for modelling and simulation under special consideration of the vertical knowledge exchange

c) The conception of an integrative system of modular and high-parameterized model components, which collects and integrates already existing knowledge in an aggregated manner and prepares this knowledge for on experimental-based access. This is adopted to fit the local conditions in the form of a detailed workflow description.

d) Exemplary execution of the material-flow simulations and optimizations to collectively determine the application domains

e) Models and optimization procedures during their transmission and use in other educational institutions and other contexts will be evaluated, analysed and at last decided on their organisational implementation.

f) Replicate of the work procedures mentioned to other countries

At the other end, models built with reference to some specific problems or tasks to perform will be simulated in different phases by partners with specialized assignment. The IDR may be responsible for teaching in cooperation with Hamburg-University while IDR together with EARO can foster research as well as the implementation. FSS advises monitors and evaluates the realisation.

The research can begin with the courses usually offered by IDR, i.e., “Natural Resources, Environment and Management”, and “Environmental Policy and Impact Assessment”. Indeed, the details of the content of and means of dissemination will be specified and determined jointly by the all participated stakeholders.

4. 3 Profile of the Course

The course will primarily focus on the competencies in supporting local innovation in agriculture and natural resource management. It will provide participants an understanding of socio-organizational arrangements needed to regulate the use of natural resources, tap into the social capital within communities or discover new ways of stakeholder interactions that will encourage local innovation development. It will also focus on the competencies needed for building capacities of staff in Participatory Innovations in Development and/or Participatory Technology Development, to prepare for and implement effective training and learning programs in this field.

Through model-based experience sharing, the participants will be aware of the challenges faced by development agents and scientists in moving local innovations further towards joint experimentation and integrating relevant information and ideas coming from others including formal research.

Participants of the course: Participants to this course (or training) are MA/MSc and/or PhD/Post-Doctorial students and researchers responsible for taking the leadership in developing the capacity of agricultural and rural development researchers, extension or integrated service providers and the farmers. These professionals are expected to train others engaged in this sector as well as government officials from agricultural, research and extension institutions, staff of local NGOs and researchers from academic and other development institutions in working with farmers to the betterment of rural development.

Learning Objectives and goal of the course:

At the end of the course, the participants will have:

- described the different strategies to identify, support and disseminate farmer/local innovations;
- identified capacity development needs of farmers, developed training design, evaluate training and set up follow-up activities after training;
- demonstrated skills that encourage participation of farmers and motivate them towards more experimentation;
- formulated a draft outline and basic “building blocks” of training manual for use by country programs; and
- Identified concrete ideas for applying learning systems from the course in their organizations’ PID efforts and/or formulated a draft country specific action plan for training and coaching in PID/PTD.

4. 4 Stakeholders

A concept is under consideration to jointly design and realise by three national institutions, IDR, EARO, FSS in Ethiopia and Computer Science Department of the University of Hamburg in Germany. The prime goals of the project idea in general are to jointly model scenarios on various factors facilitating and/or setting back agricultural development and environmental protection, simulation and demonstrating to users.

The IDR[1]: one of the most notable research centres of Addis Ababa University for more than three decades. The institute has integrated research and teaching to substantiate the researcher's findings and their knowledge, use the results as teaching baseline, and, finally, bringing about a sustainable development through interaction of all these elements. The integrated way of acting that is emphasized by this article is in full analogy to the way the IDR works.

EARO[2]: the Ethiopian Agricultural Research Organization (EARO) is one of the biggest agricultural research institutes. The tasks it performs are quite broad, to mention few, comprehensive research on crop production (higher, better quality and efficient), livestock, and forest production, harvesting, storage, protection, processing, marketing and utilization while at the same time enhancing the natural resource base. The organisation demonstration field is directly attached with end-users-the farmers and their environment.

FSS[3]: the Forum for Social Studies mainly deals with rural and environmental policy analysis, an important input to policy making and implementation. FSS organises public debates, offers consultations services and conduct research on poverty and poverty reduction in Ethiopia.

TIS[4]: The engineering and information system working group of the University of Hamburg Department of Computer Science has rich experience in designing models and simulations for different applications in the medicine, environment, industry and others and holds the necessary know-how in e-learning technology. It has accumulated extensive experience in closely working with international stakeholders.

5. Conclusion

System specification, modelling, simulation, knowledge-acquisition, problem-oriented learning strategies, workflow, and modern means of communication are to be integrated in an organisational and technical system. Initially and in close cooperation with the partners, problems will be identified, scenarios will be drawn, and models will be built and simulated. The viability of the implementation will be evaluated. Thereby each simulation process assists researchers and agricultural extension services experts to boost their knowledge (learning by doing). At last the mechanisms aggregated to instruments of tools will be demonstrated and implemented to enhance integrated rural and environmental development. This steady process, not only increases knowledge of to the scientific pool, but it assists practically the betterment of the society at large.

Integration of e-learning into rural and agricultural development especially in developing countries such as Ethiopia in cooperation with different stakeholders can be vital step in innovating teaching and research on rural development..

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[2] http://www.earo.org.et
[3] http://www.fssethiopia.org/
[4] http://www.informatik.uni-hamburg.de/TIS/

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