

INNOVATIONS IN AGRICULTURE IN DEVELOPING COUNTRIES

Radivoj Prodanović¹, Jelena Bošković²

Abstract

The aim of the paper is to present the status and innovation potential in the agriculture of developing countries.

The purpose of innovations in agriculture in developing countries is to increase food production, and recently, to produce safe food. Agricultural innovations should imply the transition from pure exploitation of natural resources to technological innovation, which would contribute to the production of quality products, while preserving resources for production (sustainable intensification).

The use of agricultural innovations in developing countries has low intensity, although it began about 4 decades ago. Bureaucratic barriers, start-up costs, lack of abilities, financing and wrong policies are the main barriers to innovation in developing countries. Developing countries have the potential to innovate their production technologies in agriculture, but they are mainly dependent on modern technologies from the developed countries.

Principally, developing countries should improve the performance of their educational systems, science and technology, institutions, increase financial and human investments for establishing local technological possibilities and learn from the experience of other innovative regions. Although the majority of developing countries have achieved significant progress in agricultural innovations, this is still not satisfactory.

Key words: *innovations, agriculture, developing countries.*

¹Radivoj Prodanović, Ph.D, Assistant Professor, University Business Academy in Novi Sad, Faculty of Economy and Engineering management, Cvecarska Street no. 2, 21 000 Novi Sad, Serbia, Phone: +381 21 400 484, E-mail: rprodanovic@fimek.edu.rs

²Jelena Bošković, Ph.D, Full Professor, University Business Academy in Novi Sad, Faculty of Economy and Engineering management, Cvecarska Street no. 2, 21 000 Novi Sad, Serbia, Phone: +381 21 400 484, E-mail: jboskovic@fimek.edu.rs

Introduction

In the 21st century, agriculture faces multiple challenges: It has to produce more food and fiber for growing human population with less rural labor force, more raw materials for potential huge market of bioenergy, to contribute more significantly to country development, to adopt more efficient and sustainable production methods and to adapt itself to climate change. This challenge can be responded by introducing innovative technologies, especially in developing countries.

The development of agriculture depends to a large degree on how the knowledge is successfully generated and applied, on the intensity of the knowledge use and new technologies, respectively.

Agricultural innovations in developing countries have the aim to change the way of life of rural household and to increase their low earnings, which are often insufficient for basic living needs. In this context, the studies in many African countries have resulted in better possibility of using the knowledge in agricultural sector. There are needs for greater establishing of capacity of local advisory services and bigger budget support, in order to ensure the use of agricultural innovations. Agricultural production is at low level, as a result not only of the lack of appropriate technologies, but the lack of access to these technologies, credit and access to the market and rural infrastructure, but also because of omission to information and skills, which preclude the producers to use efficiently and adopt the technologies (Mapila et al., 2011).

Africa has a quarter of the world's arable land, but it generates only 10% of global agricultural production. In addition, more than 75% of total arable land is degraded, with the loss of nearly 3.3% of agricultural GDP per year due to disturbance of land and loss of nutrients (Juma et al., 2013).

Transgenic technologies and their potential affect the poor in undeveloped countries. Such researches are very disputable, and so polarized that credible alternative, which can meet some of the listed aims of food safety and environmental sustainability, are often ignored (Prasad, 2007).

The Aim of the Paper

The aim of the paper is to explore to what extent agricultural innovations are applied in developing countries, to assess the potential for rural development, increasing food production and farmers' income, as well as reduction the poverty in developing countries.

This paper summarizes the results of researches about the application of agricultural innovations in developing countries and uses them to discuss key issues on the use of concept of innovation systems.

Agricultural Innovations

It is accepted that agricultural growth depends on the availability and adoption of appropriate innovative technologies. Agricultural growth can reduce the poverty in developing countries, through stronger role of the research and generating the knowledge, which will result in innovation (Asenso-Okyere and Braun, 2009).

The process of innovation introduces new techniques in agriculture, designed to remove impediments of productivity growth and environmental sustainability. In agriculture, innovations include new knowledge or technologies related to primary production, processing and commercialization, which leads to the growth of productivity, competitiveness and living standards of farmers and other (Asenso-Okyere and Braun, 2009; Boskovic et al., 2010).

Agriculture innovations are new inputs, the machines and methods that are used in agriculture production processes in order to increase production, yield or quality (Akkoyunlu, 2013). Therefore, the purpose of innovations in agriculture in developing countries is increasing the food production, and in recent time, the production of safe food, too.

The innovations in developing countries mainly refer to the agricultural sector (finding insecticide, resistant varieties, irrigation pump, genetic programs, etc.) (Oyelaran-Oyeyinka and Sampath, 2007). In African countries, only small percentage of land is under irrigation, the use of fertilizers is at low level, which results in lower yields. Compared to Asia, where 37% of land is under irrigation system, in Sub-Saharan Africa, about 4% of the area is irrigated. If we omit the Madagascar, South Africa and Sudan, share of agricultural land under irrigation in the rest of the region would be only about 13.3% (Svendsen et al., 2009).

Social inequality and the need to improve the life of poor rural households in developing countries become a preoccupation of developmental policy of agriculture. Agriculture and agriculture science and technology are actual topics and focused on innovation and idea of innovation systems with aim of providing better standard for farmers and increasing the production possibilities. However, the history of agricultural research and innovation indicate that this process is very slow (Boskovic et al., 2012; Hall, 2007).

The main obstacles for agricultural innovation in developing countries are (Aerni et al., 2015):

- Absence of political dialogue between the government and private stakeholders;
- Lack of public/private partnership;
- Lack of incentives, high interest rates, property or land rights are not suitable for commercialization of agriculture;
- Lack of institutional and regulatory framework (especially in unstable political situations), the import economy at the expense of local products.

Plenty of land in some areas, weak property rights in other and lack of markets decrease motivation for the farmers to implement innovations and to invest in production that is more intensive. The farmers, simulated by subventions, implement innovations, and if there is no subvention, the innovations are absent (Elliott and Hoffman, 2010).

Rejecting the introduction of innovative technologies, result is (Johnsen et al., 2009):

- No benefits in adverse weather conditions (e.g. drought),
- Unavailability of technologies,
- High prices of inputs related with investments,
- Increased requirements for work are not in proportion with the benefits,
- Lack of access to electricity,
- Lack of available market with purchasing power, where the attractive prices of farmers' products can be realized.

Adopting the new technologies in agriculture requires the favorable policy framework and adequate investment in infrastructure, development of capacity among farmers, as well as the access to inputs, credit and markets (Alarcon and Bodouroglou, 2011).

Agricultural innovations can play significant role in decreasing rural poverty. Diversification of rural employment and yields can be achieved by introduction of technological innovations, which affects the food price and the connection with rest of the economy. Direct effects of technological innovations refer to realizing higher profit, while indirect effects refer to lower food price, due to higher agricultural productivity, the growth of employment and comprehensive economic growth through the production growth and consumption in non-farm sector (Berdegue and Escobar, 2002).

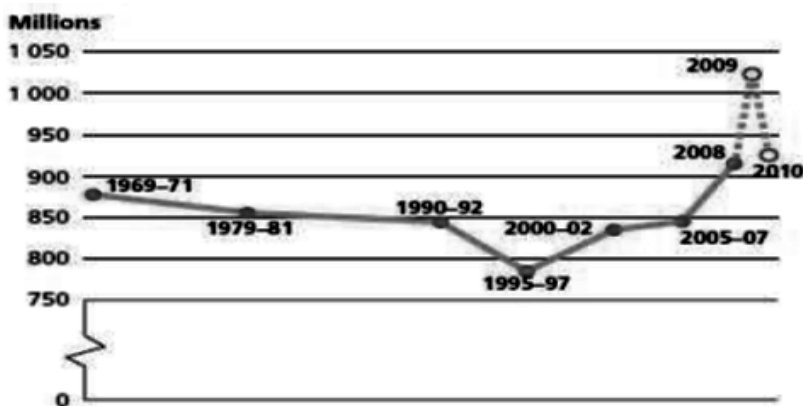
Those changes, together with better approach to the market, have led to the increasing in production, the stabilization of markets and increasing of income for poor farmers. Agricultural innovations have powerful positive impact on some, but not all aspects of life in rural areas. Innovations in poor countries have potential to influence positively on production, income and possibilities for training of rural households. The problem is sustainability of innovative policy, due to human and financial capacities for maintaining innovative strategies. In order to ensure the effects of innovation introduction in long-term, it is necessary for organizations to invest more in the research, as well as in the budget support of innovation.

Management implementation of rural innovations has six key components (Mapila et al., 2011):

- Development of agro-enterprises and participatory market research,
- Responsible management of natural resources,
- Social and human resource development,
- Gender equality and empowering of women,
- Participatory monitoring and evaluation in the community,
- Effective development and management of partnerships.

In order to alleviate the poverty and to induce economic transformation on the continent, The African Union attaches special attention to development of rural economy and agriculture. Statistics show that 239 million African do not have enough food to satisfy their basic nutritional needs, as well as that 30-40% of children under five years still suffer from chronic malnutrition (On the Wings of Innovation, 2014).

Figure 1 *Malnourished population in the world 1969-2010*



Source: FAO, 2010

The fact that over 900 million people are malnourished, where the vast majority in developing countries (98%) show the significance of introduction of innovative technologies in agriculture of those countries. Of course, the assessments are that the climate changes (drought and other natural disasters) drastically will reduce the yield in agriculture and thus, it will further induce the actions about introducing new technologies in agriculture (Alarcon and Bodouroglou, 2011).

Governments in the least developed countries, especially in Africa, do not use sufficiently experiences of new economies, such as Brazil and China, institutional capacity of development, in order to provide the innovation and sustainable development in agriculture (Aerni et al., 2015).

Agricultural innovations result in increasing the production of almost all crops, as well as the growth of yield in livestock production. In the study by Mapila et al. (2011), after innovation the technology of production, significantly higher total income of examined crops for \$812.34 is achieved in 2008, comparing to 2007. In the 2008/09 season, the value of produced corn was statistically higher than for households, which did not innovate production and for \$287.09. Part of production increase is surely result of increase in the total property and reduction of the number of parcel. The prices were not significant in achieving higher total income, because they recorded slight oscillations. Mineral fertilizers, in combination with hybrid seeds and rainfall, play key role in ensuring high corn production and food safety in Malawi. In pig production, larger number of livestock is accomplished, after the improvement of housing conditions, hygiene, nutrition and veterinary services.

Agricultural innovation in poor tropical countries contributes to more effective and sustainable using of natural resources, decreases hunger and poverty, through economic development of rural areas (Aerni et al., 2015).

Agricultural Biotechnology

Biotechnology includes biological scientific techniques for improving plants, animals and microorganisms, involving wide spectrum of solutions from genetically modified plants and animals, upgraded tools such as microbiological technology, bacteria, radically improved gene technique with great yield potential, ecology and protection (Konstantinovic and Boskovic, 2001; Boskovic et al., 2011).

Gene revolution (transgenic biotechnology)³ contributed to reduction of production expenses, yield growth, and therefore net income, decreased use of pesticides and lower consumer prices. Most transgenic technologies include corn and soybean. ‘Monsanto’ is a company that developed platform in biotechnology (seeds, crop protection), which enable the increase of productivity and competitiveness in developing countries (Boskovic and Prodanovic, 2016; Asenso-Okyere et al., 2008).

Scientific organizations such as the National Research Council, American Association for the Advancement of Science and the American medical Association have published the studies and statements, which claim that there is no evidence that GMOs presents security risk compared to conventionally grown products. Despite the evidence, 93% of respondents in the survey (2013) favor obligatory marking, and three-quarters of Americans expressed concern regarding the GMO food (Kearney, 2016).

Genetically modified crops, which are sown in many developing countries, have potential for reduction of GHG⁴ emissions, because demand for fossil fuels, which are generators of greenhouse gases, is decreased (Lybbert and Sumner, 2010). In 2007, when GM crops are cultivated on only 7% of arable land in the world, a total reduction of GHG emissions amounted over 14.200 million kg of CO₂, equivalent to removing more than 6 million cars from the trade (Brookes and Barfoot, 2009).

New sorts can lead to lower intensity of using other inputs, such as fertilizers, pesticide and additional equipment. In addition to increasing productivity, farmers achieves greater flexibility in adapting to climate change (better tolerance to drought, extreme temperatures, salinity) (Lybbert and Sumner, 2010; Boskovic and Prodanovic, 2016).

Relatively little effort is devoted to biotechnological research in poor regions in developing countries, although agricultural biotechnology is imprinted in the seed, maybe very suitable for solving the agronomic and environmental problems in less developed areas (Graff et al., 2003; Boskovic et al., 2010).

³In the United States and Europe, the production of genetically modified organisms (GMO) is followed by storm of media, consumers and political reaction.

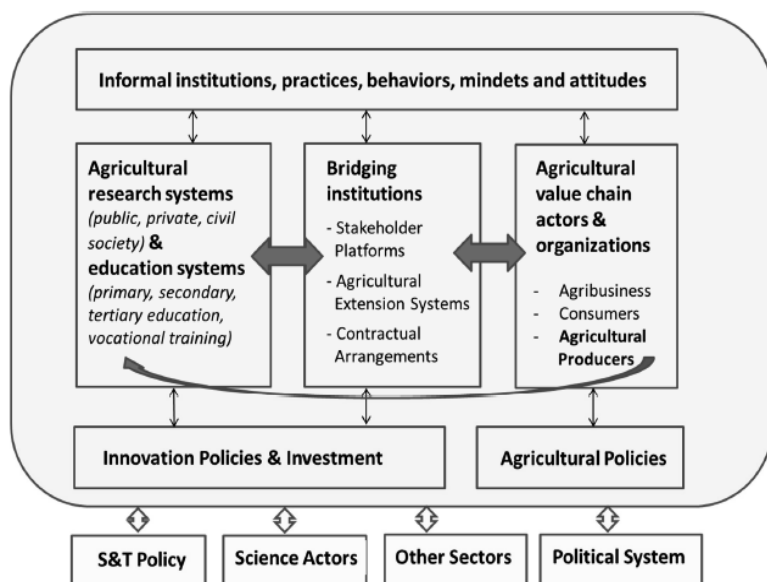
⁴Greenhouse gas emissions.

The System of Agricultural Innovation in Developing Countries

Innovation system includes organizations, enterprises and individuals, which offer and seek knowledge and technology, as well as policy, rules and mechanisms, which affect the subjects to share, access, exchange and use the knowledge (World Bank, 2006).

Within the agricultural innovation system, agricultural producers must be considered as key actors in the value chain, but also the other actors in the value chain, such as suppliers of input and producers of seeds provide significant technical assistance, as well as traders and their requires, in order to get product in accordance with the standards of good agricultural practices. Consequently, innovation is not a one-way street from research to users. Actually, innovation system in agriculture should integrate agricultural education and research sector (Aerni et al., 2015).

Figure 2 *The Conceptual Diagram of the Agricultural Innovation System (AIS)*



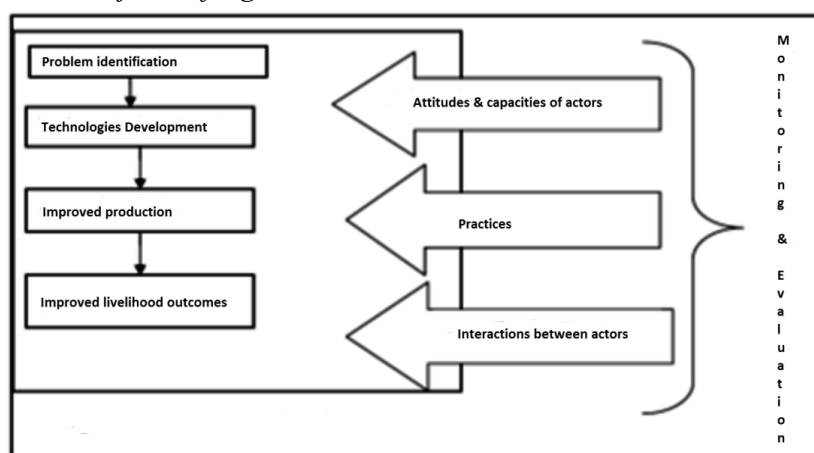
Source: *Aerni et al., 2015*

AIS presents a network of organizations, enterprises and individuals, which is focused on accomplishing economic benefits of the introduction of new productions, new processes and new forms of organizations, together with institutions and policies that affect the system, facilitate access to the finance and markets, provide training (Aerni et al., 2015).

Agricultural innovations in developing countries should be focused on areas with the biggest effects. Those areas are identified by the International Centre for Trade and Sustainable Development (ICTSD) and the International Food & Agricultural Trade Policy Council (Lybert and Sumner, 2010):

- New features, varieties, and crops which increase the productivity and are tolerant to climate change;
- Irrigation and water management systems, which are sensitive to higher variability of rainfall;
- Production, marketing and practice management, which increase soil fertility and decrease GHG emissions through efficient transport and cultivation of plants;
- Information and communication technologies (ICT) in agriculture, which provide greater flexibility at maker of decisions, through improving weather forecasts, using local and timely methods, such as SMS⁵ (smart phones).
- Insurance – Innovations that can help offset risks, which provide greater variability, allowing farmer to enhance their productivity.

Figure 3 *Platform of Agricultural Innovation*



Source: *Mapila et al., 2011*

The areas of agriculture where the innovation can be applied are: genetic improvements, either through conventional breeding or biotechnological practices, and improvement of input and agricultural techniques (Elliott and Hoffman, 2010).

⁵Short message system

Various actors, including interdisciplinary teams of scientists, end users, agents and farmers, are in interaction in order to identify the problems for which the innovation should be developed. When the problems are identified, actors work together to develop and adapt technologies in local environment and it leads to improvement of production and melioration of farmers' standard. During this process, there is constant feedback, which uses mechanisms, set at the beginning of the platform.

Despite number of recent public and private initiatives to develop capacity for agricultural innovations, such initiatives, often are not well matched with national efforts for reviving existing agricultural innovation system. Neither the institutional capacity often gets support, which is necessary to them to improve the conditions for investments in agriculture in whole (Aerni et al., 2015).

ICT in Agriculture in Developing Countries

Telecommunications infrastructure, such as telephone, mobile phone, the Internet, is not well developed in developing countries, nor is able to respond the challenges and demands of innovation and technology management (Murad et al., 2009).

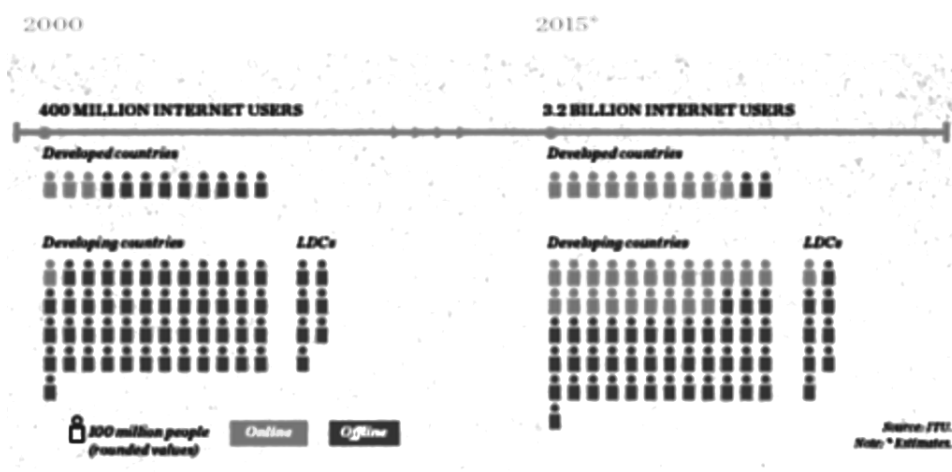
Expansion of mobile telephony network, in rural areas in developing countries, as well as arrival of banking services (SMS-based), contributes to faster integration of farmers in financial markets (Lybbert and Sumner, 2010). In Sub-Saharan Africa, mobile telephones help farmers to advance their productions. Wireless technology enables the farmers in Tanzania the access to information about weather, rainfall, market, demand and prices (Kearny, 2016). Mobile phone is primary way that individuals in undeveloped countries use the Internet. According to one study, over 60% of Kenyans accessed to the Internet from mobile phone. In Sub-Saharan Africa, for instance, there is eight times as much the Internet users with wireless comparing to wire connection (ACCESS, 2011). Availability of accessible mobile telephones to rural communities presents many opportunities for sending and receiving messages, innovation support for workers and improves the speed and coverage of reporting on emergencies. The Internet technologies are unauthorized expensive for most farmers in developing countries (Drury, 2011).

In developing countries, there is huge number of examples how mobile phones and wireless networks can afford significant advantages, where the

landlines are undeveloped or do not exist. Deducing that agriculture is basic support of the Kenyan economy, Mungai (2005) gave several examples referring to providing the farmers to get market prices in shopping malls through their mobile telephones. In this way, farmers can determine the most profitable market for their productions, and avoid unnecessary transport during seeking customers (Houghton, 2006).

Globally, 3.2 milliard people use the Internet, from which 2 milliard are from developing countries and less than 100 million in undeveloped countries (Sanou, 2015).

Figure 4 *Number of Internet Subscribers – an overview of 2000/2015*



Source: *Sanou, 2015*

According to the ITO⁶, in 2015, about 83% of people in developed countries use the Internet, while in developing countries, the Internet access has only 34% of population. However, in the least developed countries, where 940 million of people live, only 89 million use the Internet (9.5%), which corresponds to less than 1 user of 9 residents (Sanou, 2015). Using ICT in developing countries has trend growth, which gives optimism when it comes to agriculture of those countries.

⁶International Telecommunication Union.

Sustainable Agriculture in Developing Countries

Innovation policy in developing countries often neglects the principle of sustainable development, which can have both positive and huge negative effects on the environment, resources and entire economy.

While the expansion of food production is of vital significance for achieving food security and poverty reduction, it is connected also with negative consequence on the environment. Agricultural activities are recognized as major contribution to emissions of gases with greenhouse effect, water shortage and land pollution, degradation and biodiversity loss (Boskovic et al., 2013; Alarcon and Bodouroglou, 2011).

Technologies and innovations should accelerate the transition to sustainable agriculture, respectively (Alarcon and Bodouroglou, 2011):

- Improvement of management in pest control,
- To decrease pollution of water sources, soil erosion and human poisoning;
- Improvement of weed control with reducing the use of herbicides;
- Rational use of water in order to avoid depletion of water source and contamination;
- Protection of biodiversity and natural ecosystems.

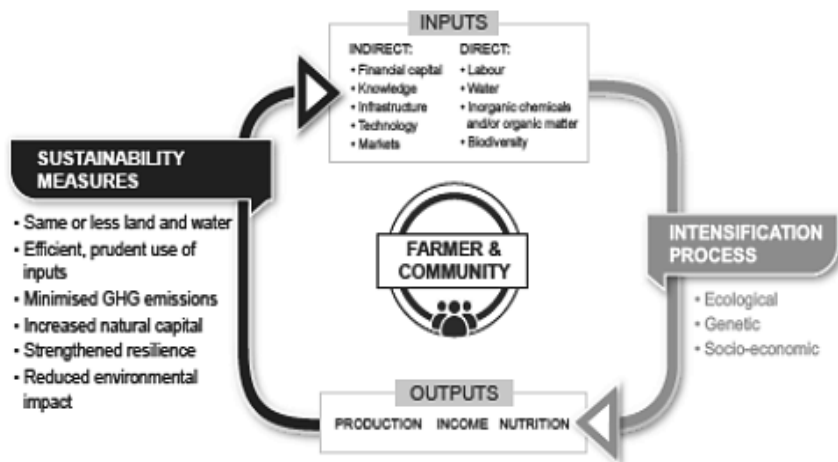
Production of safe food presents an innovation, which is being realized also in developing countries. This innovation is significant and results from intention to reduce the number from diseases, which can appear due to consumption of unsafe food.

Rural population, which is mainly in less developed countries, possesses huge resources in domain of primary food production, as well as mainly good inherited agricultural practice, which have been transferred for generations within the family and neighbors. However, the level of knowledge, which follows new technologies, modern trends and innovations in this area, is still weak, therefore, the utilization of resources is less than we should expect it realistically (Boskovic et al., 2013). Thus, every innovation, directed in the said direction, would be of great importance, especially those, which refer to innovation the knowledge, due to more efficient utilization of natural potential in the primary production sector.

A new paradigm is necessary for agriculture in developing countries, one that can support food security, stimulate the growth, decrease the poverty,

create wealth and protect natural resources. Sustainable intensification offers a solution. It is about production with several output and precise long-term use of input, with decreasing the environmental damage. Elementary innovation consists of more producing by small farmers with less negative impact on the environment, which includes enhancing the sustainability of agriculture with accomplishing higher earnings. The scientific achievements from agroecology, genetics and biotechnology establish this concept. Many can be accomplished by using existing knowledge, whether it originates from other regions or indigenous sources, but due to nature and faced challenges, the innovations are required. Form the intensification of Africa’s agriculture, it is expected that it will produce 80% required increase of food production (Juma et al., 2013).

Figure 5 *A Theoretical Model of Sustainable Intensification*



Source: *Juma et al., 2013*

In new paradigm of agricultural development, demand is not just for higher yields and production, nutritious food, but selective use of input, decreasing the impact on the environment, reducing greenhouse gas emissions and improvement of natural capital.

Main technological advancement in agriculture should open the space for adopting sustainable technologies, practices, and land management in order to enhance the food production with sustainability of resources and environment (Alarcon and Bodourolou, 2011). In addition of efficient use of natural resources through innovation, the component of long-term economic sustainability is important (Akkoyunlu, 2013).

The content of agricultural policy is focused on “food safety”, a term that is used to cover key attributes as sufficiency, reliability, quality, safety, timeliness and other aspects, necessary for health and consumers’ satisfaction (The New Harvest, 2009).

Innovations such as sustainable intensification are applied to less than 2% of area. Because of implementation of listed innovation, improvements are necessary in full range of formal and informal agricultural educational institutions, connecting the farmers with institutes strategic financing etc. (Juma et al., 2013).

Africa faces two major opportunities, which can help it to transform and advance its agriculture. Firstly, advancement in science and technology offer African countries new necessary tools for promotion of sustainable agriculture. Secondly, efforts for creating regional markets will provide new incentives for agricultural production and market. This is the focus of project the Agricultural Innovations in Africa (AIA) (The New Harvest, 2009).

Organic food production brings the benefit for entire society through reduction of production expenses, through safer and better environment, as well as healthier individual. In contrast, conservation of agriculture can not be suitable for each environment and benefits can not be achieved for a while, which makes it less attractive for farmers, who require immediate gain. Compromise should be made, for example, to combine conservative agriculture, where it is possible, with crops of more genotypes, integrated pest management and with programs in order to facilitate small farmer access to herbicides (Juma et al., 2013).

Positioning sustainable agriculture, as sector with knowledge, will require fundamental reforms in existing scientific institutions, especially universities and research institutes (The New Harvest, 2009).

Conclusion

Agricultural sectors of developing countries fall behind for those in developed countries. Main obstacles for agricultural development, respectively, enhancing its productivity, includes the lack of appropriate innovative technologies.

Developing countries have experienced many “successes” in terms of agricultural innovations, but hunger and poverty are still not eliminated.

Input and investment funds for application of innovation are unavailable for the vast majority of farmers. In addition, big innovations, which take place in many regions, are invisible, because the gains are overwhelmed by faster population growth and their demands for food, and climate changes, markets and ecosystem degradation have new annulling effect. Climate changes problems can be solved with appropriate technology, their negative impact on agricultural production, resources and environment is mitigated.

Innovations in agriculture are important regarding that the challenges are being multiplied, such as quality food production for growing population, reducing and degradation of resources for production, climate changes etc. Since that developing countries dispose of huge agricultural potentials, as necessary, implementation of new technologies is imposed, which will advance agricultural production, and in that way mitigate or solve poverty problems, hunger, and in perspective, provide achieving significant input from food production.

Despite number public and private initiatives to develop capacities for agricultural innovations, such innovations often are not in accordance with national efforts of reviving existing agricultural innovative systems.

Developing countries should improve performances of educational system, science and technology, institutions, enhance financial and human investments for establishing local technological opportunities and learn from the experiences of other innovative regions. Although most developing countries have achieved significant progresses in agricultural innovations, it is not satisfactory.

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