Asian Journal of Agricultural Extension, Economics & Sociology

21(2): 1-17, 2017; Article no.AJAEES.37584
ISSN: 2320-7027

Sustainable Agricultural Development, Climate Change and Disaster Risks Management

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Authors' contributions

This work was carried out in collaboration between all authors. Authors Alberto Bigi and Azadeh Bakhshi managed the literature searches and wrote the first draft of the manuscript, under the guidance of author Fabio Maria Santucci, who wrote the final version. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAEES/2017/37584
Editor(s):
(1) Md. Abiar Rahman,Professor, Agroforestry & Environment, Additional Director, IQAC-BSMRAU, Bangabandhu Sheikh Mujibur Rahman Agricultural University (BSMRAU), Bangladesh.
Reviewers:
(1) Jatto Ayoyinka Nurudeen, Usmanu Dan Fodiyo University, Nigeria.
(2) Bahgat M. Abdel-Maksoud, Assiut University, Egypt.
Complete Peer review History: http://www.sciencedomain.org/review-history/21895

Review Article

Received 20th October 2017
Accepted 9th November 2017
Published 14th November 2017

ABSTRACT

This review paper analyses the role and many functions of agriculture within the paradigm of sustainable development and within the scenario of climate change, which is also characterised by an increasing number of natural hazards. The fast-increasing world population, that will achieve the number of 9.7 billion in 2050, will not only demand from agricultural producers a much larger supply of all commodities, but it will also expect from all farmers – large corporations and smallholders alike - a higher level of respect towards some environmental issues. Agriculture is impacting on several natural resources (water, soils, biodiversity, etc.) and contemporarily coping with changing climates and societal demands, requires modern and efficient production systems. Within this already difficult

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scenario, climate change is altering the face of risks, not only through increased weather-related risks and sea-level and temperature rises, but also through more stresses on water availability and ecosystems. The Authors underline that these three aspects (growing food demand, higher attention to environmental aspects and resilience building to cope with natural hazards) must be tackled together, through short term and long-term measures, with an holistic planning and implementation.

Keywords: Sustainable development; resilience; smallholders; SDGs; holistic approach.

1. INTRODUCTION

The agricultural producers, especially the small and very small ones, all over the world, in developed and developing economies alike, are facing tremendous technical and economic challenges [1], because of to the long term ecological modifications due to climate change, and to the extreme violence of some natural hazards or disasters [2,3,4]. Both farmers and herders are the economic actors mostly exposed to the variations of the natural events. The expanding world population, increasingly urbanized and with new consumption patterns, demands higher quantities of ecologically expensive foods like meat and dairy products [5] while, especially in some ecologically fragile areas in developing countries, even traditional forms of farming and animal productions (shifting agriculture, grazing on wild pastures, collection of wild herbs and fruits, fishing, etc.) are showing their unsustainability [6]. This paper, articulated in three paragraphs, shows literature-based evidences calling for institutional and technological changes, as well as for better trade relationships.

2. SUSTAINABLE DEVELOPMENT AND CHALLENGES FOR AGRICULTURE

The concept of "Sustainable Development" was first introduced in 1987 in the report "*Our Common Future*", released by the United Nations World Commission on Environment and Development, commonly named the "Brundtland Report", after the commission's chairperson, Mrs. G.B. Brundtland. The report was a response to the conflicts between the globalized economic growth and the worldwide accelerating environmental degradation. The challenges posed in the 1980s were to harmonize prosperity and economic growth with the conservation of natural resources. This was to be achieved by redefining the concept of "economic development" as a new idea of "sustainable development". *"Environment is where we live; and development is what we all do in attempting to improve our lot within that abode. The two are inseparable…. Humanity has the ability to make development sustainable: to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs* [7, p.7]. Economic development and the management of natural resources were linked in time and space.

Sustainable development is defined as composed of three main dimensions: environmental, economic and social. Sustainable programs and policies are those aiming at these three goals. Sustainability has both individual and institutional applicability, and is usually a balancing act within these three main spheres [8]. The concept shares the principles of the overall sustainable development but emphasizes the rational use of natural resources as a key element within any development strategy, not only for its importance to present and future generations, but because natural resources are among the most important assets in rural areas. The importance of sustainable rural development is highlighted by the fact that approximately 75 per cent of the absolute poor in developing countries live in rural areas, where they depend mostly on agriculture for their livelihoods [9]. More recently [10], after a long discussion and several proposals by individual scientists and national and international institutions, such as UNESCO, a fourth aspect of sustainability has been added, that refers to institutional and cultural aspects.

The FAO Council has defined *Sustainable Agriculture and Rural Development* (SARD) as: *...the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development [in the agriculture, forestry and fisheries sectors] conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable* [11, p.15].

Sustainable Agriculture and Rural Development meets the following criteria [12]:

a) Satisfies the basic nutritional requirements of present and future generations, qualitatively and quantitatively, while providing a number of other agricultural products;
b) Provides durable employment, sufficient income, and decent living and working conditions for all those engaged in agricultural production;
c) Maintains and, where possible, enhances the productive capacity of the natural resource base as a whole, and the regenerative capacity of renewable resources, without disrupting the functioning of basic ecological cycles and natural balances, destroying the socio-cultural attributes of rural communities, or causing contamination of the environment;
d) Reduces the vulnerability of the agricultural sector to adverse natural and socio-economic factors and other risks, and strengthening self-reliance.

One key consideration for the achievement of SARD is the relationship between demographic and economic growth. Considering the increasing population and the rising individual consumption, agriculture must expand. It must do so not only to nourish the people, but also to contribute to the reduction of poverty, by providing food at low prices for the poor and acceptable income for the rural people. This involves educational initiatives, utilization of economic incentives and the development of appropriate new technologies, for a regular supply of raw commodities and processed foods. SARD includes production for markets, employment and income generation to alleviate poverty, while encouraging proper natural resource management and environmental protection.

The Commission on Sustainable Development (CSD) first reviewed the concept of Rural Development in 1995, when it noted that, even though some progress had been reported, many countries were still far from sustainable agriculture and rural development [13]. Sustainable agriculture was also considered at the five-year review of implementation of Agenda 21 in 1997 [14]. In 2000, the UN Assembly resolved to halve by the year 2015 the proportion of the world's population suffering from hunger [15] and established the following eight *Millennium Development Goals* (MDG): 1) Eradicate extreme poverty and hunger; 2) Achieve universal primary education; 3) Promote gender equality; 4) Reduce child mortality; 5) Improve maternal health; 6) Combat HIV/AIDS, malaria, and other diseases; 7) Ensure environmental sustainability; 8) Develop a global partnership for development.

Agriculture within a holistic rural development paradigm was a major focus of the Commission on Sustainable Development in 2000, along with integrated planning and management of land resources. The Commission identified 12 priorities for action [16] and reaffirmed that the major objectives of SARD were to increase food production and to enhance food security in an environmentally sound way. SARD should also contribute to sustainable natural resource management, but it was underlined that food security, although a policy priority for all countries, remained an unfulfilled goal.

Although several studies show positive growth and poverty reduction effects from public spending in agriculture and rural development, many low-income countries still depend on external assistance for policies and projects [17].

In more recent years, for many crops the yield growth has slowed down, and modern inputs have caused environmental damages in many regions, including degradation of water quality because of chemical pollution, salinization due to irrigation, and loss of biodiversity through habitat destruction, as well as the loss of pollinators needed to maintain sustainability. Many insects, pests, weeds, bacteria and viruses have increased their resistance to chemicals, while the promotion of high-yielding cultivars and livestock breeds has substantially reduced agri-biodiversity, increasing vulnerability to pests, diseases and climatic shocks [18].

Between 1990 and 2005, the global forest area has decreased by approximately 1.3 million square kilometres. This was a 0.2 percent average annual loss, with the largest absolute net losses taking place in Indonesia and Brazil. There are, however, substantial differences between regions, and between the first decade of that period and the last five years. The highest rates of net loss in forest cover are found in sub-Saharan Africa and in Latin America and the Caribbean. In sub-Saharan Africa, although the rate of loss declined slightly in recent years,

forest cover is increasing only in a few countries [19].

Since the Millennium declaration, much has been achieved [20]. The number of people living in extreme poverty has declined by more than half, falling from 1.9 billion in 1990 to 836 million in 2015 (MDG 1). The literacy rate among youth aged 15 to 24 has increased globally from 83 per cent to 91 per cent (MDG 2). Developing regions as a whole have achieved the target to eliminate gender disparity in primary, secondary and tertiary education (MDG 3). The global under-five mortality rate has declined by more than half (MDG 4). The maternal mortality ratio has declined by 45 per cent worldwide (MDG 5). New HIV infections fell by approximately 40 per cent [MDG 6]. Ninety-one per cent of the global population is using an improved source of drinking water, compared to 76 per cent in 1990 (MDG 7). Official development assistance from developed countries increased by 66 per cent in real terms from 2000, reaching USD 135.2 billion in 2014 (MDG 8).

However, according to UN [21] the current development strategies are not sufficient for achieving sustainable development. The accelerating environmental degradation inflicts increasing costs on societies. Food insecurity and vulnerability are still very frequent around the world. Environment degradation and unsustainable agriculture remain two of the biggest challenges for the future [22]. When inequality is high and a large number of extremely poor people live in relative isolation from the broader economy, those at the bottom of the income scale typically benefit very little from economic growth [23].

In the past, strong agricultural growth has been a consistent feature of countries that have successfully managed to reduce poverty. According to [24] GDP growth generated in agriculture was, on average, four times more effective in benefiting the poorest half of the population than growth generated outside agriculture. Improvements in agricultural productivity have been fairly widespread, but significant gaps between regions remain. Factors driving land and labour productivity trends include higher use of improved inputs in Asia, resettlement policies in Latin America, and environmental conservation programs in developed regions. High-income countries with limited supplies of land and labour (especially in Western Europe) show high and increasing land and labour productivity. Asia, with little additional land and abundant labour, has shown high and increasing land productivity but low labour productivity. Sub-Saharan Africa has low productivity in both dimensions, with some limited progress on land productivity [25].

More recently, during the United Nations post-2015 agenda summit, 17 *Sustainable Development Goals* [SDG] were proposed to be achieved by 2030 [26]. At least eight goals include actions for the agri-food value chains, from the production of raw commodities to consumption: 1) End poverty in all its forms everywhere; 2) End hunger, achieve food security and improved nutrition and promote sustainable agriculture; 6) Ensure availability and sustainable management of water and sanitation for all; 8) Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all; 10) Reduce inequality within and among countries; 12) Ensure sustainable consumption and production patterns; 13) Take urgent action to combat climate change and its impacts; and 15) Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss. It is evident that these goals are twisted together and that they can only be achieved together, with a combined and holistic approach, that considers together the many factors that are still slowing down the pace of development.

3. IMPACT OF AGRICULTURE ON ECOSYSTEMS AND NATURAL RESOURCES

Every day, agriculture produces an average of 23.7 million tons of food, including 19.5 million tons of cereals, roots, tubers, fruit and vegetables, 1.1 million tons of meat, and 2.1 billion litres of milk. Capture fisheries and aquaculture harvest more than 400,000 tons of fish daily, while forests provide 9.5 million cubic meters of timber and fuel wood. In one day, crop production uses 7.4 trillion litres of water for irrigation, and 300,000 tons of fertilizer [27]. In addition to meeting humanity's basic needs for food, feed, fibre and fuel, agriculture employs more than one third of the world's workers, and provides livelihoods for rural households totalling 2.5 billion people [28]. It contributes to social cohesion in rural areas, and preserves cultural traditions and heritage [29]. It also makes important contributions to landscape and wildlife

management, the protection of wildlife habitats, water management and quality, flood control and climate change mitigation. FAO predicts [27] that agriculture should globally produce 60 percent more food, and 100 percent more in developing countries by 2050. This forecast increases the stress on the agricultural sector, and on the natural ecosystems on which it depends.

An ecosystem is composed by all living organism and non-living components of the environment that interact together. Ecosystems [30] provide fourteen categories of services through their capacities to process matter, transform energy and alter the physical, chemical and biological characteristics of the materials:

1. Purification of air and water;
2. Mitigation of droughts and floods;
3. Generation and preservation of soils and renewal of their fertility;
4. Detoxification and decomposition of wastes;
5. Pollination of crops and natural vegetation;
6. Dispersal of seeds;
7. Cycling and movement of nutrients;
8. Control most potential agricultural pests;
9. Maintenance of biodiversity;
10. Protection of coastal shores from erosion by waves;
11. Protection from the sun's harmful ultraviolet rays;
12. Stabilization of the climate;
13. Moderation of weather extremes and their impacts;
14. Provision of aesthetic beauty and intellectual stimulation.

Farmers use several of the above-mentioned services. The natural environment provides essential inputs to agriculture, many of which are uncounted and unrecorded - sunlight, wind, and rain – which are converted into appropriable private goods such as crops. At the same time, different forms of agriculture constitute particular agricultural ecosystems, that could produce services too, such as carbon sequestration and stabilization of climate, beauty and tourism, habitats for endangered species and other wildlife, purification of air and water and decomposition of wastes, and mitigation of drought and floods.

The changes to the environment associated with agriculture affect a wide range of ecosystem services, including food and materials for human consumption, water quality and quantity, soil and air quality, carbon sequestration, pollination services, seed dispersal, pest mitigation, biodiversity, habitat change and degradation, and protection from disturbances. Food and materials for human consumption serve as prime ecological indicators since this is the main purpose of agriculture. The services provided through agriculture are usually measured as productivity or yields, calculated as the weight of material per area in cultivation. In addition to food, crops are grown for energy, fibres, oils, and other goods. Soil and water quality and quantity are important services that can be enhanced or degraded by agriculture. Agriculture also has both a direct and indirect effect on water consumption and quality. The type of farming system employed, and the agricultural practices used, determine agriculture's positive or negative interaction with ecosystems [31].

In 2005, the Millennium Ecosystem Assessment [32] appraised the state of global ecosystem services, and found that most were being degraded or used unsustainably. Growth in global food production over the past half century has required trade-offs between ecosystem services, resulting in an overall decline in the supply of services other than food, feed and fibre. Climate regulation, water provision, and soil fertility are impacted by agricultural production, yet most farmers have little or no financial incentive to protect them and consequently agriculture is a leading cause of soil erosion, water pollution, biodiversity loss, and greenhouse gas emissions from negative land uses.

Practically, all agricultural practices and techniques adopted by farmers have a direct impact on natural resources sustainability, thus influencing sustainable development.

3.1 Water Deterioration

One major component of environmental degradation is the depletion of the resource of fresh water. Approximately only 2.5 percent of all of the water is fresh water, with the rest being salt water. 69 percent of the fresh water is frozen in ice caps located on Antarctica and Greenland, so only 30 percent of the 2.5 percent of fresh water is available for consumption. Fresh water is an exceptionally important resource, since life is ultimately dependent on it. Water transports nutrients within the biosphere to all forms of life, sustains both plants and animals, and moulds the surface of the planet with transportation and

deposition of materials [33]. Approximately 85 percent is used for irrigation of farmland, golf courses, and parks. Six percent is used for domestic purposes such as indoor bathing and outdoor garden and lawn use. Four percent is used for industrial purposes such as processing, washing, and cooling in manufacturing centres [34]. It is estimated that one out of three people over the entire globe is already facing water shortages. Almost one-fifth of the world's population lives in areas of physical water scarcity, and almost one quarter of the world's population lives in a developing country that lacks the necessary infrastructure to use water from available rivers and aquifers. Water scarcity will continue to be a problem due to population growth, increased urbanization, higher standards of living with increased consumption, and climate change. Agriculture carries a high responsibility for the management of water resources in quantitative and qualitative terms. Careful management of water resources and efficient use of water for rainfed crops and pastures, for irrigation where applicable, and for livestock, are critical for good agricultural practices.

The agricultural techniques include maximizing the infiltration of rain water on agricultural land and maintaining soil cover to avoid surface run-off and minimize leaching to water tables. The maintenance of adequate soil structure, including continuous macrospores and soil organic matter, is an important factor to achieve this. Efficient irrigation methods and technologies minimize losses during the supply and distribution of irrigation water by adapting the quantity and timing to agronomic requirements to avoid excessive leaching and salinization. Water tables should be managed to prevent excessive rise or fall. The use of chemical products also plays an important role, since every chemical substance not utilized by crops will leach into groundwater, contaminating aquifers. In this sense is extremely important to calculate the exact quantity of chemicals needed, in order to avoid exceeding these limits.

3.2 Land Degradation: Soil Erosion, Compaction, Salinization and Desertification

It has been estimated that, worldwide, land degradation costs USD 40 billion annually even without considering the hidden costs of increased fertilizer use, loss of biodiversity and loss of unique ecosystems [35]. Degraded land is costly to reclaim and, if severely degraded may be no longer of use. Land degradation is the reduction in the capacity of the land to perform ecosystem services [including those of agro-ecosystems and urban systems] that support society and development. It includes damage or change to soil structure and influences water bodies, vegetative cover and fauna. Land degradation may occur through different processes:

- *Physical*: crusting, compaction and erosion;
- *Chemical*: acidification, leaching, salinization and pollution;
- *Biological*: changes in biodiversity and eutrophication.

The growing demand for food leads to intensification of farming which, if not done through sound practices, may lead to land degradation. In addition to intensification, other factors can contribute to land degradation, including land tenure status, fragmentation of land and differences in management, lack of knowledge of environmentally sound technologies, reduction of extension services, natural disasters, and lack of incentives to practice environmentally sound agriculture. The overuse of inputs and inappropriate land management practices are not only wasteful, but also damages agricultural products as well as the environment and human health.

Soil erosion is defined as the washing or blowing away of surface soil. It is one of the most widespread and dangerous forms of land degradation. When cultivation, grazing, burning or use of heavy machinery disturbs soil vegetation cover, soil becomes vulnerable to erosion. Erosion accelerates when sloping land is ploughed, grass is removed, cattle and goats are allowed to overgraze, and hillside trees are cut. Cropland is at the highest risk of erosion especially when farming systems leave the land bare exposed to wind and water. The physical and chemical structure of the soil, as well as its biological activity, are fundamental to sustaining agricultural productivity and they determine, in their complexity, soil fertility. Soil management maintains and improves soil fertility by minimizing losses of soil, nutrients, and agrochemicals through erosion, runoff and leaching into surface or ground water. Such losses represent inefficient and unsustainable management of these resources as well as to their potential deleterious off-site effects. Sound soil management seeks to enhance the biological activity of the soil and protect surrounding natural

vegetation and wildlife. If the land is not well managed, heavy precipitation could cause landslides.

Soil compaction is another serious environmental problem caused mainly by the use of heavy machinery on farm fields. The immediate consequences of soil compaction are decreased water and fertilizer efficiency and increased soil erosion. Soil compaction increases the risk of crop failure under reduced water supply and it increases farming costs. Compaction is a subsurface phenomenon that requires soil excavation in order to view and describe it. The two most common visible forms of soil compaction are massiveness [soil aggregates compressed into large and dense blocks] and platiness [the soil forms plate-like structures horizontal to the soil surface].

Salinization: the accumulation of salts from improper soil and water management is a serious problem worldwide. The global cost of irrigation-induced salinity is estimated to be USD 11 billion per year. This phenomenon occurs naturally in areas where rocks are rich in soluble salts. In these cases, primary salinization occurs if the ground water table is shallow and there is insufficient rainfall to leach soluble salts from the soil, or where drainage is restricted. Secondary salinization occurs when significant amounts of water are provided through irrigation, but there is no adequate provision of drainage for the leaching and removal of salts. Salt-affected soils reduce both the ability of crops to take up water and the availability of micronutrients. Salts can also be toxic to plants. Salinity can also be considered a form of pollution. The reclamation of salt-affected land is costly and often difficult.

Desertification is an extreme type of land degradation in which a relatively dry land region becomes increasingly arid, typically losing its bodies of water as well as vegetation and wildlife. It is caused by a variety of factors, such as climate change and human activity. The process of fertile land transforming into desert is typically a result of deforestation, drought or inappropriate agriculture [36]. Today, dry lands occupy approximately 40–41 percent of global land area and are home to more than two billion people. It is estimated that some 10–20 percent of drylands are already degraded, and that the total area affected by desertification is between six and 12 million square kilometres. It is estimated that a billion people are under threat from further desertification [37].

Table 1 provides a summary of the main processes of natural resources degradation influenced by agricultural activities.

The farming system and agricultural practices chosen by farmers influence the impact of agriculture on natural resources and eco-systems sustainability. The ways in which agricultural production factors are managed and interact with weather and climatic agents have an important role in defining ecosystem sustainability and the rate of land and water degradation within a specific watershed. Agricultural practices can substantially affect the functioning of ecosystems, both positively and negatively (Table 2).

3.3 Climate Change, Risk Management and Resilience

Various definitions of climate change exist, but the Australian Academy of Sciences [39] defines climate change as *a change in the average pattern of weather over a long period of time, typically decades or longer*.

Climate change has already significantly impacted agriculture [40] and it is expected to further impact food production, both directly and indirectly. Increase of mean temperatures, changes in rain patterns, increased variability both in temperature and rain patterns, changes in water availability, frequency and intensity of “extreme events”, sea level rise and salinization, perturbations in ecosystems, will all have profound impacts on agriculture, forestry and fisheries [2]. The extent of these impacts will depend not only on the intensity and timing [periodicity] of the changes, but also on their combination. These are more uncertain, and more dependent on local conditions. Since the Intergovernmental Panel on Climate Change report in 2007 [41], some studies have attempted to anticipate these impacts and provide projections, allowing for more concrete visions of projected changes.

The impacts of climate change have major effects on agricultural production, with a decrease in output in certain areas / crops and increased variability of yields, to the extent that important changes may need to be made by primary producers. Broadly speaking, with everything else being equal, climate change may lead to an increase in both crop and livestock productivity in mid- to high latitudes and a decrease in tropical and subtropical areas.

Table 1. Influence of agricultural activities on natural degradation processes

Process of degradation	Causes	Effects
Water Deterioration	Overuse of agrochemicals [fertilizers, pesticides, etc.], overuse of water, mismanagement of wastes and sewer	Water shortage and pollution
Soil erosion	Crops on steep slope or inadequate land, lack of soil covering during rainy seasons, deforestation, lack of contour line ploughing or anti-erosion structures, lack of windbreakers, burning	Productivity reduction, soil infertility, landslides, increasing of lakes and tanks level,
Salinization	Waterlogging because of unsustainable irrigation schemes, too water demanding crop according to local water availability, lack of drainage systems	Productivity reduction, soil infertility, water shortage
Desertification	Overgrazing and over-cropping, ploughing, deforestation, salinization	Productivity reduction, soil infertility, water shortage

Source: own elaboration

Table 2. Overview of agricultural technologies and impacts on ecosystem services

Technology	on Soils	on Water	on Biodiversity	on Air/Climate
Monoculture			*Reduces habitat for insects and wildlife, leading to increased need for pesticides*	
Continuous Cropping	*Soil fertility declines due to nutrient mining*		*Reduces farmers' ability to use natural pest cycles, leading to increased need for pesticides*	
Conventional Tillage	*Reduces soil organic matter, leading to increased erosion*			*Contributes to CO2 emissions due to decomposition of soil organic matter*
Intensive Hillside Cultivation	*Increases erosion, leading to soil degradation*			
Intensive Livestock Systems	*Increases erosion and soil compaction due to overgrazing and hoof action*	*Untreated livestock waste degrades water quality; water usage competes with other needs*	*Degrades grassland habitat due to overgrazing*	*Contributes to CH4 and N2O emissions due to enteric fermentation and manure management*

Technology	on Soils	on Water	on Biodiversity	on Air/Climate
Inorganic Fertilizers	*Increases soil acidification due to nitrate leaching*	*Reduces oxygen levels due to runoff, harming aquatic ecosystems; impairs water for human uses*		*Contributes to smog, ozone, acid rain, and N2O emissions*
Pesticides			*Harms animal and human health by accumulating in soils and leaching into water bodies*	
Irrigation Systems	*Inadequate drainage and over-irrigation causes waterlogging and salinization*	*Degrades downstream ecosystems due to polluted run-off and over-extraction of water*		
New Seed Varieties	*May increase need for inputs that negatively impact soils*	*May increase need for inputs that negatively impact water quality and quantity*	*Reduces maintenance of genetic diversity in landrace varieties*	*May increase need for fertilizer, leading to increased greenhouse gas emissions*
Intensive Rice Production	*Inadequate drainage and continuous flooding causes waterlogging, salinization, and nutrient problems*	*Degrades downstream ecosystems due to polluted run-off and over-extraction of water*		*Contributes to CH4 emissions due to anaerobic conditions in paddy fields*
Industrial Crop Processing		*Degrades downstream ecosystems due to water requirements and discharge of untreated wastewater*		*Contributes to CO2 emissions due to energy requirements of machinery*

Source: [38]

Among the most affected areas, economically vulnerable countries that are already food insecure could be specifically impacted. This will induce significant changes in trade, prices and the overall situation of net food importing countries. Consequently, climate change will increase the gap between developed and developing countries, exacerbating their relatively lower technical and economical capacity [3]. Smallholders and pastoralists will suffer complex, localized impacts [42]. According to the International Food Policy Research Institute [4], climate change will cause an increase between 8.5 and 10.3 percent in the number of malnourished children in all developing countries, relative to scenarios without climate change.

People have always adapted to climate variability through a variety of means, including switching to new agricultural practices. However climate change is pushing at risk populations beyond their capacity to cope and adapt to the changes they have traditionally dealt with, as well as making more people vulnerable due to their increased sensitivity and exposure to climate change impacts. Governments and institutions are realizing that food security, poverty reduction and prosperity will depend on the integration of climate change adaptation strategies in all sectors, and their implementation at all levels.

Climate Change Adaptation (CCA) is a dynamic process and not an end state, given the uncertainty of climate change impacts and the need to support at-risk populations [43].

Agricultural activities in many countries are likely to be adversely affected by climate change. There is still some debate regarding the extent to which climate change will affect agricultural productivity at global level, mainly because of uncertainty regarding the effects of higher carbon concentration on plant growth, or carbon fertilization. By one of the different estimations, climate change will reduce world agricultural production capacity by about 16 percent by the 2080s. Other studies are more optimistic. There is, however, wide consensus that, even if a moderate increase were the outcome at the global level, there would be serious losses for many countries and regions, particularly those in the developing world. For instance, it is estimated that India and a large number of countries in Africa will still face major losses in crop yields. Furthermore, the likely increase in the frequency of extreme events, such as droughts, hurricanes, floods and pest outbreaks suggests that it would be risky to focus the response to climate change exclusively on adaptation [44,45]. Natural extreme events and disasters can undermine the capacity to sustain a sustainable development process in a specific area.

Disasters are defined [46] as situations with a major and widespread disruption to life in a community or society, from which most people are not able to recover without assistance from others, often from outside that community or society. Disasters typically involve loss of lives, infrastructure and other assets, and impact people's wellbeing, security, health and livelihoods. Some disaster impacts are immediate and others can be exacerbated by the way people react to the situation and attempt to recover afterwards

During the past four decades, major losses to human lives and livelihood, as well as damage to economic and social infrastructure, have been caused by natural hazards such as earthquakes, volcanic activity, landslides, tsunamis, tropical cyclones and other severe storms, tornadoes and high winds, river floods and coastal flooding, wildfires and associated haze, drought, sand/dust storms, and insect infestations [47].

Recorded disasters from 2001 to 2010 affected, on average, 232 million people per year, killed 106 million people, and caused USD 108 billion in economic damages [48]. Apart from direct losses and damage to infrastructure, goods and services calculated after a disaster, many other indirect effects could hamper socio-economic development. An empirical model [49] estimates that the disasters in small developing countries affect their exports by an average of 22 percent; such negative effect tends to last for about three years.

According to Munich RE, which is one of the most reliable worldwide and complete database on disaster records and statistics, in 2014 980 events were recorded, with losses estimated at USD 110 billion (Fig. 1). The agriculture sector, including crops, livestock, fisheries and forestry, absorbs approximately 22 percent of the economic impact caused by medium and large scale natural hazards and disasters in developing countries. Yet, despite being so vital for food security and livelihoods, the sector received less than five percent of post-disaster aid [50].

The growing incidence of natural disasters is highly correlated to the increasing vulnerability of households and communities in developing countries, because pre-existing socioeconomic vulnerabilities may exacerbate the impact of a natural disaster, making the process of recovery more difficult [51]. Thus, the impacts of such events could result in an immediate increase in poverty and deprivation [52].

Risk is defined as the probability of harmful consequences, or expected loss [of lives, people injured, property, livelihoods, economic activity disrupted or environment damaged] resulting from interactions between natural or human-induced hazards and vulnerable/capable conditions. Vulnerability is expressed as a set of conditions and processes resulting from physical, social, economic, and environmental factors, which increase the susceptibility of a community to the impact of hazards. Conventionally, risk is expressed by the equation:

Risk = [Hazards x Vulnerability] / Resilience

Countless small-scale, unreported disasters put a cumulative strain on health, lives and livelihoods. It is now widely accepted that disasters are not unavoidable interruptions to development, to be dealt with solely through rapid delivery of emergency relief, but they are the result of unmanaged risks within the development process itself.

Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.

Disaster risk can be significantly reduced through strategies seeking to decrease vulnerability and exposure to hazards, within the wider efforts to address poverty and inequality. Humanitarian responses to disasters and other crises can be designed and implemented in ways that protect the affected people's right to life and other basic rights in the short and longer term. This approach is known as disaster risk management.

Fig. 2 shows how a specific shock or disaster can affect the development process of a vulnerable or resilient community.

Disaster risk management is defined as: "*The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness and response to adverse events*" [53].

Poor rural people around the world constantly seek ways to reduce disaster risks. Some combine diverse livelihood strategies, such as fishing, farming and selling manual labour, to reduce their vulnerability. In many cases, however poverty and marginalization restrict their options, and only rural-to-urban migration remains a likely way of escape.

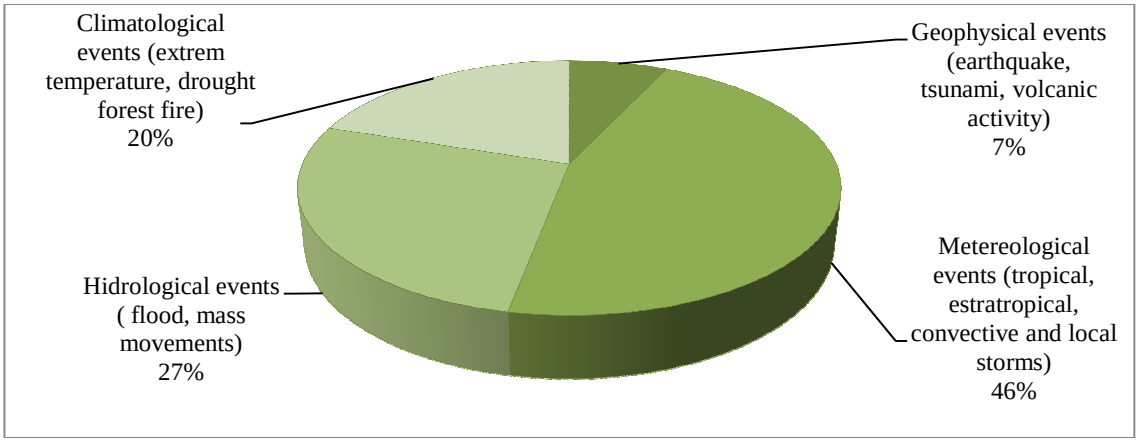

Fig. 1. Distribution of economic losses by types of disaster in 2014
Source: Own elaboration based on on-line data from Munich RE

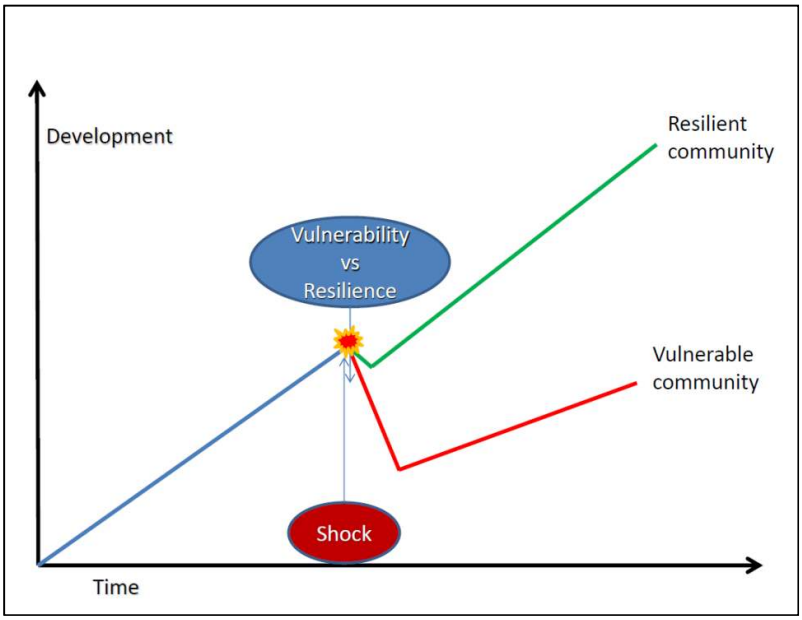

Fig. 2. Linking development processes with disaster impact
Source: Own elaboration

Today, there is increasing awareness that Governments, with their obligation to respect, fulfil and protect human rights, have the primary responsibility for reducing disaster risks. The international community has the duty to provide support and create an enabling environment for this obligation to be met. By signing in Japan the *Hyogo Framework for Action* [HFA] at the World Conference on Disaster Reduction in 2005, 168 governments and all leading development and humanitarian actors committed to a 10 year multi-stakeholder and multi-sectorial plan to invest in disaster risk reduction to building disaster-resilient societies [53]. The HFA had five priorities:

a) Prioritize disaster risk reduction by providing high-profile leadership, establishing relevant policies and programs, and allocating resources to implement them;
b) Identify, assess and monitor disaster risks and improving early warning systems;
c) Create awareness at all levels of society about risk and providing information about how to reduce it;
d) Reduce social, economic and environmental vulnerabilities and those related to land use through improved development planning and post-disaster reconstruction by all sectors;
e) Strengthen disaster preparedness for effective response at all levels.

Since the HFA was agreed, many governments have introduced legislative and policy frameworks for disaster risk reduction, established early warning systems and increased their level of preparedness to respond to disasters. However, the goals of the HFA are still far from being achieved, particularly in terms of addressing the causes of risk and ensuring full participation of at-risk populations in risk assessments, planning processes and programs. A massive effort is needed to bring change at the heart of each country's "development system" through the involvement of all sectors and all stakeholders, from local to national, in disaster risk reduction.

Since May 2015, the *Sendai Framework* [2015-2030] has replaced the Hyogo agreement. It was adopted at the 3rd UN World Conference on Disaster Risk Reduction, held in Sendai, Japan. Taking into account the experience gained in the previous years, focus has been given to actions within and across sectors by States at local, national, regional and global levels, in four priority areas [54]:

a) Understand disaster risk;
b) Strengthen disaster risk governance to manage disaster risk;

c) Invest in disaster risk reduction for resilience;
d) Enhance disaster preparedness for effective response and to "Build Back Better" in recovery, rehabilitation and reconstruction.

As scientific knowledge of global climate change increases and its impacts are experienced around the world, there is a clear need for a broader approach to reducing risks.

Climate change is altering the face of risks, not only through increased weather-related risks and sea-level and temperature rises, but also through increases in societal vulnerabilities, for example, from stresses on water availability, agriculture and ecosystems. Disaster risk reduction, resilience building and CCA share a common space of concern: reducing the vulnerability of communities and achieving sustainable development.

4. CONCLUSIONS

We have analysed how the concept of sustainable development is strongly linked with properly managed agricultural systems. The four pillars of sustainable development - ecological, social, economic, and institutional goals – require an holistic approach, with locally appropriate and feasible solutions.

Today's large diversity of semi-natural and manmade landscapes is the result of centuries of human interventions [55]. The management and use of natural resources and ecosystem services have provided for the multiple needs for food, fibre, fodder, fuel, building materials, medicinal products and water of a slowly growing world population. Nowadays, also because of the demographic explosion of the last decades, this has often been undertaken in an unsustainable manner, causing the degradation of the natural resource base and loss of ecosystem services. Increasing pressures from population growth, changes in food consumption patterns, climate change and competition from other sectors are further weakening the viability of many current farming systems [56].

The triple challenges to simultaneously mitigate the effects of climate change, safeguard natural resources more efficiently and produce more food and ensure food security for future generations require effective policies and approaches to promote sustainable agricultural practices [57].

This is not only a public responsibility, at all levels [local, national, regional and international] but it also calls for private intervention. From the smallest producer living in a marginal area in developing country to the largest cross-national food processors and retailers, there are opportunities to change, re-actively and pro-actively, to ensure long term sustainability to farming and food value chains [1,58].

However, due to the extreme heterogeneity of the ecological, technological and socio-economic situations that can be found on our planet, it is obvious that blanket recommendations cannot be advanced. Each farming system and each food value chain demand to develop different paths, location and product specific, to meet the short term and long term needs of the various stakeholders. Applied, location and product specific research is required [59], managed with an holistic and participatory approach, to favour the elaboration of appropriate innovations and their fast diffusion among the farmers and other interested parties. Due to its extreme importance for agriculture, special attention should be devoted to water and water management, where technical and institutional innovations have been already tested [60]. Training and extension activities are also needed [61], managed and funded by private profit oriented companies, as well as by public entities and by Civil Society Organizations (cooperatives, associations, advocacy movements). To favour the adoption of innovations, grants and credit are also necessary [62,63], with a specific focus on smallholders and disadvantaged groups, which normally do not hold any collateral; micro-credit, in this case, could really make the difference and favour the involvement of even the smallest producers. New forms of marketing, linking together small producers, traders, processors and retailers, should be part of the game [64], to increase the economic resilience of the food value chains, and to ensure the long term supply of all commodities. Last but not least, a major effort should be directed to solve the problem of land tenure rights that in many countries are still in a greyish area, because producers who are not entitled with any formal property rights, well recognized in a public land register, normally do not invest their physical energies and finances to defend the soil with appropriate measures [65,66].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Bruni M, Santucci FM. Agribusiness at global scale and smallholders. Bulgarian Journal of Agricultural Science. 2016; 22(1):01-09.
2. Thornton P, Cramer L. Impacts of climate change on the agricultural and aquatic systems and natural resources within the CGIAR's mandate. Working Paper 23. Copenhagen. CCAFS; 2012. Available:https://cgspace.cgiar.org/bitstream/handle/10568/21226/ccafs-wp-23-cc_impacts_CGIAR.pdf
3. Padgham J. Agricultural development under a changing climate: Opportunities and challenges for adaptation. Joint Discussion Paper. Agriculture and Rural Development and Environment Departments. Washington D.C. The World Bank; 2009. Available:http://siteresources.worldbank.org/INTARD/Resources/climate_change_combined.pdf
4. International Food Policy Research Institute (IFPRI). Climate change: Impact on agriculture and costs of adaptation. Food Policy Report. Washington D.C.; 2009.
5. Elferink M, Schierhorn F. Global demand for food is rising. Can we meet it? Harvard Business Review; 2016. Available:https://hbr.org/2016/04/global-demand-for-food-is-rising-can-we-meet-it
6. Hall M, Dixon J, Gulliver A, Gibbon D. Farming systems and poverty: Improving farmers' livelihoods in a changing world. Rome and Washington D.C. FAO and The World Bank.; 2001.
7. World Commission on Environment and Development. Our Common Future. Report of the General Assembly A/42/427, New York; 1987. Available:http://www.un-documents.net/our-common-future.pdf
8. University of Michigan. Sustainable Assessment and Reporting for the University of Michigan's Ann Arbor Campus, Report N. CSS02-04. Center for Sustainable Systems. Ann Arbor; 2002. Available:http://css.snre.umich.edu/css_doc/CSS02-04.pdf
9. Food and Agricultural Organization (FAO). FAO statistical yearbook 2013. World Food and Agriculture. Rome; 2013. Available:http://www.fao.org/docrep/018/i3107e/i310e.pdf
10. Burford G, Hoover E, Velasco I, Janouskova S, Jimenez A, Piggot G, et al. Bringing the "Missing Pillar" into sustainable development goals: Towards intersubjective values-based indicators. Sustainability. 2013;5:3035-3059.
11. FAO. The concept of SARD. Rome; 1989. Available:http://www.fao.org/docrep/w7541e/w7541e04.htm
12. Pétry F. Sustainability issues in agricultural and rural development. Trainer's Kit. Training Materials for Agricultural Planning. Rome. FAO. 1995;2.
13. Commission on Sustainable Development. Report on the Third Session, 11 04 1995. Economic and Social Council, Official Records. Supplement 12. New York. United Nations; 1995. Available:http://www.un.org/ga/search/view_doc.asp?symbol=E/CN.17/1995/36&Lang=E
14. European Commission. Agenda 21, the first 5 years: Implementation of Agenda 21 in the European Community. Brussels; 1997. Available:http://www.a21italy.it/medias/12408638E82723B6.pdf
15. United Nations. Resolution adopted by the general assembly: UN millennium declaration. New York; 2000. Available:http://www.un.org/millennium/declaration/ares552e.pdf
16. Commission on Sustainable Development. Report on the 8th Session, 30 04 1999 and 24 04-5 05 2000. Economic and Social Council. Official Records. Supplement 9. New York. Available:http://www.un.org/ga/search/view_doc.asp?symbol=E/CN.17/2000/20&Lang=E
17. Ackroyd S, Smith L. Review of public spending to agriculture, a joint DFID/World Bank study. Oxford Policy Management; 2007. Available:http://www1.worldbank.org/publicsector/pe/pfma07/OPMReview.pdf
18. Foley JA, DeFries R, Asner GP, Barford C, Bonan G, Carpenter SR, et al. Global consequences of land use. Science. 2005;309:570-574. DOI: 10.1126/science.1111772

19. FAO. The State of the World's forests. Rome; 2007
20. United Nations. The Millennium Development Goals Report 2015. New York; 2015. Available:http://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20[July%201].pdf
21. United Nations. Zero draft of the outcome document for the UN summit to adopt the Post-2015 development Agenda: Transforming our world by 2030. New York; 2015. Available:https://sustainabledevelopment.un.org/content/documents/7261Post-2015%20Summit%20-%202%20June%202015.pdf
22. United Nations. Global trends and challenges to sustainable development post-2015. Chapter 1. New York; 2015.
23. Von Braun J, Patel A, Soyinka W. Eliminating hunger and reducing poverty, three perspectives. Washington D.C. IFPRI; 2007. Available:http://ebrary.ifpri.org/cdm/ref/collection/p15738coll2/id/33766
24. World Bank. World Development Report. Washington D.C.; 2008.
25. FAO. FAOSTAT. Rome; 2015. Available:http://faostat3.fao.org/home/E
26. United Nations. Transforming our world: The 2030 Agenda for sustainable development. New York; 2015. Available:http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E
27. FAO. Building a common vision for sustainable food and agriculture, principles and approaches. Rome; 2014. Available:http://www.fao.org/3/919235b7-4553-4a4a-bf38-a76797dc5b23/i3940e.pdf
28. FAO. World food and agriculture. Rome; 2013. Available:http://www.fao.org/docrep/018/i3107e/i3107e.pdf
29. Van Huylenbroeck G, Vandermeulen V, Mettepenning E, Verspecht A. Multifunctionality of agriculture: A review of definitions, evidence and instruments. Muncherberg. Leibniz Centre for Agricultural Landscape Research; 2007. Available:http://landscaperesearch.livingreviews.org/Articles/lrlr-2007-3/download/lrlr-2007-3Color.pdf
30. Daily GC. Nature´s services, societal dependence on natural ecosystem. Washington D.C. Island Press; 1997.
31. Zhang W, Taylor H, Ricketts C, Kremen KC, Scott MS. Ecosystem services and dis-services to agriculture. Ecological Economics. 2007;64:253–260. Available:http://beahrselp.berkeley.edu/wp-content/uploads/2010/06/Ecosystem-Services-and-dis-services-to-agriculture.pdf
32. Millennium Ecosystem Assessment (MEA). Ecosystems and human well-being: Synthesis. Washington D.C. Island Press; 2005.
33. Young GJ, James CI, Rodda JC. Global water resource issues. Cambridge. Cambridge University Press; 2004.
34. Frederick KD, Major DC. Climate change and water resources. Climatic Change. 1997;37(1):7-23. Available:http://www.rff.org/rff/documents/rff-ccib-03.pdf
35. FAO. Climate smart agriculture sourcebook. Rome; 2013. Available:http://www.fao.org/3/a-i3325e.pdf
36. Geist H. The causes and progression of desertification. Aldershot. Ashgate Publication; 2005.
37. Bauer S. Desertification. In Thai K.V., Rahm D., Coggburn J.D. (Eds.) Handbook of globalization and the environment. Chapter 5: 77-94. Boca Raton. CRC Press; 2007.
38. Killebrew K, Wolff H. Environmental impacts of agricultural technologies. Evans School Policy Analysis and Research, University of Washington D.C.; 2010. Available:http://econ.washington.edu/sites/econ/files/old-site-uploads/2014/06/2010-Environmental-Impacts-of-Ag-Technologies.pdf
39. Australian Academy of Science. The science of climate change: Questions and answers. Canberra; 2010. Available:http://www.forestandbird.org.nz/files/file/The%20Science%20of%20Climate%20Change-%20Questions%20%20Answers%20-%20AAS%2016%208%2010%20[2].pdf
40. Lobell D, Schlenker W, Costa-Roberts J. Climate trends and global crop production since 1980. Science. 2011;333(6042):616-20. Available:http://biblio-climat.fr/wp-content/uploads/2014/01/69_Lobell_Climate-Trends-and-Global-Crop-Production-Since-1980.pdf

41. Metz B, Davidson OR, Bosch PR, Dave R, Meyer LA, (Eds.). Climate change, Mitigation of climate change. Working group III. Contribution to the 4th Assessment Report of the IPCC. Cambridge. Cambridge University Press; 2007.
42. IPCC. Managing the risks of extreme events and disasters to advance climate change adaptation. A Special Report of Working Groups I and II of the IPCC. Cambridge. Cambridge University Press; 2012.
43. Pettengell C. Climate change adaptation: Enabling people living in poverty to adapt. Oxfam International, Oxford; 2010. Available:https://www.oxfam.org/sites/www.oxfam.org/files/climate-change-adaptation-apr2010.pdf
44. Cline WR. Global warming and agriculture: Impact estimates by country. Washington D.C. Center for Global Development; 2007. Available:https://www.imf.org/external/pubs/ft/fandd/2008/03/pdf/cline.pdf
45. IPCC. Food, fiber and forest products. Chapter 5 in climate change: Impacts, adaptation and vulnerability. 4th Assessment Report; 2007. Available:http://www.ipcc.ch/pdf/assessment-report/ar4/wg2/ar4-wg2-chapter5.pdf
46. United Nations International Strategy for Disaster Reduction (UNISDR). Terminology on disaster risk reduction. Geneva; 2009. Available:www.unisdr.org/files/7817_UNISDRTerminologyEnglish.pdf
47. Munich RE. Topics GEO: Natural Catastrophe 2013, Analyses assessments, positions. Munich; 2014. Available:http://www.munichre.com/site/corporate/get/documents_E1060573842/mr/assetpool.shared/Documents/0_Corporate%20Website/_Publications/302-08121_en.pdf
48. Center for Research on the Epidemiology of Disasters (CRED). Disaster data: A balanced perspective, CRED CRUNCH, 27. Brussels Institute of Health and Society; 2012. Available:file:///C:/Users/bigi/Downloads/CredCrunch27.pdf
49. Cernat L, da Silva JA. Coping with loss: The impact of natural disasters on developing countries s' trade flows. Chief Economist Trade, Brussels. 2012;1. Available:http://trade.ec.europa.eu/doclib/docs/2012/march/tradoc_149246.pdf
50. FAO. The impact of natural hazard and disasters on agriculture and food and nutrition security, a call for action to build resilient livelihoods. Rome; 2015. Available:http://www.fao.org/3/a-i4434e.pdf
51. Kreimer A, Arnold M. Managing disaster risk in emerging economies. Disaster risk management series 2. Washington D.C. The World Bank; 2000. Available:https://openknowledge.worldbank.org/handle/10986/15196 License: CC BY 3.0 IGO
52. Carter MR, Little P, Mogues T. Poverty traps and natural disasters in Ethiopia and Honduras. World Development. 2007; 35(5):835-856.
53. UNISDR Hyogo framework for action 2005-2015 - Building resilience of nations and communities to disasters. World Conference on Disaster Reduction. Kobe; 2005. Available:http://www.unisdr.org/2005/wcdr/intergover/official-doc/L-docs/Hyogo-framework-for-action-english.pdf
54. United Nations Sendai framework for disaster risk reduction 2015-2030. Geneva; 2015. Available:http://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf
55. Hall M. (ed.) Farmers' systems and poverty – Improving farmers' livelihoods in a changing world. Rome and Washington D.C. FAO and World Bank; 2001.
56. WWAP (UN World Water Assessment Programme) UN World Water Development Report. Paris. UNESCO; 2015.
57. FAO. Building a common vision for sustainable food and agriculture – principles and approaches. Rome; 2014. Available:http://www.fao.org/3/a-i3940e.pdf
58. Gatzweiler FW, von Braun J, (Eds.). Technological and institutional innovations for marginalised smallholders in agricultural development; 2016. Available:Springerlink.com
59. Francis J, Mytelka L, Van Huis H, Roeling N, (Eds.). Innovation systems: Towards effective strategies in support of smallholder farmers. Wageningen. CTA; 2016. Available:https://publications.cta.int/media/publications/downloads/1829_PDF.pdf
60. Santini A, Lamaddalena N, Severino G, Palladino M, (Eds.). Irrigation in the Mediterranean agriculture: Challenges and innovation for the next decades. Options

Méditerranéennes 84. Paris and Bari. CIHEAM; 2008.
61. Christoplos I. Mobilizing the potential of rural and agricultural extension. Rome. FAO; 2010.
62. Ruete M. Financing for agriculture: How to boost opportunities in developing countries. Policy brief 3. Winnipeg. IISD; 2015.
Available:https://www.iisd.org/sites/default/files/publications/financing-agriculture-boost-opportunities-devloping-countries.pdf
63. Hartarska V, Nadolnyak D, Shen X. Agricultural credit and economic growth in rural areas. Agricultural Finance Review. 2015;75(3):302-312.
64. Bright D, Seville D, Borkenhagen L. Think big. Go small. Adapting business models to incorporate smallholders into supply chains. Oxford. Oxfam; 2010.
65. Tsikata D, Golah P, (Eds.). Land tenure, gender and globalization – research and analysis from Africa, East Asia and Latin America. Ottawa. IDRC; 2010.
66. Neef A. Land tenure and soil conservation practices - evidence from West Africa and Southeast Asia, in Stott D.E., Mohtar R.H. and Steinhardt G.C. (Eds.), Sustaining the Global Farm. Lafayette. Purdue University. 2001;125-130.
Available:http://tucson.ars.ag.gov/isco/isco10/SustainingTheGlobalFarm/P238-Neef.pdf

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/21895