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Ecological Intensification of Natural Resources for Sustainable Agriculture

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Preface

The population explosion has taken place at an unprecedented rate which is expected to reach more than 9 billion by 2050. Thus, it was observed that 70% higher production in the agricultural sector is required in 2050 when compared to the last two decades (FAO 2018). These indicate a higher level of agricultural intensification is required through ecological intensification. It is also questionable whether the earth's carrying capacity would sustain such an unprecedented rate of intensification which is totally unsustainable. Under this context, the concept of eco-intensification is the need of the hour which aims to reduce the pressure on earth resources along with maintaining the balance and harmony in production sectors.

Ecological intensification comprises genetic intensification and socio-economic intensification to give an all-round eco-friendly development. Policies under ecological intensification should be synergistic in the approach to keep the balance between the production sector and consumer sector. The development of new farming systems of intensive to semi-intensive in nature may promote natural resources conservation. Ecological intensification is such an issue which has not been explored properly till date. It encompasses better food production at a low environmental cost, broader perspectives in environmental conservation, and maintaining the integrity of the earth ecosystem. Under these circumstances, new research and development need to be done to exploit the possibility and opportunity for sustainable eco-intensification, hence the target to develop new principles and management policies towards sustainable development. Ecological intensification tends to improve the productivity of various production systems as well as reduce the ecological footprint. It also helps to conserve the diverse ecosystem services such as maintaining soil quality, inhibition of soil degradation, reducing GHGs emission, establishing proper source–sink relationship of carbon to maintain carbon balance, soil and water conservation, maintaining bio-resource, ecosystem resistance and resilience to autochthonous and allochthonous changes along with overall sustainability of the ecosystem.

The present book discussed the critical issue of ecological intensification to fulfill the current demand for food as well as address the issue of sustainability in relation to natural resources and sustainable agriculture. Natural resource is the central point of all social, economic, and environmental development. Therefore, proper management requires proper priority. The present title is an attempt to understand the concept of ecological intensification, its role towards natural resource management and its approach towards sustainability of the agroecosystem. In the introduction, various aspects of ecological intensification have been clarified for resource management and sustainable productive perspective. Further, specific issues such as food security, biodiversity conservation, climate change, sustainable agriculture, soil contaminant, eco-modeling, eco-designing, and animal breeding in relation to ecological intensification were addressed. The book also covered some allied aspects of mulching, vertical greenhouses, pollination, ecosystem services, and soil carbon stock and sequestration in a holistic way to provide a pathway of sustainable agricultural practices for the learned society of the globe. The book concluded the proper management strategies with various issues related to natural resource, environment, ecology, sustainable agriculture, and allied fields with new updated knowledge that would enrich and create a platform of discussion on ecological intensification at the global level.

From a global perspective, multidisciplinary approach is required to address the issue of sustainability and conservation. It includes wide disciplines such as forestry, agriculture, environmental science, and ecology. Reference textbook and separate edited volumes are not available addressing specific issues of "Ecological Intensification of Natural Resources for Sustainable Agriculture." However, most of the books are focused on natural resources and their conservation. The integration of the concept of ecological intensification with natural resource is the biggest challenge of twenty-first century. It is also a limiting factor in terms of knowledge for academicians, scientists, research scholars, and policymakers of the present time. This edited book would act as a basic to update knowledge base for the scientists and academicians for the future goal. The objectives of this book are: (1) to address the issue of ecological intensification for natural resources, (2) to generate awareness and proper understanding of the concept and its associated issues and challenges, and (3) to educate the learned society about the recent trend and development to formulate strategies for future research and development.

The present attempt is for the national and international audience to clearly understand the concept of ecological intensification and its applicability in the field of natural resource management and sustainable agriculture. Highly professional and internationally renowned researchers are invited to contribute, authoritative and cutting-edge scientific information on a broad range of topics covering agroecology, environment, ecological footprints and sustainability. All the chapters are well illustrated with appropriately placed data, tables, figures, and photographs and supported with extensive and most recent references. The submitted chapters are reviewed by the members of the Editorial Committee in the relevant field for further improvement and authentication of the information provided. The editors also provided a roadmap for ecological intensification for natural resources aiming towards sustainable agricultural development.

Ambikapur, India — Manoj Kumar Jhariya
Varanasi, India — Ram Swaroop Meena
Ambikapur, India — Arnab Banerjee

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Manoj Kumar Jhariya is Assistant Professor at the Department of Farm Forestry, Sant Gahira Guru Vishwavidyalaya (formerly, Sarguja University), Ambikapur (Chhattisgarh), India, and the author or co-author of more than 68 scientific papers, 9 books, 33 book chapters, and several extension articles. He acquired his B.Sc. (Agriculture) and M.Sc. and Ph.D. (both in Forestry) degrees from Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India. He was awarded a UGC-RGNF Fellowship, New Delhi, India, and received a Chhattisgarh Young Scientist Award from Chhattisgarh Council of Science and Technology in 2013. He is an editorial board member for several journals and a life member of numerous societies.

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Ecologically Harmonized Agricultural Management for Global Food Security

2

Yevhen Mishenin, Inessa Yarova, and Inna Koblianska

Abstract

About 11% of global population is undernourished today and the society is expected to run into the grave concerning the 2030 zero hunger goal achievement. The environmental factors are among the keys threat in this case, specifically, climate changes and shocks, deterioration of land and soils, ecosystems' destruction influencing agriculture's capacity to provide enough food of certain quality. These environmental problems are caused by agriculture itself in a large measure. In view of this there is the need to come to grips with socio-ecological and economic aspects of agricultural greening on the way towards the global food security.

The chapter provides the systemic overview of environmental aspects of agriculture and food provision, outlining the main nature-sector interrelations, the most urgent environmental problems associated with feeding the world, as well as reveals social and environmental peculiarities of industrial model of agriculture using the Ukrainian case. It should be outlined, that along with positioning the Ukraine as a "Food Basket of Europe", the National food security is failed as the amount of basic food in the diet of average Ukrainian is lacking. Moreover, every dollar of agricultural output is becoming more expensive for Ukrainians considering all types of environmental impact (air emissions, wastes, including pesticides wastes, sown area with pesticides, freshwater consumption

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and withdrawal). This case highlights the importance of sound policy towards the agriculture sustainability. Under these circumstances, modern challenges of the world were identified and are facing on the way to food and environmental security, namely: the production of sufficient food for the own consumption, as well as for the import; the creation of strategic and insurance food stocks, as well as the food export possibility; the provision of optimal and rational structure of foodstuffs consumed; ensuring the ecological quality of the consumed food within the existing food structure; the socio-economic accessibility of food; the environmental component associated with the agricultural production.

It is stated that the greening of agribusiness and agro-food sphere embraces the transformation of existing technological agro-production methods towards maximizing the output of high-quality ecological agricultural products along with preserving environment. In this context, the chapter investigates and classifies the possible existing innovative solutions within the framework of eco-intensification, climate smart agriculture and sustainable agriculture concepts.

All the same, institutional transformations are the key for the movement towards the environmentally friendly agricultural practices. It embraces the conceptualization of sustainable agriculture and its basic principles such as partnership, integration, ecosystem and environmental management, equity for all generations and civilized competitiveness. The appropriate organizational and economic mechanism needs to be put in place to promote the sustainable agriculture. It is a set of subsystems of supporting, organizing, regulating and controlling agriculture resource use nature, and requires the implementation of environmentally adjusted prices for agriculture resources and food, as well as changes of agriculture producers' behaviour, i.e. more environmentally and socially responsible. Specifically, in order to fully compensate the economic damage from environmental pollution through the pricing system, it is suggested to calculate and use a price increase index considering the ecological component of the production cost.

Finally, the chapter also disclosures the role of agriculture in local communities' development, searching for the best model of agriculture organization and agrarian policy consistent with sustainable rural development goals. The local food concept implementation is seen as a main strategy for the elaboration of a policy addressing the issues of industry and community sustainable development.

Keywords

Agriculture · Agricultural sustainability · Eco-intensification · Environment · Food security · Sustainable development

Abbreviations

FAO	Food Agriculture Organization
IFPRI	International Food Policy Research Institute
R&D	Research and Development
GDP	Gross domestic product
EU	European Union
CSA	Climate smart agriculture
SDG	Sustainable development goals

2.1 Introduction

Modern agri-production methods, which have increased its efficiency and volume, deplete agro-ecosystems at different scales (from local to global) (Mishenin and Koblianska 2016; Spiess 2016; Müller et al. 2016; FAO 2017; Yatsuk 2018; Pingali et al. 2019; Koblianska and Kalachevska 2019; World Bank 2020). This leads to a search for improved methods of agricultural management (Bartolini and Brunori 2014; Pangaribowo and Gerber 2016; Delzeit et al. 2017; Zilberman et al. 2018; Asfaw and Branca 2018; Ickowitz et al. 2019).

The environmental deterioration due to a significant increase in anthropogenic and technogenic load on the environment requires the dominant achievement of resource-ecological safety of nature and agricultural management (Delzeit et al. 2017; Ickowitz et al. 2019; Raj et al. 2020; Banerjee et al. 2020; Kumar et al. 2020). Thus, among the priorities of sustainable socio-economic development is the necessity of environmentally balanced agro-economy (Ullah et al. 2020), which is impossible without reorientation of the agricultural organizational-economic mechanism to the rational use and conservation of natural and land-resource potential (Mishenin et al. 2015; Mishenin and Yarova 2019). That is the desirable way to solve the problem of food security ensuring (Gaffney et al. 2019; Nicholls et al. 2020), which is multifaceted (Breeman et al. 2015; Devaux et al. 2020) and covers issues on providing the enough food supply, the availability, stability and quality of the latter (Delzeit et al. 2017; Ickowitz et al. 2019), and appears both at local (Strochenko et al. 2017; GRFC 2020) and global scale (FAO 2018, 2019b; GRFC 2020; World Bank 2020).

Feeding about 9.7 billion people in the next 30 years will require an increase of food supply over 50% of current volume (Diaz-Ambrona and Maletta 2014; Konuma 2018; World Bank 2020). This poses a significant risk of environmental pressure aggravation (Gowdy 2020), concerning the nature driven character of agriculture (Gaffney et al. 2019; Nkonya et al. 2016; Chakravorty et al. 2007; Andrade et al. 2019; Lipper and Zilberman 2018; Tonitto et al. 2018; Adenuga et al. 2019). It is clear now that disregarding the ecological and economic foundations of agricultural land use will continue the acceleration of the eco-degradation of land-resource potential (Diaz-Ambrona and Maletta 2014), reduce the ecological and economic efficiency of agricultural management (FAO 2017), deepen the socio-environmental problems of food security (GRFC 2020; Meena et al. 2020) and even threaten the achievement of the development goal of zero hunger (FAO 2017, 2018, 2019b; Gowdy 2020). Despite that, many socio-ecological and economic issues in the field of agro-economy (in particular, sustainable land-potential use) are still remaining unresolved concerning development of strategic guidelines and mechanisms for greening agriculture to ensure global food security (Spiess 2016; Ickowitz et al. 2019; Gaffney et al. 2019). Under these circumstances, we have investigated the socio-ecological and economic aspects of agricultural greening on the way towards the global food security.

2.2 Agriculture and Nature: Interrelation, Influence and Issues to Be Solved

Agriculture is a vital industry as it provides humanity with food at any form of social organization (from times of gathering and hunting until modern with genetic and nanotechnologies of food production). At the same time, the industry is very nature-dependent and environmentally driven (Gaffney et al. 2019; Andrade et al. 2019; Tonitto et al. 2018; Adenuga et al. 2019; El Bilali 2019). Agricultural practices carried out in all parts of the world affect a single natural space, resulting in a change in both local and global conditions for agricultural activities, and, in particular, the production of the required amount of food. Therefore, natural constraints for humans in meeting their basic needs are on full display in agriculture (Meena et al. 2018; Meena and Lal 2018). That covers available land areas, water resources, favourable weather and climate, etc. However, the whole range of complex agriculture and nature interrelations is not fully investigated and recognized. Moreover, a fairly large number of agricultural producers neglect scientifically sound principles of rational land use because of lag time in cause-effects and for the sake of need to provide a certain level of income (Mishenin and Koblianska 2016; Fatemi and Rezaei-Moghaddam 2019). This leads to the sweeping and irreversible adverse environmental effects, which are already palpable.

Basically, agricultural activities commit land, water, space (infrastructure) and ecosystem resources under certain climate conditions, consuming nutrients, energy, human-made inputs and thus resulting in water and air pollution and emissions, land and soils deterioration, ecosystem degradation, climatic change, etc. (Fig. 2.1) (Gaffney et al. 2019; Nkonya et al. 2016; Chakravorty et al. 2007; Andrade et al. 2019; Lipper and Zilberman 2018; Tonitto et al. 2018; Adenuga et al. 2019). In particular, agriculture uses 70% of water (World Bank 2020) and consumes about 30% of global energy consumption (FAO 2017). The sector also accounts for 18% of globe carbon dioxide emissions (with animal husbandry accounting for about 64% and 21% for growing rice) (Pingali et al. 2019).

Along with that, there is a need to investigate the whole food chain for the assessment of total environmental impact caused by agriculture food production.

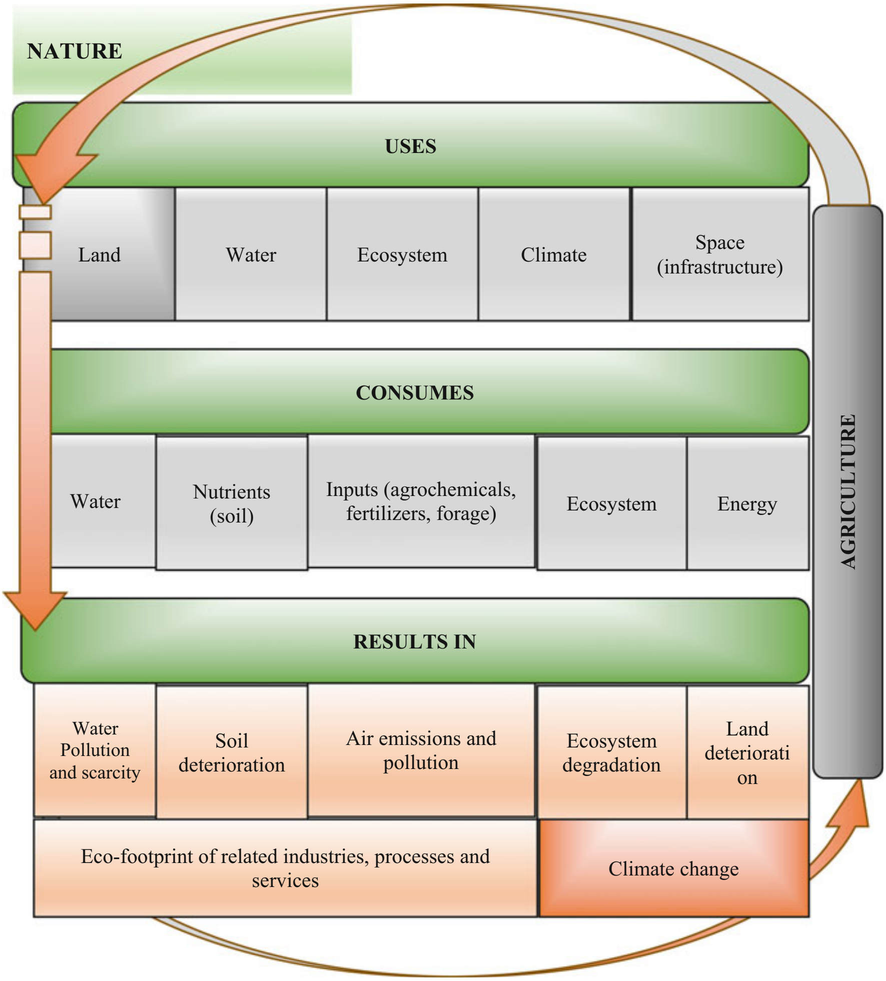

Fig. 2.1 Agriculture and Nature: the main interrelations (developed by Koblianska on the base of Gaffney et al. 2019; Nkonya et al. 2016; Chakravorty et al. 2007; Andrade et al. 2019; Lipper and Zilberman 2018; Tonitto et al. 2018; Adenuga et al. 2019; Pingali et al. 2019)

In this regard, one should emphasize on the significant ecological footprint of agriculture related industries both upper and downstream, e.g. the so-called virtual water footprint of animal husbandry (Spiess 2016). In this context, the production of human-made inputs (agrochemicals, mineral fertilizers, antimicrobials, industrial feed) is gaining attention (Andrade et al. 2019; Lipper and Zilberman 2018; Meena et al. 2020), as well as appropriate wastes generation (Spiess 2016). The application of human-made materials leads to the irreversible change in all components of natural environment (soil and water pollution, pest and weed resistance, losses of biodiversity, etc.) (Gaffney et al. 2019; Nkonya et al. 2016;

Chakravorty et al. 2007). Additionally, economic growth provokes changes in dietary and lifestyle (e.g. growing trend of eating out), leading to additional environmental burden, related with losses and wastes of food along the supply chain (Duque-Acevedo et al. 2020; Read et al. 2020).

All above affects not only the environment quality and humans' well-being, but also the opportunities for agriculture and related industries further development. This relationship is revealed, in particular, through the understanding of agriculture impact and dependence on ecosystem services (Nicholls et al. 2020; Meena 2020a, b) and related economic parameters (Kopittke et al. 2019).

Under the sustainable development paradigm, the sustainable agriculture is a raising issue (Lipper and Zilberman 2018; Jhariya et al. 2019a, b). It aims at providing growth or at least stable yields while reducing environmental impact, preserving nature and counteracting climate change (Gaffney et al. 2019). Under this background, the competing objectives come to the fore, namely: to ensure production in a volume that guarantees a sufficient supply of food, to alleviate poverty, to provide better health and nutrition for the growing population, the nature conservation (Gaffney et al. 2019). The coherent achievement of the objectives outlined is the main challenge facing modern agriculture and society.

2.3 Environmental Problems of Agriculture in the Context of Food Security: Global Trends

The human population is expected to amount about 9.7 billion people until 2050 (World Bank 2020). This requires an increase of the amount of food by 50–70% (Diaz-Ambrona and Maletta 2014; Konuma 2018). Alongside this, only the increase of food volume is not enough to provide food security. This notion is multidimensional (Breeman et al. 2015) and embraces also such issues as food availability, quality, stability (Devaux et al. 2020), and adequacy to the goals of a healthy life (Delzeit et al. 2017; Ickowitz et al. 2019). Within this framework, a food security assurance requires lesser agriculture production growth, than as sound economic, social and technological policy and measures. However, the increase of agriculture productivity and output remains the important target in this context, especially for agriculture dependent people, social groups and even countries (Funk and Brown 2009). Under these circumstances, environmental problems of agriculture are getting new sound, because increase of production results in corresponding increase of input resources and waste (Diaz-Ambrona and Maletta 2014). Thus, ensuring environmental security towards achieving the food security goals at the global scale is one of the main challenges for further agriculture development.

According to FAO's estimates, the scarcity of resources available for food production will increase until 2050 significantly, leading to aggravation of competition, unsustainable and destructive use of resources, thereby endangering the welfare of millions of farmers, foresters, fishermen and other agriculture dependent groups. About 33% of agricultural lands are already medium- and highly degraded and further expansion of agricultural land threatens deforestation, especially in countries of Asia, South and Central America (FAO 2017).

Despite the sufficiency of existing resources to provide food for up to 10 billion people, the major concern is the allocation of available resources to fully meet food security goals (Spiess 2016). This results in a fair amount of undernourished people and even hunger.

According to the FAO, over 820 million people were hungry and undernourished in 2018 (FAO 2019b), that is every ninth (World Bank 2020). Among them, over 113 million people felt severe hunger, being unable to provide the necessary food and nutrition (Table 2.1). That was observed in 53 countries (GRFC 2020). Upward of 100 million people annually was suffering from severe hunger across the world, despite the gradual decline in their number for 2016–2018. Additionally, about 143 million people in 42 countries in 2018 were living on the edge of starvation (GRFC 2020). Alongside this, the existence of millions of people liable to obesity and overweight reveals another dimension of food security concept, i.e. food quality (World Bank 2020).

The problem of hunger and undernourishment is deepened under the background of continued climatic changes and existing climate shocks. Particularly, climatic factors caused 25.7% of severe hunger cases (29 million people) in 2018 (GRFC 2020). Climate changes lead to further deterioration of natural capital, degradation of ecosystems, water scarcity, climate shocks (drought, floods, storms), etc. (Khan et al. 2020a, b). That influences the agricultural production substantially, especially on crop production (49% of the total climate-related losses in agriculture) and animal husbandry (36% of industry's losses) (FAO 2018). This leads to a decline of incomes of agriculture dependent people (FAO 2018), challenging their capacities to provide enough food of a needed quality, as well as national and global food security (Spiess 2016).

Climate changes are expected to continue significantly threatening the food security through droughts, winds, flooding, affecting total food production across the world and small farmer's activities mainly (GRFC 2020). In this context, the maintenance of the achieved level of agricultural productivity needs substantial investments, as well as clear policy aimed at responding to climate change (World Bank 2020; FAO 2018). At the same time, the last data show a decline of agricultural research funding in different regions of the world (Fig. 2.2). Moreover, according to the IFPRI IFPRI (2020), government and donor funding for agro-research in Africa declined by 5% over the 2014–2016 period, and a share of R&D spending in 2016 have been slided to only 0.39% of GDP, which is critical. In particular, it was expected that agricultural productivity in the Sub Sahara African countries could increase by 62% until 2050 compared to the current level with the agricultural R&D funding as of 1% GDP (IFPRI 2020). It should be emphasized that only high-income countries finance agro-research at the level of more than 1% of GDP, whereas for other countries this figure did not exceed 0.6% since the century (Fig. 2.2). Therefore, the significant potential of the industry remains untapped in a global scale.

Table 2.1 Number of undernourished, 1990/92–2030 (FAO 2017)

Region	1990–1992		2000–2002		2005–2007		2014–2016		2030	
	%	million	%	million	%	million	%	Million	%	million
High-income countries	<5.0	32	<5.0	36	2.2	29	1.6	23	1.1	16
Low- and middle-income countries	29.7	978	24.5	894	17.6	920	13.2	775	9.3	637
East Asia	28.2	432	20.3	339	15.9	311	11.1	233	7.8	175
South Asia	25.1	284	19.0	258	20.5	311	14.9	257	9.3	188
Sub-Saharan Africa	45.9	173	40.4	201	29.0	212	23.3	213	17.4	216
Latin America	22.1	66	18.3	60	8.4	47	6.1	37	4.0	27
Near East	14.5	20	24.8	33	8.3	36	6.5	33	4.7	29
World	18.6	1011	14.9	930	14.4	949	11.0	797	7.9	653

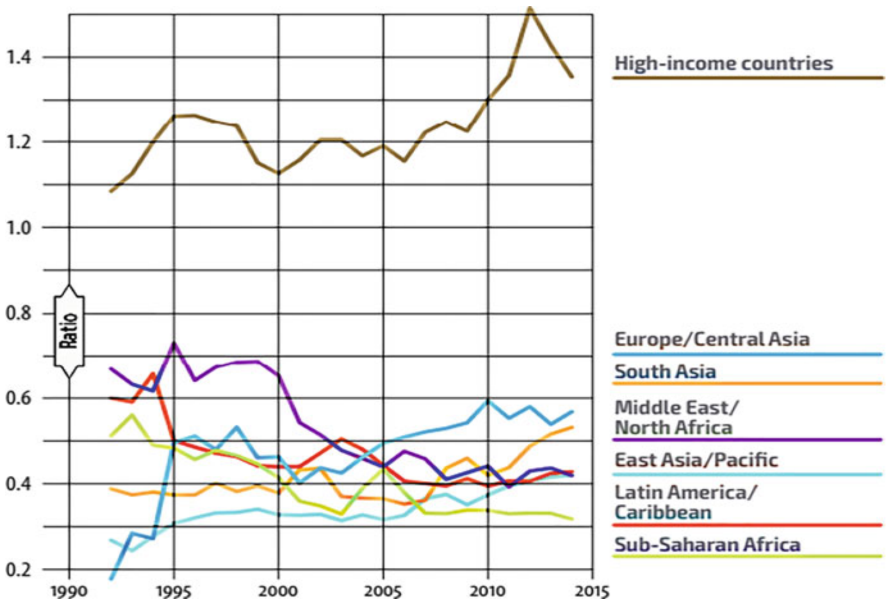

Fig. 2.2 Agricultural investment orientation ratio, 1990–2015 (FAO 2017)

Unfortunately, nowadays it becomes obvious that humans are not able to ensure food security until 2030 (FAO 2018, 2019b) and environmental factors are one of the key affecting that (FAO 2017, 2018).

Following the above, it is desirable to investigate the trends of agriculture development in countries with substantial potential in terms of ensuring the global food security goals and the Ukraine is one of them.

2.4 Food Provision and Environmental Impact: National Peculiarities for Ukraine

According to 2019 data, Ukraine reached the third position in the rankings of food exporters for the EU with exports of EUR 6.3 billion. In 2019 agricultural exports counted for 42.9% of the country's total export with the grain as the main export product. The agricultural products of Ukrainian origin were exported to China (8.9%), India (8.3%), Egypt (8.2%), Turkey (7.6%), the Netherlands (7.1%) and other countries including the EU (BUM 2019). Thus, the Ukraine regained the title “Food Basket of Europe”, however, social and environmental consequences of rapid agriculture growth and development remained behind the scenes (Koblianska and Kalachevska 2019).

First of all, it should be noted that Ukrainian agriculture is a bipolar with large scale export targeted agro-holdings and small-scale (mainly of a semi-subsistence nature) producers competing for resources (Strochenko et al. 2017; Koblianska and

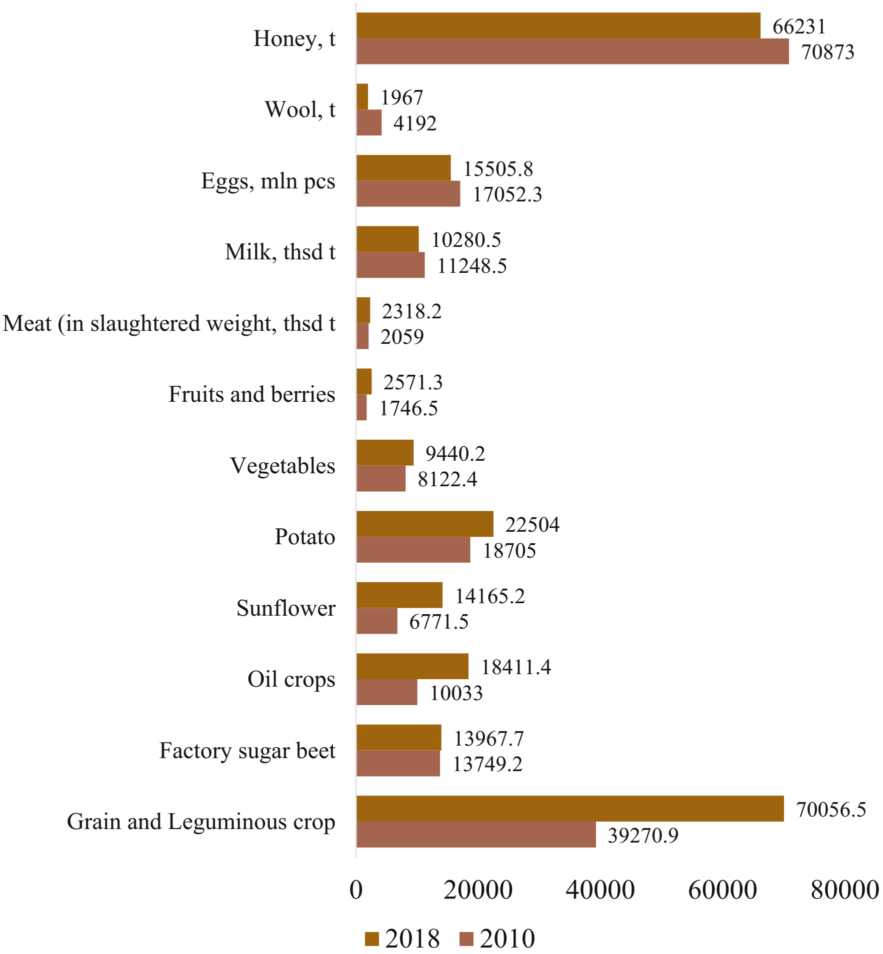

Fig. 2.3 The agricultural output in Ukraine, thsd.ton (http://ukrstat.gov.ua)

Kalachevska 2019). The small agri-producers provide the main share of agricultural products for final consumption, i.e. vegetables, potatoes, milk, meat, fruits, etc.

The offensive development of the industry, specifically, the expansion of a large agribusiness has led to the significant changes of agriculture gross output for the last years (Fig. 2.3). It is notable that the production of grain and leguminous, oil crops has increased by 1.8 times, sunflower—more than 2 times, but livestock output and honey—have decreased in 2018 compared to 2010 (Verner 2019). The significant increase of cereals production is also notable with a view to the gross agricultural output per capita (Fig. 2.4).

Having regard to the above, it is necessary to investigate whether such an increase in agriculture output provides income growth (Fig. 2.5).

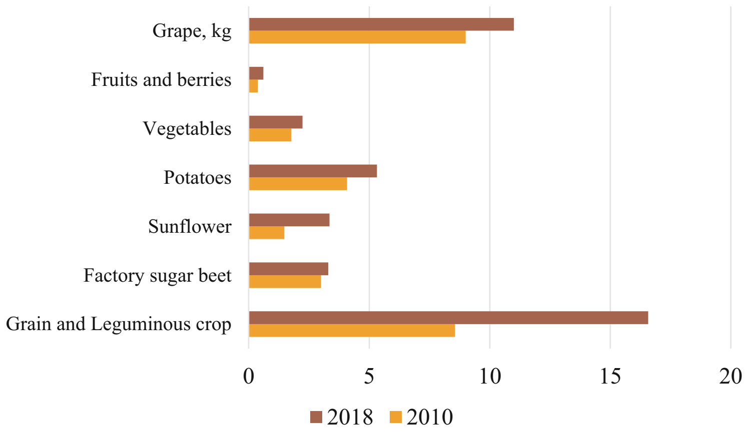

Fig. 2.4 Production of agricultural crops in Ukraine per capita (http://ukrstat.gov.ua)

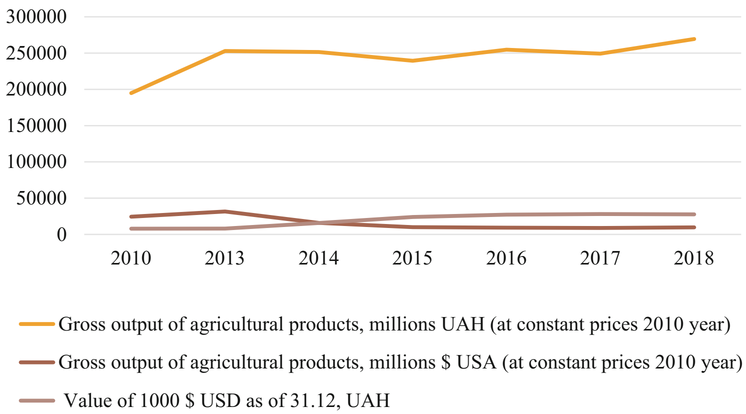

Fig. 2.5 Dynamics of gross output of agricultural products in Ukraine, 2010–2018 (http://ukrstat.gov.ua)

The data presented in Fig. 2.5 show that the real value of gross agricultural production (in million USD) in Ukraine in 2018 is lower than in 2010 more than twice. More concrete, it was 24,483.23 million USD in 2010, while only 9730.34 million USD in 2018. Under these conditions the availability, accessibility and quality of food (i.e. variety of diet) for Ukrainians require in-depth study (Fig. 2.6).

As it is shown in Fig. 2.6, the amounts of food consumed by the Ukrainians are not sufficient almost in respect of all food groups. It is true for both rural and urban residents. The diet of the average Ukrainian resident is not healthy, considering the excess consumption of bread and bakery products and the lack of other necessary products. Moreover, rural residents experience the lack of basic food more than urban habitants, revealing the adverse social and economic effects of agriculture industrialization. Taking into consideration that about 1.1 million of people in the

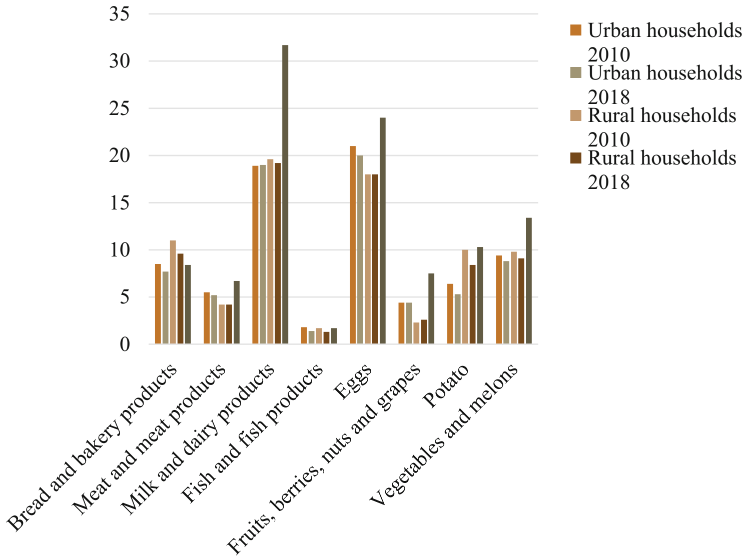

Fig. 2.6 Consumption of food in Ukraine by one person per month, kg (http://ukrstat.gov.ua)

Luhansk and Donetsk regions felt severe hunger in 2018 caused by military conflict and economic problems (GRFC 2020), thus ensuring of food security in Ukraine is quite challenging.

The problem of extensive land use should be pointed the first concerning the environmental dimension of agriculture development in Ukraine. According to official statistics for 2018 (Verner 2019), agricultural land occupies 68.7% of the total Ukraine's land (60354.9000 ha), while forests count only for 17.7% and water 4%. The latter has decreased by 0.02%, that is 1.5000 hectares, compared to 2010, showing the increase of water scarcity (Verner 2019).

Given the high share of agricultural land in Ukraine, it is necessary to investigate the forms of its exploitation (Table 2.2). The data presented show the extensive unsustainable use of agricultural land. In particular, there is a significant decrease of an ecologically important areas, i.e. conversions (by 192.3000 hectares), pastures (by 99.8000 hectares) and areas under perennial crops (by 37.1000 hectares). On the back of an overall reduction in agricultural land by 0.81%, the arable land decreased by only 0.06%. So, as of early 2018, arable land occupies 54% of the country.

Figure. 2.7 shows the allocation of land resources for different crops. It is notable that there is an increase of areas under export targeted crops (wheat, maize, sunflower). The share of area under grain and leguminous crops reached 53.57% of sown areas, under industrial crops—33.45%, fodder—6.39% in 2018. So, it is obvious that export orientation of agriculture leads to the problem of monoculture, resulting in over-exploitation, degradation and depletion of land and soils. In particular, the results of the 10th round of agrochemical survey of Ukrainian soils (2010–2015) indicate that the soils have lost a considerable part of humus, and the

Table 2.2 Dynamics and structure of agricultural land in Ukraine (http://ukrstat.gov.ua)

Land type	31 December 2000		31 December 2017		Change for 2000–2017	
	thsd. ha	Share (%)	thsd. ha	Share (%)	thsd. ha	Share (%)
Agricultural land, total	41,827	100.00	41,489.3	100.00	−337.7	−0.81
Incl. arable land	32,563.6	77.85	32,544.3	78.44	−19.3	−0.06
Perennial crops	931.9	2.23	894.8	2.16	−37.1	−3.98
Conversions	421.6	1.01	229.3	0.55	−192.3	−45.61
Hayfields	2388.6	5.71	2399.4	5.78	10.8	0.45
Pastures	5521.3	13.20	5421.5	13.07	−99.8	−1.81

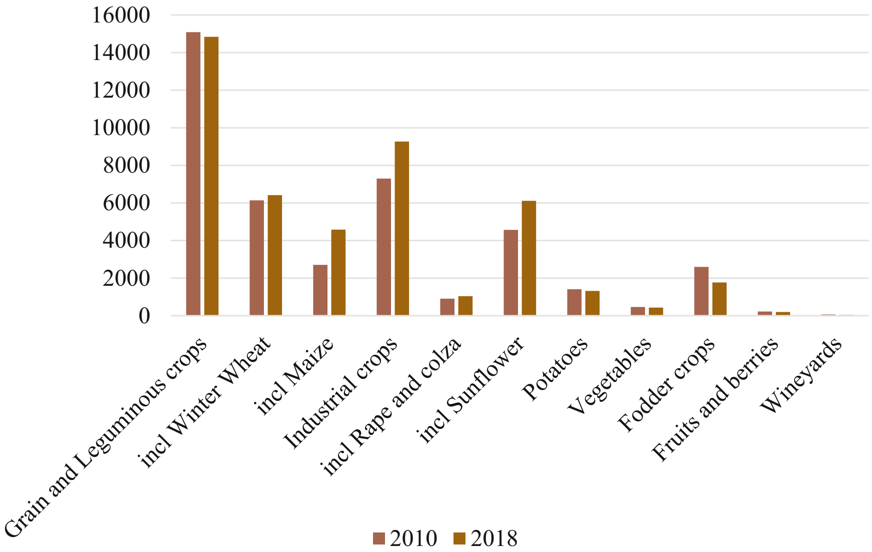

Fig. 2.7 Areas under crops in Ukraine, thsd.ha (http://ukrstat.gov.ua)

most fertile black soils turned into soils with medium and low fertility (57% and 23% of soils) and continue to deteriorate. As of the end of 2016, 57.5% of agricultural land was eroded, and in the period 2010–2016 the humus content in soils decreased from 3.19 to 3.16%. The nutrient balance in soils was negative (Yatsuk 2018).

Farmers have increased the application of mineral fertilizers trying to compensate the losses of natural soil's fertility. However, as of end of 2018, 9% of the area under cultivation remained untreated. The application of organic fertilizers is also insufficient, covering only 4.4% of the sown areas with the amount of 0.6 tons/ha, while the minimally required quantity to support soil fertility is 8 tons/ha. All this leads to a dampening of the soil formation process and further dehumidification (Yatsuk 2018). The implementation of certain measures of agriculture biologization

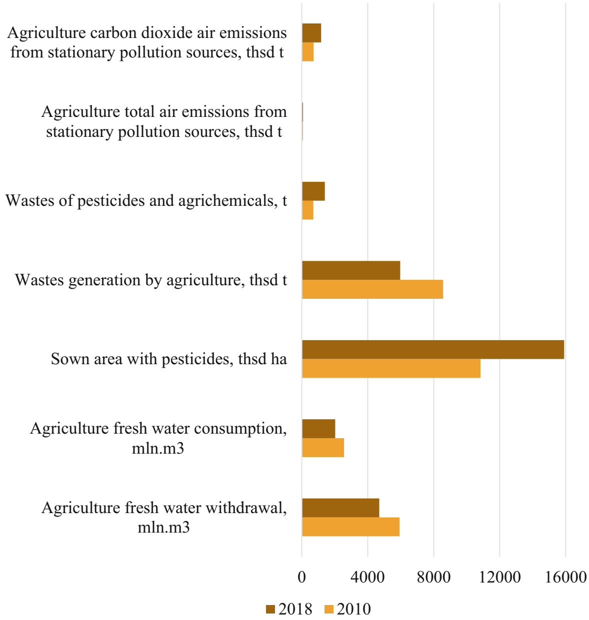

Fig. 2.8 Environmental impact of agriculture in Ukraine (http://ukrstat.gov.ua)

(ploughing of by-products) in 2014–2016 allows to improve soil quality partially. As a result, the humus deficit in 2015 amounted to 130 kg/ha against 530 kg/ha in 2010. Unfortunately, these measures were conducted only for small areas (about 35% of the total area under cultivation) being insufficient to mitigate the problem of soil deterioration throughout the country (Yatsuk 2018).

As it was pointed above, the water scarcity becomes another challenge in the light of further agriculture development. According to 2018 official statistics, agriculture consumes about 30% of total fresh water consumption in Ukraine and the share of water withdrawal counts for over 43%. Despite this, there is a decrease of irrigated land area by almost 15% for the last 15 years, and an increase of water losses due to poor management (FAO 2019a).

Concerning other components of the agriculture ecological footprint (Fig. 2.8), an increase of the sown areas with pesticides is the most palpable (up to 15,908.8000 hectares in 2018).

An increase of amount of wastes of pesticides and unsuitable agrochemicals, greenhouse gas emissions from stationary sources of pollution significantly threaten the environmental quality, but the amount of water consumed and withdrawal, as well as wastes generated demonstrates the positive trends in absolute terms (Fig. 2.8). Alongside this, our estimates of the environmental burden in reference to the value of gross output indicate that every dollar of agricultural output is becoming more expensive for Ukrainians by all types of environmental impact (Fig. 2.9).

Ukraine also does not keep out of climate change processes although the negative impact of these processes on the domestic industry will not have catastrophic

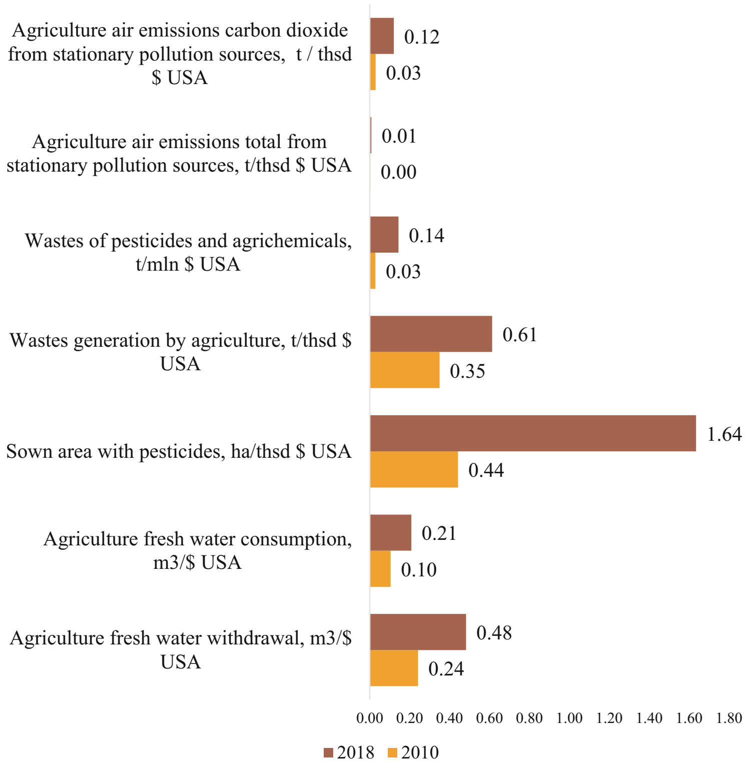

Fig. 2.9 Environmental impact of agriculture in Ukraine per unit of gross output (http://ukrstat.gov.ua)

consequences in the nearest future (Müller et al. 2016; FAO 2015). Specifically, it is expected that wheat yields in a southern Steppe zone will decrease with concurrent modest increase at the North of the Ukraine under the higher emissions scenario, which is seen the most probable (Müller et al. 2016). The similar results were outlined by FAO (2015). The forecast made for 2020 shows that governments' expectations for an increase of grain production have been overestimated. Based on the historical trends of climate changes it is forecasted the reduction of yields in traditional zones due to drought with slightly increase of yields in northern parts of the country (FAO 2015).

The researchers called for the elaboration of the regional specific sound policy and measures dealing with climate change (Müller et al. 2016; FAO 2015). However, government action towards responding the climate changes is relatively slow. In particular, the "Strategy for Prevention and Adaptation to Climate Change of Agriculture, Forestry, Hunting and Fisheries of Ukraine by 2030" is under approval by the ministries as of March 2020 although its approval was planned for 2019–2020 (CMU 2016). As for now, there are no any progressive approaches aimed at promoting measures for both to mitigate and to adapt to climate changes, as it is envisaged by Paris agreement.

2.5 Food and Environmental Security: New Challenges

The food problem has been high on the international agenda for the past several years and therefore it appears to be one of the overarching problems of our times (Gowdy 2020). Providing the population with high-quality, ecologically safe and economically affordable foods as well as the formations of necessary insurance stock are at the heart of the modern agriculture management at different scales (from local to global). The complex nature of food security problem requires a systematic vision and integrated solutions towards the economic, organizational, technological, social, environmental and legal issues (Shkuratov 2016; Kupinets 2010; Mishenin et al. 2015; Gaffney et al. 2019; Ickowitz et al. 2019). Among them the following issues are of great importance:

1. The production of sufficient food for the own consumption, as well as for import. It shows the interconnection of food and economic (national) security.
2. The creation of strategic and insurance food stocks, as well as the food export possibility.
3. The optimal and rational structure of foodstuffs (assortment) is consumed by the population. One of the important indicators of providing the country's residents with food products is the observance of scientifically based norms of rational nutrition. An integral indicator of the rational nutrition is the calorie content of the daily set of food products per capita. An almost complete correspondence between the norms of nutrition and the actual provision of the population with food products in Ukraine was achieved in 1990. However, in 1995 the calorie content of the daily set of food products was only more than 70% compared to the base year (Kupinets 2010). At present, the situation has gone worser. It is important and necessary to evaluate the diversity (assortment, structure) of the actual caloric content for daily food consumption, which can significantly determine the level of public health.
4. The ecological quality of the consumed food is within the existing food structure. At the same time, the quality of agricultural products can largely determine its competitiveness. The ecological quality of food significantly affects the elements of economic and national security and the level of life quality.

   Studies indicate that almost all food products are contaminated with a complex of hazardous substances at a level higher than sanitary and hygienic standards (Kupinets 2010). It leads to large losses, which until recently have not been sufficiently estimated. At least half of cases of morbidity, disability and mortality are due to consumption of contaminated food. These losses as a whole account for more than half of all damage from environmental pollution, which in Ukraine exceeds $12 billion/year (Tsarenko 2001).

5. Socio-economic accessibility of food, taking into account quantitative and qualitative parameters of consumption for harmonious human development.
6. The environmental component is associated with the agricultural production. It is especially worthwhile to environmental safety of the agricultural land use (Kupinets and Zhavnerchik 2016).

The main goal of greening agribusiness and agro-food sphere is to solve ecological and economic contradictions between society and nature by transformation of existing technological agro-production methods in the direction of maximizing output of high-quality ecological agricultural products while the environment preserving. Greening the food security is an objective process, aimed at the more rational agro-natural resources use by reducing the negative environmental effects of agricultural production and avoiding disturbances of ecological equilibrium on the basis of reproductive ecological processes. Therefore, greening of the agro-production cannot be considered as an isolated area of activity, but it should be a harmonious component at all levels of sustainable spatial development. Here it should be noted that agriculture plays a dual role: firstly, it produces food and secondly, it creates jobs for households. As agriculture is the largest employer in the world, at the same time, productivity gains can create additional purchasing power for the rural population, which in turn will use this extra income to purchase more food and other basic consumer goods (Mishenin et al. 2011). Large scale agricultural production will also help expand agrarian-based food industries, which will also stimulate new businesses and jobs.

Improving the agricultural land productivity through the use of safe innovation technologies will stimulate the real incomes and savings increase; job creation and diversification of agricultural production; increasing land value and investments; creation of new agricultural markets; increase of the public purchasing power in the services sphere; increase of public social security. The sustainable agriculture is closely related with the food security (Fig. 2.10).

However, the sustainable agricultural production is not sufficient to achieve food security goals. Even in case of the adequate food supply the lack of employment opportunities can lead to malnutrition. Sustainable agricultural development must be considered in a broader political context: strengthening the role of other employments will help to reduce eco-destructive pressure on lands.

Thus, achieving food security depends on the key prerequisites as follows:

1. The volumes and quality of agricultural production are determined by the following components: production, human capital; greening reproduction processes (agricultural management); natural (land) capital. All these components should be formed on an innovative basis, which implies an entrepreneurial approach to their effective implementation.
2. Food consumption is characterized by the main parameters as follows: socio-economic availability of food, consumption structure and food quality (general, technological and ecological).

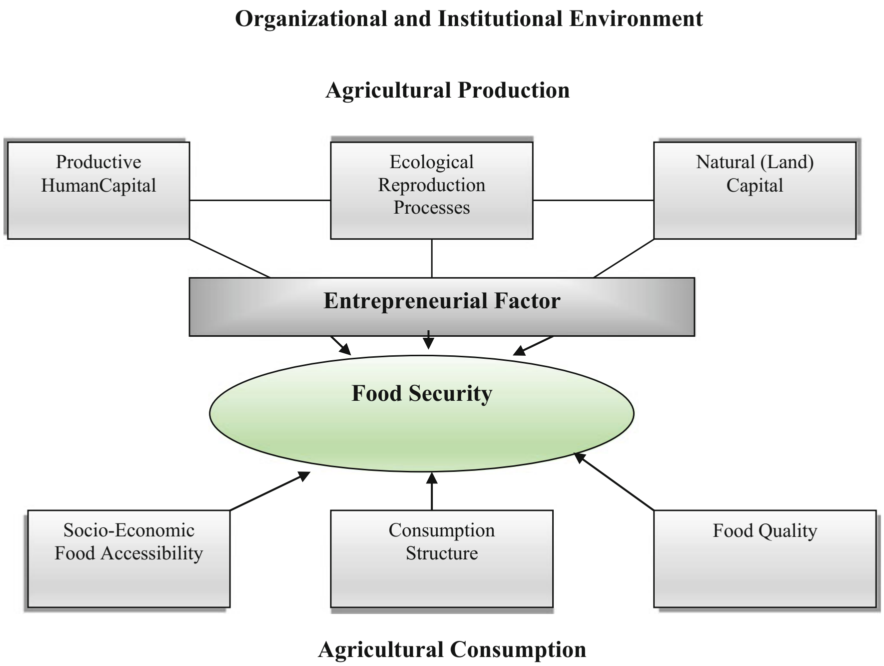

Fig. 2.10 The links between sustainable agriculture and food security (Author's development on the base of Mishenin et al. 2015)

We define *environmentally oriented food security* as a state of development of competitive, eco-balanced, ecologically safe agribusiness, which provides an optimal level of quantity and quality of food production and consumption in accordance with formed socio-environmental parameters of life quality on the basis of legal, technological, innovative, economic, informational and social mechanisms. The wide range of modern technological as well as management solutions is available to support environmentally oriented food security. Among them the eco-intensification measures are of great importance.

2.6 Eco-Intensification in Agro-ecosystem: Possible Ways and their Outcomes

The need to intensify agricultural production becomes evident addressing the problem of feeding the global growing population (Diaz-Ambrona and Maletta 2014). This not only provides enough food supply, but also making food prices lower, thereby ensuring the food security (Delzeit et al. 2017). However, one should emphasize that traditional agriculture intensive practices lead to soil degradation, water pollution, ecosystems' destruction, etc., as a rule (Ickowitz et al. 2019). The regard on environmental perspective has led to the concept of sustainable

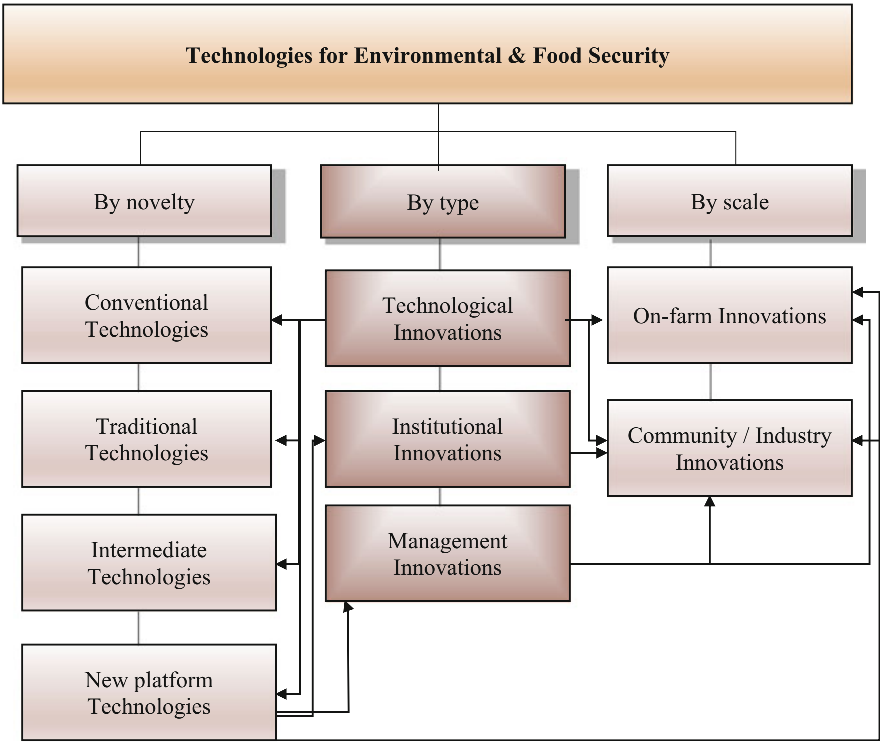

Fig. 2.11 Classification of eco-targeted technologies in agriculture (generalized on the base of Zilberman et al. (2018) and Pangaribowo and Gerber (2016)

intensification mitigating the environmental impact of agriculture industrialization (Ickowitz et al. 2019), ecological intensification concept applying ecosystem services to replace external inputs (Kleijn et al. 2019). Environmentally friendly intensification appears as win-win strategy leading to both an increase of crop yields and decrease of environmental impact (in particular, carbon emissions and nitrogen losses (Ullah et al. 2020), compared to traditional or industrialized agriculture practices. The eco-intensification promotion and implementation require a solid knowledge and technological changes, as well as institutional transformations favourable for innovations' spread and application (Delzeit et al. 2017; Kleijn et al. 2019; Ickowitz et al. 2019; Ullah et al. 2020).

Modern innovative agricultural practices make it possible to achieve the food security goals and improve the environmental quality. In particular, a wide range of solutions was released under the framework of CSA concept, addressing climate changes mitigation and adaptation issues (Zilberman et al. 2018; Asfaw and Branca 2018), and sustainable agri-practices (Pangaribowo and Gerber 2016). It is desirable to classify the prominent eco-intensification solutions for agriculture (Fig. 2.11).

Commenting on Fig. 2.11 data one should indicate that technological innovations are fundamental in terms of responding to climate change in agriculture. However, these solutions are not necessarily radical innovations and could be found in conventional and traditional technologies and business practices.

Conventional technologies represent modern inputs, i.e. seeds, fertilizers, irrigation solutions (Pangaribowo and Gerber 2016). They are exposed to disseminate knowledge among farmers and increase agriculture productivity (Pangaribowo and Gerber 2016). These technologies form the basis of on-farm CSA practices while addressing the specific climate features of certain region (Zilberman et al. 2018; Bartolini and Brunori 2014). Traditional technologies are of a local origin and respond to local climate problems, representing a transformation of traditional agricultural practices (Pangaribowo and Gerber 2016; Andrade et al. 2019). Such technologies cover the use of underutilized and traditional crops, gardening, crop rotation, etc. They contribute to the achievement of food security goals, the increase of farmers' income, as well as support biodiversity preservation, ecosystem functioning, etc. (Konuma 2018).

Intermediate technologies combine the first two through the application of modern inputs in traditional practices (e.g. low-cost irrigation, pumps). Such technologies allow poorer farmers to increase their productivity (Pangaribowo and Gerber 2016). These types of solutions include technologies and systems for on-farm storage that prevent the loss of products after harvesting (Zilberman et al. 2018).

New platform technologies are first and foremost related to the implementation of information and communication technologies, as well as biotechnologies and nanotechnologies. The modern technologies of data processing and exchange, communication gives producers the knowledge and necessary market information access, enhance the local farmers' organizations capacity, and facilitating farmers market entrance (Pangaribowo and Gerber 2016). These technologies are applicable both at the farm level (mobile farm management applications) and at the community/ industry level. The latter include, but are not limited to, weather information dissemination technologies, which reduce the production uncertainty and prevent losses (such information should be available to poorer farmers as well) (Zilberman et al. 2018). Successful implementation of such technologies is closely linked to the transformation of management systems both on-farm (automation of processes) and throughout the local community (proper infrastructure, interaction and cooperation, coordination and support from all stakeholders). Therefore, new platform technologies are directly related with management and institutional innovations.

Actually, management innovations are realized by use of data processing and communication technologies use. The improved farm management through implementation of information systems for processes' monitoring, and precision agriculture technologies could serve as an example. The increased productivity and prevention of over-spending are the main outcomes of such innovative decisions (Zilberman et al. 2018).

At the community level information-based innovations may include the following: collective actions to improve the use and management of inputs (above all, sharing of new knowledge, collective action concerning externalities, regional institutions for collaboration and support for public services); insurance products; improved supply chain management (providing market access for SME farmers)

(Zilberman et al. 2018). This implies a change in the management paradigm with the formation of multilateral platforms bringing together different stakeholders and their activities towards the food security and sustainability goals. Such a scheme should provide reflexivity, resilience, response, recovery and generation of required outputs at different levels, from local to global (Breeman et al. 2015). At the same time, an imperfect system of innovation infrastructure, the lack of knowledge and skills, a weakness of the intellectual property rights system, limited funding and weak government form the obstacles to the implementation of the above technologies. In this context, conservative views (counteraction to genetic research and development) are also quite threatening. All listed problem issues are of an institutional nature and require appropriate institutional transformations (Zilberman et al. 2018).

Institutional innovations involve the transformation of values, knowledge, culture and practices of management and governance (Zilberman et al. 2018; Pangaribowo and Gerber 2016). This type of innovations encompasses social and political processes that enhance farmers' ability to act in a coordinated and collective way, combining their interests and technologies (Pangaribowo and Gerber 2016). Institutional innovations embrace an implementation of ecosystem thinking at on-farm and industry scale, the development of advisory services and knowledge dissemination, an enhanced interaction and cooperation, trade assistance and regulation, aid and its distribution (subsidies, reduction of transaction costs), conflict resolution mechanisms, insurance, development of cooperative actions (Zilberman et al. 2018), field schools, regulation of land relations, financial market development, overall market transformation (Pangaribowo and Gerber 2016).

A clear policy to support environmental risks mitigation is an important direction of an institutional transformations, as the adaptation is a restrictive measure.

2.7 Conceptual Basis for the Ecologically Harmonized Multi-Scale Agricultural Management

In the period of globalization of agricultural markets and distribution systems, the problem of ensuring world food security is becoming of great relevance. Therefore, the food security can be defined as an ability of various agricultural systems to satisfy the basic needs of a growing population and to solve environmental problems. Increasing the food production is considered to be the only prerequisite for improving food security. From these perspectives, it is worth analysing the way sustainable agriculture contributes to the food security (Spiess 2016; Horton et al. 2017; Ickowitz et al. 2019; Nicholls et al. 2020).

It is important to characterize major science schools concerning the food security (Mishenin et al. 2011; Pretty 1995; Pretty and Thompson 1996; Thompson 1996; Hazell 1995; McCalla 1994; CGIAR 1994).

1. *Environmental pessimists*: They argue that the population is growing too fast compared to the rate of increase in the yield of basic crops. With the current knowledge level, new technological breakthroughs are unlikely to take place, and

some agro-ecological systems are already so degraded that they are no longer reproducible.
2. "*Business-as-usual*" *optimists*: Proponents of this approach believe that supply will always meet growing demand. Biotechnological innovations will boost food production. The area of arable lands is also expected to increase significantly.
3. *Proponents of the industrialized approach* (*industrialized world to the rescue*): It is argued that developing countries never feed themselves due to a wide range of economic, institutional, political and environmental factors. Increasing the volume of production with the help of innovative technologies is advisable to carry out by creating large scale agrarian industrial complexes.
4. *New modernists*: It is believed that the growth of agricultural production is possible only through the involvement of a large number of external resources. New modernists believe that agricultural producers are using insufficient mineral fertilizers, pesticides, heavy yielders and other modern inputs to increase the agricultural output with simultaneous environmental impact reduction. High-resource agriculture is seen more environmentally friendly compared with the low-resource one, because an intensive use of local resources can lead to their degradation.
5. *Sustainable intensification*: This group of scientists argues for the steady intensification of agricultural production, since sustainable development contributes to the protection or even regeneration of agrarian natural resources. Low-resource agriculture can be highly productive, because land use productivity is primarily a function of human capital, and only then of biological processes.

The better utilization of available resources, in particular, biophysical and human is the main objectives of sustainable agriculture. This requires the minimization of the external resources involved, an optimization of the internal resources use, or a combination of these methods. In light of this, sustainable agriculture aims to integrate a wide range of pest management technologies, nutrients, forest plantations, soils and water resources. The by-products or waste from one element of the agro-ecosystem must be resources for its other component. As external resources are replaced by natural processes, the environmental impact will be reduced.

Consequently, the sustainable agriculture represents an agricultural food production system aimed at achieving the following objectives:

– an involvement, recurrence and restoration of natural processes (nutritive cycle, nitrogen fixation, trophic webs);
– a minimization of the non-replenishable resources use, as well as external ones;
– a participation of agricultural producers in the processes of analysis of problems, technology development, adaptation, monitoring and evaluation;
– equal opportunities and fair access to resources required for agricultural production;
– an effective and fruitful use of local resources and knowledge among others;
– raising self-sufficiency among rural communities.

2.8 Strategies for Sustainable Agriculture Addressing Food Security

Today, the search for sustainable agricultural strategies in the context of food security is necessary and undeniable. For example, it is argued that innovative farming practices that have increased its efficiency and agricultural output are depleting the agro-ecosystem, which has necessitated the search for environmental agricultural land use methods. Concerns about pesticide use, biotechnology and other issues have focused public attention on ecological quality and food security (Horton et al. 2017; Ickowitz et al. 2019), drawing interest in alternative environmentally friendly and balanced methods for its production (Mishenin et al. 2011; Lipper and Zilberman 2018; Diaz-Ambrona and Maletta 2014).

In our opinion, environmental sustainability of agriculture should mean that the used agricultural resources must be renewed by the same process of their use. In order for a system of agrarian nature management to be sustainable, it must be based on natural processes of the local ecosystem, regardless of external resources or chemical systems of agriculture. Environmentally sustainable agriculture should function indefinitely without depleting its land and resource potential. The implementation of the concept of environmentally safe and balanced agriculture development requires a fundamental conceptual departure from the economic perspectives which have guided agrarian science for the last hundred years.

The environmentally safe prospect of agribusiness is characterized by the complexity of the factors that are included in the system, as well as the long-term nature of their analysis and control. In the greening system of agrarian nature management, the complexity of natural ecosystems is the subject of value, and the traditional economic approach tries to simplify them.

It is worth noting that it will not be possible to improve the long-term efficiency of agricultural land use without the application of an ecosystem approach to the agrarian nature management. So, if the agrarian development institutions are unable to ensure the environmental sustainability of the various farming methods, then they are actually damaging to society, households, citizens and individual industries. It is important to note that land use productivity should be improved according to the population growth through increased crop yields.

Most scientists believe that land productivity can be improved, as we have already noted, only through the implementation of innovative technologies based mainly on the use of agrochemicals. According to such an industrial model, the main criteria for success are technical and economic efficiency. Proponents of the ecological model of agrarian environmental management support the development of more efficient low-resource agro-ecosystems based on the biological cycle of energy and chemical elements. The effectiveness criteria for this model include indicators of ecological and economic efficiency of agriculture, socio-environmental sustainability and energy efficiency of agrarian nature management (Targetti et al. 2019).

Thus, the ever-increasing need for productive and sustainable agriculture prompts the introduction of a new vision for the development of agrarian environmental management, and in particular for the land use and its risk reduction.

Agro-ecology should ensure efficient energy and materials circulation within agro-ecosystems. In this regard, the need for a holistic approach that would include agriculture research at enterprise or ecosystem level has been raised. This approach makes it possible to implement complex ecological and economic relations into agriculture. For example, instead of improving one variety at a time, a holistic ecological perspective involves searching for a set of plants and animals that, together, produce high environmental, economic and social outcomes (Mishenin et al. 2011).

As agricultural management extends its environmental approach from conservation of natural agro-resources to the impact of its functioning on larger ecosystems, new problems would arise as a result of concern for human health and external environmental effects. Other issues will include social and environmental responsibility, compliance with regulatory requirements, and monitoring of potential socio-environmental and economic risks associated with agro-resources. The environmental future of agricultural land use will be shaped primarily by socio-economic factors, in particular, the global demand for food, its prices, government programs, international trade agreements, technology and new knowledge of agricultural research.

The basic principles of sustainable development strategy for agrarian nature management should include the aspects as follows:

- *partnership*: active interaction between different groups of stakeholders in order to ensure sustainable agricultural production;
- *integration*: promoting the integration of environmental and social thinking into management decision-making processes and innovative ways of doing eco-business;
- *ecosystem and environmental management*: the focus is on preventing, not eliminating, negative environmental impacts;
- *equity for all generations*: equitable sharing of costs and benefits (effects) between generations to encourage the use of socially environmentally responsible methods to minimize the ecological responsibility of future generations;
- *civilized competitiveness*: supporting the effective market mechanisms that ensure the use of innovative ecological management methods, identifying links between environmental sustainability and economic productivity (Mishenin et al. 2015).

It is possible to implement the above-mentioned principles through the following solutions of a strategic nature:

- improving the essence of sustainable agriculture based on the knowledge economy;
- improving the ability of decision-makers to integrate ecological factors into this process;

– ensuring environmental, ecosystem and resource management;
– providing the management and sustainable resource use in the agricultural food sector;
– development of innovative solutions;
– research focusing on the environmental issues to ensure the agricultural sustainability; identifying market opportunities;
– stimulating the agricultural food marketing and trade that have a positive impact on ecological quality and sustainable development.

2.9 Organizational and Economic Mechanisms for Ecologically Safe Agriculture Land Use

The growing needs for productive and sustainable environmentally safe and balanced agriculture are leading to the need for a new vision for the development of agrarian nature management and, in particular, for resource-saving land use (Ullah et al. 2020). This position requires understanding of the ecological principles of agriculture, as well as the putting in place an organizational and economic framework needed to support the agrarian ecosystem management wide implementation.

We define the *organizational and economic mechanism ensuring the environmentally safe and balanced agricultural land use* as a complex system of forms, methods and tools of organizational, economic and social influence on the environmental behaviour of agricultural entities in the direction of increasing socio-ecological and economic efficiency of use, reproduction, protection and conservation of land-resource potential, as well as the effectiveness of the functioning of agro-natural and land capital.

The general purpose of the organizational and economic mechanism is the effective organization of reproductive processes in the use, reproduction, protection and conservation of land and implementation of land management regulation based on an ecosystem approach.

An integrated function of the organizational and economic mechanism of ensuring environmentally safe and balanced land use is the harmonization of socio-ecological and economic needs and interests of economic entities, society as a whole in the process of practical implementation of the principles of environmentally safe and balanced organization of sustainable land and resource potential use, the functioning of land capital, as well as the resolution of contradictions and certain ecological-economic conflicts.

The formation of an organizational and economic mechanism for ensuring environmentally safe and balanced agriculture involves the interaction of the regulatory subsystems of the external organizational and institutional mechanism and the internal mechanism of agricultural enterprise management, using the principles and tools of ecosystem management that provides motivation for environmental behaviour (Mishenin et al. 2002).

Therefore, the economic assessment of agricultural land use consequences through ecological and economic losses is important to form an innovative market-based mechanism of environmentally safe and balanced agricultural land use.

The determining component of the organizational and economic mechanism for ensuring environmentally safe and balanced agricultural land use is *the result-oriented subsystem*, which can be an integral result of the interaction of the external mechanism with the internal one and determines the economic, environmental and social results of management.

External organizational and institutional mechanism of environmentally safe and balanced agricultural land use includes providing institutional and resource subsystem (sub-mechanism), subsystem (sub-mechanism) of organization and regulation of environmentally safe and balanced agricultural land use, and controlling subsystem.

Supporting institutional-resource subsystem (sub-mechanism) includes regulatory, resource (financial, information, human resources), infrastructure (in particular, it concerns the activity of credit institutions, innovation-investment funds, environmental insurance companies and consulting agencies) security.

The subsystem (sub-mechanism) of the organization and regulation of *environmentally safe and balanced agricultural land use* are aimed at the implementation of mechanisms of state regulation of land relations, as well as programming and planning of protection and conservation of lands at national and regional levels. Regional forecasts and programs for the use and protection of land potential are important for ensuring ecological security and balanced farming. These measures should be preventive and should include scientific analysis of the ecological destructive status of land use, tendencies of negative processes in agro-landscape formations (erosion, pollution by heavy metals, soil fertility decreasing).

The subsystem of control within the external organizational and institutional mechanism of regulation of environmentally safe and balanced *agricultural land use* should have a *program-oriented focus* on ecological and economic indicators of agrarian land management on an ecosystem basis. For example, it requires monitoring the eco-destructive state of the land-resource potential, control over the ecological quality of agricultural products on a logistical basis, etc.

It is important to emphasize that the practical reproduction of the prerequisites for environmentally safe and balanced agricultural land use requires the formation of a favourable economic environment capable to support the ecosystem-based agricultural management expansion. Harmonization of economic interests of agricultural business structures with ecological and economic regional and national goals requires the development of not only administrative and regulatory mechanisms, but also the formation of effective motivational and incentive systems. The administrative and regulatory subsystem is aimed mainly at creating a system of restriction of eco-destructive economic activity in the process of land management, in particular, through the application of ecological expertise, external eco-audit, as well as environmental certification of agricultural enterprises, etc.

Available conceptual and methodological approaches (Kupinets and Zhavnerchik 2016; Medvedev 2010; Stepchin 2006; Shkuratov 2016) to the creation of incentive factors, mechanisms, and levers of ecological and economic regulation of rational nature management are divided into the following types of instrumental support (Stupin 2017):

1. Focused on compliance with rules, requirements, norms of rational nature management and the implementation of the obligatory system of environment protection measures (in particular, normative regulation, penalties, payments for the environmentally destructive state of natural objects).
2. Promoting the implementation of environmental activities (in particular, the environmental tax system and payment system for the use of natural resources, and financial incentives).
3. Incentive, aimed at supporting economic entities to implement environment protective (environmental) measures (subsidies, preferential crediting and taxation, special funding).

In this context, the compensation mechanism for the afforestation of agricultural lands is a prime focus. This includes economic incentive tools important for encouraging environmentally balanced use and protection of agricultural lands based on the creation of protective forest plantings. These tools relate to the measures of economic impact aimed at changing the financial and property status of entities of agrarian land use in order to equalize the imbalance between ecologically balanced, environmentally safe agribusiness within a certain agricultural landscape.

Compensatory and stimulating mechanism of agrarian natural management with an emphasis on the issues of agroforestry production (Stepchin 2006) may include the following components:

7. Partial reimbursement of the lost revenue, in particular, in the form of rent payments in the case of conservation of land, depending on their intended purpose and degree of degradation.
8. Payments for the increase of soil fertility and reduction of their pollution due to agroforestry improvement of agricultural lands.
9. Subventions (grants) for the production of environment-friendly agricultural products under the conditions of the land arrangement on the agricultural forest reclamation basis.
10. Some compensation (reimbursement) of expenses for carrying out works on the conversion of the intended use of land within the limits of expansion of the agroforestry reclamation complex.
11. Compensation (reimbursement) of capital and current expenses for the implementation of investment agroforestry projects.

The presented components are cost-compensatory and can be implemented in the form of rent payments, as well as provide for the transfer of payments by environmentally responsible entrepreneurs. Of course, the system of financial and economic incentives should provide for a variety of tax and credit benefits.

It is important to focus on the environmental taxation systems and environmental policies and payments for nature conservation from the perspectives of agroforestry spatial development (Lindgren et al. 2018; Gaffney et al. 2019). At the conceptual plan, from the point of view of preventing environmental pollution and creating ecological and economic prerequisites for the transition to conservation forms of agriculture, the maximum use of the system of environmental taxes and payments for natural resources that already exist in Ukraine is needed (Mishenin and Yarova 2019). This system provides payments for a land use, environment pollution, a violation of the rules and regulations of environmental legislation, and payments for compensation for the harm caused by environmental offenses. It is worth noting that the adopted system of environmental taxes is almost non-functional in relation to agrarian environmental management (Mishenin and Yarova 2019). This is due to a number of reasons. First, the share of the agricultural sector in environmental pollution is generally thought to be minimal. Second, in agroforestry areas, there is no environmental service to control the quality of the natural agricultural environment, which explains the misconceptions about the extent of the agrarian sector's influence on natural objects. Third, the economic crisis in the agrarian sphere has more severe consequences than in the manufacturing, specifically concerning negative social and economic outcomes for households and agricultural enterprises. However, this is not a reason for not taking measures to prevent pollution and environmental degradation within the agriculture activities. It is obvious that the environmental system function should taking into account the real economic condition of agricultural enterprises (Ovsyannikov 2000).

In a number of European countries, to increase motivation in the transition to conservation forms of agriculture, taxes (payments) are imposed on the use of chemicals (Ovsyannikov 2000; Chakravorty et al. 2007), which can be used to form incentives in the afforestation of agricultural land.

Effective ways of influencing users in the agricultural sector can be:

- payments for the pollution caused by mineral fertilizers, plant protection products and cattle-breeding drains of soil and water bodies;
- payments for the pollution of water bodies with the soil washed off from the fields;
- payments for the soil destruction resulted from erosion.

To increase the arable land protective forest cover, the creation of protective forest plantings on erosion-free agricultural lands, as well as the introduction of environmental methods of cultivation of crops should be used:

- preferential payments (taxes) for the use of land resources;
- preferential taxation of land ownership.

Thus, the development of an organizational and economic mechanism for ensuring environmentally safe and balanced agrarian farming should be carried out on the basis of enhancing the environmental behaviour of business-entrepreneurial structures under the influence of an external organizational and institutional mechanism, which should exert a dynamic regulatory influence on the internal mechanism of the entity.

The theoretical and methodological orientations for the construction of organizational and economic mechanism of agrarian nature of the economy allow to form the systematic management processes for the greening land use at different spatial levels of management (Mishenin et al. 2015).

2.10 Economic Reforms Towards Agricultural Sustainability and Development

Scientific and technological progress may serve the interests of human to a certain extent, but having passed the peak of usefulness, it begins to play the opposite role, although it continues to promote economic growth (Mishenin et al. 2011; Diaz-Ambrona and Maletta 2014). Society is gradually becoming aware that fact. Entrepreneurs are gradually beginning to understand that consumers have increasingly begun to demand a higher life quality, the availability of ecological food. The desire of companies for continuous expansion, the achievement of a monopoly position in the market, maximizing profits by reducing costs and raising sales prices was until recently a commonly accepted motivational basis for entrepreneurship. However, the increasing interdependence of economic, social and environmental interests ultimately led to including the environmental protection, healthy lifestyles, humanization of working conditions, rational nutrition and agro-industrial products safety in the marketing conception (Mishenin et al. 2011).

A necessary prerequisite for sustainable development is to consider environmental, economic and social factors in the pricing mechanism (Lindgren et al. 2018; Gaffney et al. 2019). In general, in a market environment, the role of prices for goods and services is difficult to overestimate because they reflect a shortage of production, natural resources (factors) and consumer goods. The price of a particular product is determined not only by the amount of costs required for its production, but also by the benefits it can bring (which ensures the efficiency of scarce resources). From these perspectives, Hoffmann (1991) noted that the market mechanism broadens the boundaries for profitable investments in the natural resources conservation with increasing their scarcity (Hoffmann 1991). So, this fact explains the achievements of developed countries in the field of reducing environmental intensity of public production.

Market pricing mechanism is based on the assumption that all the benefits and costs are associated with the production and consumption of each environmentally friendly product and it is fully reflected in the market demand and supply curves. In other words, it is considered that there are no externalities in the production and consumption of goods and services (Mishenin et al. 2011; Gaffney et al. 2019).

The value of prices for the normal reproduction processes of environmental quality is determined by their main functions. First of all, prices serve as a measurement and information function. With their help, it is possible to express various natural indicators of natural resource potential (in particular, ecological potential, the total economic value of agricultural lands, etc.), costs and results of environmental activities in a single monetary form, as well as other different environmental and economic indicators. Ultimately, price is an important criterion for choice, and also a benchmark for making optimal eco-management decisions, providing the necessary information about the needs of environmentally friendly goods, the cost of their production and the ability to take into account the negative nature externalities. The environmental factor also affects the distribution function of prices in the pricing mechanism. Price mechanisms help to compensate the negative externalities of environmental management based on the system of ecological taxation and payments for the natural resources use (Mishenin and Yarova 2019).

For a more comprehensive consideration of the environmental factor in pricing, the incentive function of prices is of particular importance. The price incentive effect on the products of enterprises—polluters can be manifested in different directions. Increasing or decreasing price due to the environmental component can stimulate, or vice versa, impede the purchase of products (Chakravorty et al. 2007; Lindgren et al. 2018; Gaffney et al. 2019; Targetti et al. 2019). It should be noted that in developed countries, along with market prices, there remains a place for regulated prices for certain products (Mishenin and Yarova 2019).

State regulation of prices can be carried out using the following methods: setting fixed prices for specific goods (this method is characterized, mainly for the administrative-command economy), direct impact on prices through certain restrictions, or individual components of the price (this method is applied to the functioning of contractual prices system and its liberalization), and indirect impact on prices through the use of state economic levers (for example, ecological taxation). State price regulation, taking into account the environmental factor, can be presented as a system of organizational and institutional measures designed to fully reflect the environmental costs of production based on a corresponding change in price levels to overcome the economic and socio-environmental contradictions related to pollution (degradation) of the environment and rational resources use. Price regulation, taking into consideration environmental factors, can also be defined as a system of influence on prices, which creates new legal conditions in a particular economic and environmental situation (Mishenin and Yarova 2019). Pricing ecologization involves regulating prices for nature-intensive and eco-friendly products in order to reflect the real socio-ecological value of natural resources and their scarcity, as well as the environmental production cost (Gaffney et al. 2019; Targetti et al. 2019).

Involving full environmental costs into enterprise costs is often called *absolute cost accounting* (Schmidheni 1994). Today, this is just a theory, but it also undergoes dynamic changes depending on different conditions, time and place (Gaffney et al. 2019; Targetti et al. 2019). The inaccuracy in determining the actual and future costs of pollution cannot be used to justify a difficulty to determine the cost of environmental disruption. In industry, total cost includes the cost of production plus the cost expression of environmental damage associated with production. It is often claimed that not only the polluter but the consumer pays. However, this is the main task of this principle. The inclusion of environmental costs in the production cost, of course, has the changing effect for the price of goods, because high prices for

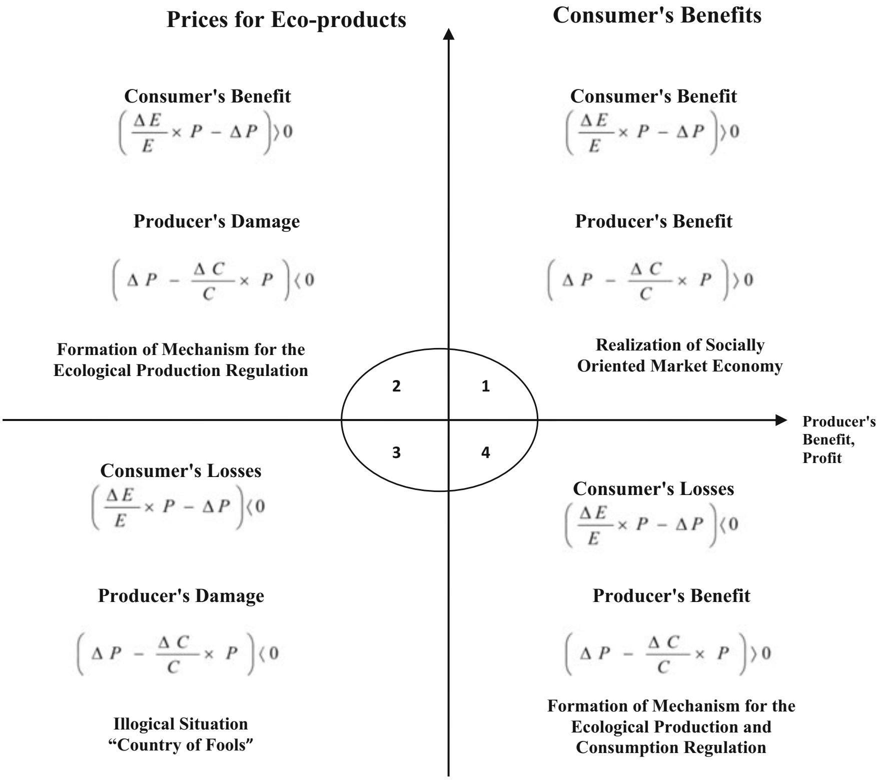

Fig. 2.12 The "benefits—losses" matrix of producers and consumers of ecological agricultural products (formed by Yarova, on the base of Mishenin et al. 2011)

products of environmentally harmful production can be a kind of signal to the consumer to purchase more "environmentally friendly" goods. Possible socio-economic and environmental-economic consequences of different priorities in the approaches to production and consumption of organic products, as well as the need for environmental regulation of production can be illustrated by the "benefits—losses" matrix (Mishenin et al. 2011) (Fig. 2.12).

The market price for products should theoretically meet the normative level of their ecological quality and socially necessary production costs (Chakravorty et al. 2007; Lindgren et al. 2018). The consumer is interested in the fact that with increasing quality the price increases in proportion to the ecological compatibility of the products. But, the manufacturer, of course, is interested in the fact that the new price will offset the costs and brings additional profit to the enterprise. The state should be interested both in meeting the needs of the population with minimum negative socio-environmental and economic consequences, and in obtaining part of the income through an ecological tax system (Mishenin and Yarova 2019).

If the costs of improving the environmental parameters of product quality increase in proportion to the increase in the level of environmental friendliness and, consequently, the price increases, then there is no contradiction between the environmental and economic interests of consumers and producers. In this case, the price does not encourage the producer to the quality improvement. Demand for organic products is holding back. If the cost of production increases to a greater extent than the rate of improvement of environmental quality parameters, then there is a conflict between the producer's and the consumer's interests: the producer is interested in the price to be raised, at least in proportion to the increase in costs; the consumer is interested in lower price increases—at least in proportion to the increase in product quality.

The highest degree of ecological and economic interests' reconciliation of the consumer and the producer will take place when the level of ecological quality increases more than the production cost (Mishenin et al. 2011).

In this case, it is possible to set such a new price ($P + \Delta P$) when the relative price increase is less than the relative increase in the level of ecological quality, $\frac{\Delta E}{E}$ and above the relative increase in the total cost, $\frac{\Delta C}{C}$.

This approach can be represented as follows

$$\left(\frac{\Delta E}{E}\rangle \frac{\Delta P}{P}\rangle \frac{\Delta C}{C}\right), \tag{2.1}$$

where P the price; ΔP the price increase; $\frac{\Delta E}{E}$ the relative increase of ecological quality of products; $\frac{\Delta C}{C}$ the relative cost increase.

Given the environmental interests of society as a whole, expression (2.1) may look like:

$$\left(\frac{\Delta PC}{PC} \geq \frac{\Delta E}{E}\rangle \frac{\Delta P}{P}\rangle \frac{\Delta C}{C}\right), \tag{2.2}$$

where ΔPC reducing external environmental costs of production and consumption; $\frac{\Delta PC}{PC}$ the relative reduction of production external environmental costs.

This is the best balance between the quality (ecological) of products, prices and costs from the perspectives of socio-environmental interests of society as a whole. In this case, utility of the new product (its ecological quality) for the individual consumer has increased to a greater extent than its cost of purchasing this product. For the producer, the price has increased to a greater extent than its cost. So, the consumer and the manufacturer have benefited. The price in this case stimulates the increase of ecological quality and demand for these products. With the increase in the environmental friendliness of new products, external environmental costs (ecological and economic damage) for both the individual consumer and society as a whole are decreasing (Mishenin et al. 2011).

The terms of harmonization of ecological and economic interests of the producer and the consumer can be considered as follows: if the price of products of higher ecological quality for the individual consumer was set in proportion to the quality level:

$$\frac{\Delta PC_E}{PC} = \frac{\Delta E}{E}, \tag{2.3}$$

then

$$\Delta P_E = \frac{\Delta E}{E} \times P, \tag{2.4}$$

where $\boldsymbol{\Delta} P_E$ the price increase due to the ecological quality increasing by $\boldsymbol{\Delta} E$.

If the price for these products was set in proportion to the cost,

$$\frac{\Delta Pc}{\Delta P} = \frac{\Delta C}{C}, \tag{2.5}$$

then

$$\Delta Pc = \frac{\Delta C}{C} \times P, \tag{2.6}$$

where ΔPc an increase in the cost due to the increase in cost by ΔC.

The condition of reconciliation of the consumer’s and the producer’s interests can be considered as follows:

$$\Delta P_E \rangle \Delta P \rangle \Delta P_C, \tag{2.7}$$

The producer’s benefits can be presented as follows:

$$\Delta P - \Delta P_C = \Delta P - \frac{\Delta C}{C} \times P, \tag{2.8}$$

The consumer’s benefits can be presented as follows:

$$\Delta P_E - \Delta P = \frac{\Delta E}{E} \times P - \Delta P, \tag{2.9}$$

The total benefit for the producer and the consumer is determined as follows:

$$\Delta P_E - \Delta P_C = \left(\frac{\Delta E}{E} - \frac{\Delta C}{C}\right) \times P, \tag{2.10}$$

This total benefit can be divided into three parts: the benefit of the individual consumer, the benefit of the producer (enterprise) and the society's benefit as a whole.

Consider the content basis of the quadrants of the above-mentioned matrix (Fig. 2.12).

Quadrant 1. “*Consumer’s benefit, producer's benefit*” follows the principles of socially oriented market economy and sustainable development, and reflects the complex of long-term mutually beneficial “buyer-producer” relations, as it provides both return on investment and satisfaction of social and environmental needs within acceptable prices.

Quadrant 2. "*Consumer's benefit, producer's damage*" corresponds to the situation when external environmental costs of production, lack of the positive effect assessment of production and ecological products consumption are subject to environmental production regulation in terms of stimulating the "greening" of the enterprise economy.

Quadrant 3. "*Consumer's losses, producer's damag*e" corresponds to the situation that, in the terminology of I. Ansoff, is called "the country of fools".

Quadrant 4. "*Consumer's losses, producer's benefit*" reflects the case where the manufacturer makes a profit from sales, but does not provide the consumer with goods of the certain ecological quality. This situation often occurs in industries with the low technological development. However, such a situation may occur in the process of manufacturing new products in highly sophisticated industries based on "fashionable technology", when the buyer's interests are not always taken into account.

Let us now consider some methodological possibilities for a more complete account of environmental costs in the pricing mechanism for enterprises–polluters. Our calculations have shown that about 19–60% of the damage from environmental pollution is compensated through the ecological payment system (Mishenin and Yarova 2019).

Thus, in order to fully compensate the economic damage from environmental pollution through the pricing system, it is possible to calculate *a price increase index*, taking into account the ecological component in the production cost. But it is very difficult to implement this proposal, especially in conditions of unstable economic development, monopoly power and distortions in the pricing system.

The price increase index for environmentally misbalanced industries, but in terms of providing the full economic damage compensation caused by environmental pollution and the relative equal supply and demand $\left(I_P^E\right)$, can be calculated as follows:

$$I_P^E = \frac{D + T_E + P}{T_E + P}, \tag{2.11}$$

where D the economic damage from environmental pollution, which is not compensated through the ecological tax system (payments); T_E ecological tax (payments) within the limits of normative indicators for environmental pollution; P the price of products.

Indicative price indices for the products of enterprises of some industries are presented in Table 2.3.

The calculated price indices, taking into account the environmental factor, implement the principle of *absolute cost accounting*. The presented indices can be used to regulate the external economic activity of enterprises based on the indicative price system. But there is a certain deviation of contract (foreign trade) prices from indicative in crisis market conditions of economy. That is why the proposed and

Table 2.3 Indicative price indices for products in terms of full compensation for economic damage from environmental pollution (Mishenin and Yarova 2019)

Industry	Indices
Chemical	1.142
Manufacture of agricultural machinery	1.143
Manufacture of equipment for various industries	1.153
Food	1,146

calculated *price increase indices*, with absolute accounting for economic loss may be some benchmarks to regulate and balance contract price deviations for enterprises–polluters (Schmidheni 1994).

It should be noted that world prices for natural resources, reflecting the degree of their natural scarcity and demand, also do not take fully into account their external effects to the process of their extraction. For example, timber prices do not reflect the socio-ecological value of forest resources, and therefore deviation of contract prices for timber products from indicative prices may be subject to environmental regulation. Methodical approaches to the cost estimation of social consequences of economic activity (including those that are not in kind and are not valued in money) have been scientifically considered (Bohm 1979; Boulding 1970; Chakravorty et al. 2007; Lindgren et al. 2018; Gaffney et al. 2019; Targetti et al. 2019).

The assessment of social and environmental efficiency in terms of the “cost-benefit” method includes its natural determination, and then a monetary estimate is made (Mishenin et al. 2011). The economic assessment of social and environmental goods and services has nothing to do with market prices because the market is unable to account for them. This aspect stipulates the necessity of environmentally oriented state regulation of prices for nature-intensive and eco-intensive products (Mishenin et al. 2011).

2.11 Social and Environmental Responsibility as Systemic Element for Agricultural Sustainability

Social and ecological responsibility makes a significant contribution to the national food security, as the problem of providing quality of food is critical to the population. From time to time, scandals with newly discovered dangerous substances occur in the world and the emergence of new viral infections types threatens the society’s sustainable development in a whole. This situation may lead to the fact that increasing consumption of agricultural products can reduce the life quality in general (Bengtsson et al. 2018). This decline in life quality is primarily defined as a decrease in the level of public health, which leads to the loss of human capital. From these perspectives, we believe that an important idea of the economic paradigm of greening agriculture as a whole is the socio-ecological and economic responsibility for the food quality and the environment in all chains of agribusiness.

Therefore, the creation of an effective mechanism of socio-ecological and economic responsibility is a logical development of the market agricultural sector, which requires effective ecological and economic regulation. The need to increase the level of responsibility for the eco-destructive effects of agricultural management is largely determined by its complex impact on the agricultural sustainability, eco-balanced production results. That is why the formation and further development of organizational, economic and legal mechanisms of social and environmental responsibility should become an integral part of the agrarian economy (Mishenin and Yarova 2015).

Socially and environmentally oriented responsibility in the field of agriculture often acts as a responsibility for the consequences of the irrational use of agrarian natural resources that affect the environmental, economic and social interests of society, economic entities and individuals. Social responsibility directly has a complex socio-ecological and economic character and implies management responsibility that goes beyond the specific (real) mechanisms for generating profit. Also it should be taken into account protecting and enhancing social well-being under various parameters of sustainable development. Therefore, it should be emphasized that the most important structural elements concerning the social responsibility are social commitment and responsiveness in the long-term socially beneficial goals of agribusiness (Robbins and Coutler 2007). Of course, the processes of social responsibility implementation require the formation of appropriate mechanisms of environmental management. At the same time, the social activity of the enterprise is a set of measures for the effective realization of the entrepreneurial social responsibility, which should have both internal and external orientation.

Analysis of theory and methodological background of social responsibility in view of environmental management concept indicate certain versatility concerning essential and meaningful basis of social and ecological responsibility (Belousov 2016; Makarova and Stepanova 2014; Mishenin and Yarova 2015; Pakhomova and Malyshkov 2008). The structural components of social responsibility are also ambiguously identified. In particular, according to Pakhomova and Malyshkov (2008) the social and ecological responsibility is conscious and motivated business participation in various preventive measures concerning environmental damage and irrational nature management; also in providing social and ecological benefits, measures for labour protection, environmental quality improvement and sustainable nature management (Pakhomova and Malyshkov 2008).

Social and ecological responsibility of agricultural enterprises of different forms of ownership and organizational forms of agribusiness must be determined by their responsible attitude regarding a rational use and reproduction of natural resources, as well as towards workers, society in general and individual citizens, as well as concerning negative changes in the ecological and economic parameters of land and resource potential (capital) (Mishenin and Yarova 2015).

The social and ecological responsibility in agribusiness is determined by the certain factors as follows (Mishenin and Yarova 2015):

1. Voluntary and initiative ecological and economic measures of enterprises go, especially at the initial stage, beyond the limits of profit, the legislative regulation of environmental agriculture.

2. Ecological and economic measures to improve agrarian nature and resource potential are of social importance for the local population to contribute its employment.
3. "Greening" of the agricultural production has undoubtedly social effects, both in terms of improving the level of labour safety and increasing incomes for workers. It, no doubt, positively affects the environmental dimension of food security.
4. The relations of enterprises with the public are social in the system of environmentally responsible agricultural management.

We define *social and ecological responsibility of enterprises* as an initiative-voluntary internal and external activity aimed at responding and forming commitments concerning economic, social and environmental aspects of sustainable, environmentally balanced development of rural community under the background of the established system of environmentally oriented regional agricultural management (Mishenin and Yarova 2015).

The peculiarity of this definition is that it reflects the basic signs of social responsibility—*responsiveness and commitment*, as well as its external and internal orientation (Mishenin and Yarova 2015).

Socially responsible enterprise management on an ecological and economic basis is defined as a process of implementation and integration of social and environmental measures into agro-economic activities that go beyond the formation of profit and the legally established principles, rules, norms, standards of rational use and restoration of agricultural resources of nature's origin to ensure the sustainable agricultural development (Mishenin and Yarova 2015).

Social and ecological responsibility in nature management within the framework of the enterprise's activity is formed and determined by the main factors as follows: social and environmental initiative; ecological and economic knowledge management system; ecological culture; ecological and economic technologies of socially responsible agricultural management (Targetti et al. 2019).

Generally, it is necessary and appropriate to talk about a comprehensive organizational and management mechanism of socio-ecological and economic responsibility, which is necessary to support the agricultural land use greening and environmentally safe nature economy in the context of food security. Such a mechanism should be defined as a set of forms and instruments in the system of social, ecological and economic regulation of agricultural development on the basis of simultaneous application of administrative, economic and social management methods (Mishenin and Yarova 2015).

Forms and methods of economic and at the same time legal responsibility should also be optimally combined with instruments not only of purely economic stimulation, but also motives for realization of environmental, social interests of society and individual economic entities (legal entities and individuals), as well as with other functional links of the mechanism of agricultural management (Mishenin and Yarova 2015).

Agricultural economic, social and ecological responsibility should be based on the following principles: ensuring the economic parity, environmental and social values of the agro-economic activity results; achieving the optimal combination of vertical and horizontal responsibilities; the most complete compensation for socio-economic and environmental damage; inevitability of economic and legal sanctions; ensuring a balance between economic sanctions and economic incentives (socially and environmentally responsible behaviour of agribusiness entities should be encouraged through subsidies, tax breaks, preferential lending) (Mishenin and Yarova 2015; Gaffney et al. 2019; Targetti et al. 2019).

The construction of a comprehensive mechanism of social, ecological and economic responsibility in the field of agriculture takes into account some specifics of ecological and economic, social and legal relations within the system of greening agro-production, the need for optimal maintenance of ecological safety of agricultural products (Pingali et al. 2019). The implementation of the functions of economic and legal environmental responsibility affects the behaviour of subjects of agrarian relations, focuses on providing motivation to comply with the rules, requirements and norms of rational agricultural production and land use.

Economic responsibility, administrative and legal sanctions for irrational agro-production, violations of environmental legislation can fulfil the main functions as follows (Mishenin and Yarova 2015):

1. *Incentive function:* This function of responsibility is fundamental, since it is expedient to prevent the negative impact of irrational agricultural land use, eco-destructive production on the level of quality (ecological) of products, and then eliminate them. The implementation of the incentive function requires a wide variety of motivational tools for the greening of agricultural production, rational land use. This function acts as counterparty to the compensation function.
2. *Compensation function:* Full compensation for the loss is a prerequisite and, at the same time, a demand for the development of market relations, one of the factors for ensuring socio-economic sustainable development. Compensatory nature is aimed at the rational use of financial, material and labour resources to eliminate, neutralize and prevent the negative consequences of environmental damages.
3. *The preventive function:* Social, ecological and economic responsibility requires the awareness of agribusiness entities of the extent of material liability for violations of environmental quality, in particular, land and capital. It can be reflected, for example, in the system of contractual relations. The implementation of the preventive function is ensured by the inevitability of economic sanctions, assessment of their impact on the final financial and economic results, which causes the conduct of socio-environmental analysis.
4. *The control-information (communication) function:* Precedes the compensation function, facilitates the detection of environmental violations in the agricultural sector, and provides the information base of natural indicators of loss for their further transformation into cost indicators. The implementation of the control and information function involves the creation and operation of various social and environmental monitoring systems of agricultural use.

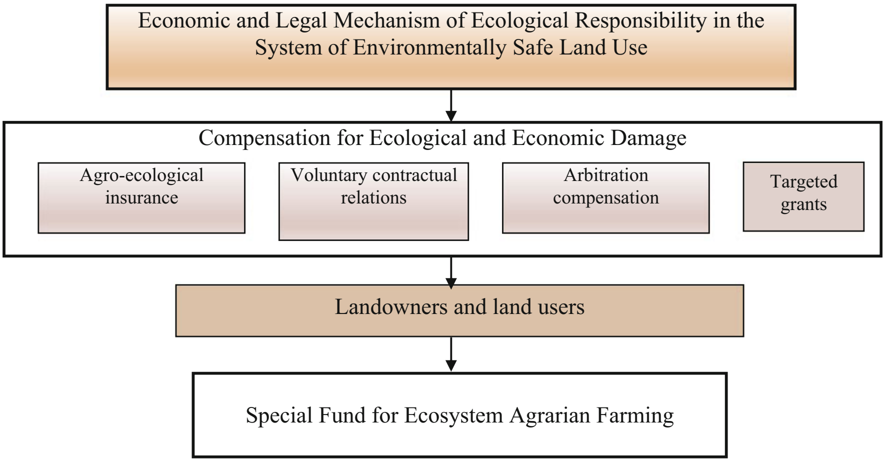

Fig. 2.13 Organizational and economic bases of ecological and economic losses compensation to the system of environmentally safe agrarian farming (developed by Yarova, on the base of Mishenin et al. 2017)

5. *The evaluation function:* Creates opportunities for measuring the level of socio-ecological security of the economic behaviour of agricultural entities and forming relevant conclusions. This function is a process of more accurate determination of the full cost of social work, social and ecological losses due to the environmental agricultural use.
6. *The regulatory function:* Ensures the application of organizational, economic and social instruments to the environmental behaviour of business entities, which largely depends on the application of sanctions and the threat of their use.

Thus, the ecological responsibility's economic and legal mechanism should provide for compensation of ecological and economic damage caused by external and internal ecological destructive factors, to promote the environmentally safe and balanced agrarian farming system (Fig. 2.13).

It is advisable to accumulate a share of the compensation payments within the framework of the special ecosystem agrarian farming fund, which needs to be formed at the regional level in order to solve common regional problems of agri-management.

Thus, it should be noted that the basis of providing environmentally oriented food security is the formation of complex socio-ecological and economic mechanisms that would contribute to the development of agriculture and a whole society in a sustainable manner, as well as guarantee meeting economic and socio-environmental requirements of individual citizens.

2.12 Ecologically Harmonized Agriculture, Food Security and Sustainable Rural Communities: Way Forwards

The environmental effects caused by modern agriculture development shape the calls to counter-industrialization strategies of social development like population reduction, protection of traditional cultures, rewilding and so on. The latter means moving away from markets and the industrialized economy to harvesting and hunting (Gowdy 2020). Taking into account the controversy of rewilding decisions, implementation of local food concept in agriculture could be seen promising strategy (Strochenko et al. 2017; Koblianska and Kalachevska 2019). This presupposes the reduction of food chain, development of SME farming, diversified agricultural activity and land use (Koblianska and Kalachevska 2019). Such strategy supports sustainable development of agriculture and local communities, as the agri-sector still remains a main economy driver in rural areas (specifically, in developing countries) and a key industry within the framework of SDG achievement (Fig. 2.14). Briefly commenting on Fig. 2.14, one should emphasize a substantial role of agriculture in poverty alleviation, economic and income's growth, conflict mitigation, supporting

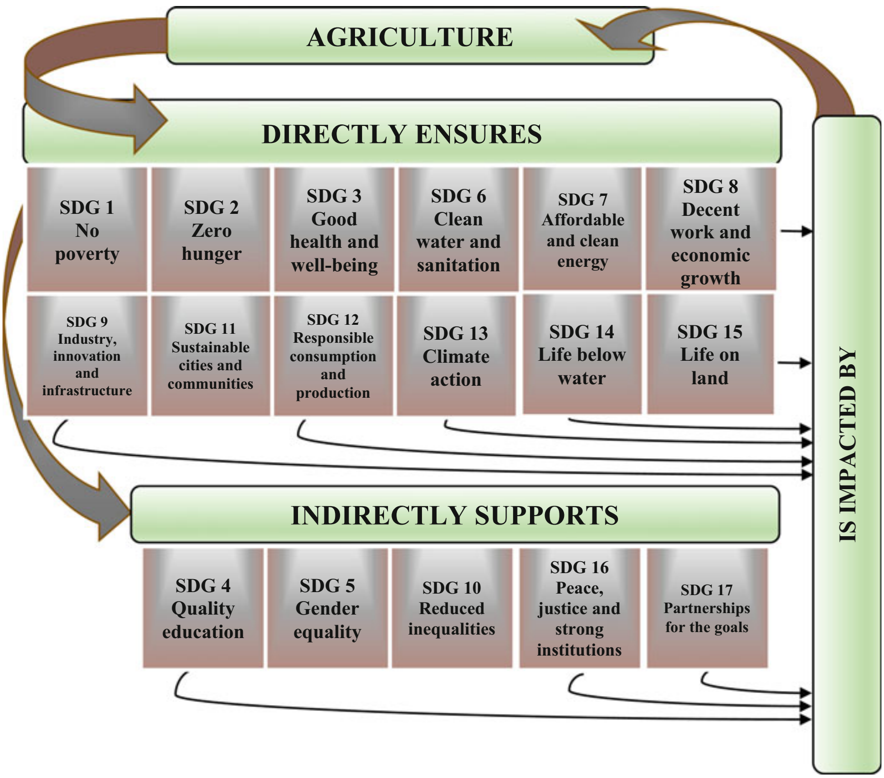

Fig. 2.14 Agriculture within the sustainable development goals' framework (developed by Koblianska with the use of (UNO 2016)

employment. The sector also substantially influences the health through the food quality, especially in developing countries. World Bank's estimates show that agriculture growth is double and even fourfold more effective with regard to the growing incomes of the poorest people than measures in other industries. Actually, agriculture provides the income for more than 65% of poor working adults worldwide (World Bank 2020).

Concerning the above, implementation of local food concept is economically, socially and environmentally beneficial and thus ensures the local community's sustainable development. The development of small farms is contrary to the industrialization of agriculture (Nicholls et al. 2020) and due to traditional farming practices supports ecosystem services (Ickowitz et al. 2019). This strategy not only provides environmental benefits but is also a way to diversify nutrition (especially for the poorest rural residents) and to support institutional shifts and innovative solutions. The key aspects of its implementation are the development of an appropriate set of measures to stimulate the development of local diversified business in rural areas representing the multifunctional and eco-friendly agriculture. In this context the sound market-based economic incentives are of great importance, in particular, to counter the commercialization of production activities (Ickowitz et al. 2019), that is an evident tendency in Ukraine. These incentives should provide, namely:

- The internalization of public benefits generated by diversified agricultural activities (Targetti et al. 2019; Gaffney et al. 2019; Funk and Brown 2009; Adenuga et al. 2019), for example, through the ecosystem service payment mechanism.
- The internalization of negative externalities of farming (Adenuga et al. 2019), for example, through the introduction of compensation for marginal costs associated with livestock contamination and use of chemicals (Hediger and Lehmann 2007).

Monetary incentives have traditionally been regarded as basic to stimulate environmentally friendly agricultural practices, but recent research (van Westen et al. 2019; Targetti et al. 2019) has shown that locally and regionally an institutional context is of great importance, and therefore a development of sustainable agriculture is a result of the spread of knowledge and awareness of public goods and their status (among consumers, local community, government) and possible technologies (among farmers) (Targetti et al. 2019). This requires the improvement of appropriate policy and legal framework.

2.13 Policy and Legal Framework

The policy improvement is an urgent task to be solved for the achievement of coherent goals of food and environmental security, and sustainable development of agri-sector worldwide. Actually, this is an institutional transformation that gives the ground for further technological improvements.

The new policy should be of an inclusive, integrated and multi-sectoral nature, flexible and adaptive with respect to the whole complex of agriculture and nature interrelations (Devaux et al. 2020; El Bilali 2019). This touches both the developed and developing countries.

For developing countries, the major concern is to integrate environmental aspects into a whole agrarian and economic policy context (Fatemi and Rezaei-Moghaddam 2019). At the same time, developed countries need to ensure high flexibility and adaptability of political measures to the new challenges, including climate mitigation efforts (Candel and Biesbroek 2018). The closer communication and interaction between different stakeholders are needed for both.

The change of consumer preferences is another important area of policy reform towards the food and environmental security. The promotion of a healthy and sustainable diet, as well as raising public awareness on the need to prevent food losses and wastes are the important areas of government activities in this area (Bahn et al. 2019).

The policy measures to support small-scale agri-producers are needed to ensure diversified multifunctional agriculture with all related benefits such as food security for the poorest, healthy diet, income growth, ecosystem services, etc. (Ickowitz et al. 2019). The recent studies show that the model of local food is the win-win strategy in this case, providing the reduction of environmental footprint, biodiversity losses without a decrease of food supply per capita. Such a model is the most beneficial for the simultaneous achievement of food security and environmental goals and is opposite to land polarization and specialization that are characteristics of a neoliberal policy (Rega et al. 2019).

However, the deficit of funding is a major modern challenge for food security provision and sustainable agriculture development, especially for developing countries cases. It is possible to stimulate economic growth and poverty alleviation through the investments in public goods like agro-research, consulting, road infrastructure, etc. (Funk and Brown 2009). In this context, the public goods concept (proper identification and assessment of public goods provided by sustainable agriculture practices) could serve as a baseline for elaboration of a new economic policy towards the food and environmentally secure future (Gaffney et al. 2019; Targetti et al. 2019).

2.14 Conclusions

The agriculture appears as a key sector under the food security agenda that is overcoming the hunger in all its forms and manifestations, providing the adequate income and ensuring the quality of food. At the same time, agriculture is the main industry where interrelations with natural conditions are the key factors to be taken into account for successful sector's development. However, the full set of relationships between the sector and the nature is not understood, recognized, reflected and responded to enough, especially in the agriculture dependent countries. Due to this, currently agriculture is one of the main industries influencing natural environment, causing irreversible climate changes, depleting the land and ecosystems, etc. In light of that, the existing and future ability of society to overcome hunger is extremely questionable, and agriculture environmental security is a growing concern with the food one.

Against this background the attention of scientists, international organizations and politicians is riveted on the search for an optimal model of agriculture, i.e. an industrial system, which provides food supply and income, or an organic farming with environmental benefits, or diversified local food systems providing an income to the poorest and necessary ecosystem services, etc. At present, there is no single view concerning these approaches, however, the experience of Ukraine convincingly shows that the industrialized model is an environmentally loosing strategy if proper economic, institutional and technological transformations are not in place. At the same time, it is not possible to provide at least the achieved level of food supply (per capita) without increasing the food production. In this context the eco-friendly intensification appears as a desirable way of agricultural development in a globalized world and requires systemic transformations of society, economic models, policy tools and solutions. In particular, the most important areas for improvements cover environmentally adjustable pricing for food and other agri-products, implementation of the social and environmental responsibility of agribusiness concept, as well as recognition of industry's role regarding the sustainable community development. In this case, the policy of localism (support for diversified local producers) appears to be quite promising as it addresses the whole range of food security dimensions.

2.15 Future Research Roadmap

The ecological and economic regulation of balanced agricultural development in the food security context must ultimately be defined from the point of view of natural capital itself. So, further research should be aimed at shaping the organizational, institutional and economic conditions of capitalization and "securitization" of territorial agrarian natural resources. The elaboration of a fair system of externalities internalization is of great importance in this regard.

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