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Strategic planning in the management of agricultural production resources for Cyprus

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Table of Contents

TABLE OF ACRONYMS/ABBREVIATIONS

ARI	Agricultural Research Institute
BPS	Basic Payment Scheme
CAP	Common Agricultural Policy
CAPO	Cyprus Agricultural Payments Organization
CGAP	Codes of Good Agricultural Practice
CSA	Climate-Smart Agriculture
DSS	Decision Support Systems
EEA	European Environment Agency
EAFRD	European Agricultural Fund for Rural Development
EAP	Environmental Action Programmes
EC	European Commission
EFSA	European Food Safety Authority
EIS	Environmental Impact Studies
E.P.	Equivalent Population
EU	European Union
EWRA	European Water Resources Association
FAO	Food and Agriculture Organization
FAS	Farm Advisory System
GAEC	Good Agricultural and Environmental Condition
GAEP	Good Agricultural and Environmental Practices
GDP	Gross Domestic Product
GIS	Geographic Information Systems
GPS	Global Positioning System

HACCP	Hazard Analysis and Critical Control Points
HNV	High Natural Value
ICT	Information and Communications Technology
IIMI	International Irrigation Management Institute
IIS	Integrated Information Systems
IWA	International Water Association
mcum	Million Cubic Meters
M1-20	Measure 1-20
mm	Millimeters
MOA	Ministry of Agriculture
MSFD	Maritime Strategy Framework Directive
PA	Precision Agriculture
PAF	Prioritized Action Frameworks
RAA	Regulatory Administrative Act
RASFF	Rapid Alert System for Food and Feed
RDP	Rural Development Program
RES	Renewable Energy System
R&I	Research & Innovation
VRT	Variable-rate technology
WDD	Water Development Department
WFD	Water Framework Directive
WFO	World Food Organization
WSI	Water Stress Index

1 CHAPTER: INTRODUCTION

Cyprus is an arid to semi-arid island state situated in the north-eastern Mediterranean with highly constrained renewable freshwater resources due to the intense spatial and temporal scarcity caused by the seasonal distribution of precipitation and the topography.

Although many various water supply investments and interventions have been made (surface water dams, groundwater exploitation, inter-basin water transfers, desalination, and reuse of tertiary processed effluent), Cyprus is still a long way from reconciling the demand to the availability of water. Competing market and the dynamic competitive tension between agriculture, urban growth, tourism, and the environment challenge the island's existing water management practices.

To protect and use resources efficiently, through Agricultural Policy of Cyprus, they are promoted Thematic Objective 4 (Supporting the transition to a low-carbon economy in all sectors), Thematic Objective 5 (Promoting climate change adaptation and risk prevention) and Thematic Objective 6 (Protecting the environment and promoting the efficient use of resources).

Concerning Thematic Objective 4, the interventions will focus on the energy sector and aim to ensure energy supply and meet the country's energy needs, with the least possible burden on the economy and the environment, contributing to achieving the national objectives of the Strategy "Europe 2020". Targeted interventions under this Objective will promote nitrogen oxide, ammonia, and methane emissions reduction from agriculture. In particular, the reduction of greenhouse gas emissions in the agricultural sector will be held by reducing polluting inputs (promoting nitrogen oxide, ammonia and methane emissions from agriculture by reducing the use of nitrogen fertilizers and by improving livestock management methods for animal waste treatment) as well as by increasing the carbon sequestration with forestry aid (targeted reforestation measures and sustainable forest fire management and prevention). Incentives for mechanical weed cultivation instead of chemical fertilizers affect reducing pollutant emissions from the production of herbicides. In contrast, mechanical cultivation requires less energy (and therefore yields fewer pollutants) than the application of chemical herbicides.

Regarding the thematic objective 5, the interventions will focus on specific adaptation actions in implementing the Cyprus National Strategy for Adaptation to Climate Change. The main thematic investment modules promoted under the thematic Objective are the Implementation of Forest

Measures and measures to encourage adaptation and risk prevention. The rational management of natural resources, combined with the expansion of green development technologies and solar energy utilization, is also among the priorities studied in detail.

Concerning Thematic Objective 6, the interventions will aim at the country's full compliance with the acquis communautaire in the field of environment and promote interventions aimed at sustainable development (including green and blue development), contributing to restructuring the economy. The main thematic investment modules selected are water and soil management and the protection and restoration of biodiversity.

In the agricultural sector, measures are sought to reduce water consumption and conservation of the structure of aquatic ecosystems, surface water and groundwater aquifers. In this context, the transfer of know-how for the adoption of ICT applications is aimed at (e.g., telemeters, precision farming methods). It is also aimed at adopting agri-environmental measures, including the application of crop rotation cycles in annual crops, the mechanical cultivation of weeds, and the reduction in plant protection products and chemical fertilizers. The promotion of organic farming also contributes to improving water and soil quality. It also seeks to maximize the exploitation of recycled water and strengthen the water balance by providing sufficient water quantity for irrigation of crops, fields, green spaces, etc. It seeks energy savings and reduces pollution from desalination since the reuse of processed wastewater for irrigation purposes increases the available quantities of water dams for water supply and reduces the production requirements for desalinated water accordingly.

In the agricultural sector, it is necessary to address agricultural land abandonment phenomena, especially in mountainous areas, and land degradation by implementing agri-environmental measures. Creating a necessary institutional framework for the definition of HNV areas, combined with the characterization of crops as traditional (vine, deciduous), will preserve the characteristics of the landscape and biodiversity in these areas. Actions promoted under Thematic Objective 6 are expected to contribute substantially to creating conditions for the economy’s sustainable development and improving its inhabitants' life standard and quality, as pursued through Europe 2020 Strategy. The Water sector, through EAFRD, will promote the solution of irrigation problems (saving water, improving water use efficiency, and water transport and storage infrastructure to meet irrigation needs). The selection of interventions aims to achieve the following results:

- Increasing water use efficiency in agriculture, for example, through the implementation of intelligent systems for recording and managing irrigation networks, improved irrigation systems, etc.
- Increase the use of recycled water for irrigation purposes.
- Conserve the structure of aquatic ecosystems, surface waters and groundwater aquifers.
- Reducing agricultural land abandonment and preventing soil degradation in mountainous areas.
- Improve visits to selected cultural resources in rural areas.
- Improving soil management, preventing erosion, reducing nitrates, pesticides in soils and water resources
- Protect and improve biodiversity and upgrade of Areas of HNV and NATURE 2000 in rural and forest areas.

The present study will analyze the methodology and the basic directions of the "road" map regarding implementing a resource management plan for agricultural production in Cyprus. More specifically, chapter 1, which is the introduction, was presented the importance of good management of natural resources for the most efficient, effective and productive agricultural production and the correlation with the thematic objectives 4, 5, and 6 of the Agricultural Policy of Cyprus. The second chapter presents Cyprus's water resources' current situation, the RDP of Cyprus and the legislative framework. In contrast, the third chapter refers to the environment and the conditions for sustainable management of water resources, emphasizing reducing groundwater abuse and improving irrigation systems' efficiency. The fourth chapter analyzes the agricultural practices related to the proper management of water resources of rural production in Cyprus. The present derivable concludes with the fifth chapter, which assesses the feasibility of implementing GAEPs on a large scale.

2 CHAPTER: CURRENT SITUATION AND LEGISLATIVE FRAMEWORK

2.1 Introduction

Cyprus' climate is characterized as semi-arid with frequent and gradually increasing droughts, while its rainfall has an uneven distribution both geographically and seasonally. Cyprus is one of the poorest countries in water, with many small watersheds but no significant runoff. Its water resources are limited, directly dependent on precipitation, scattered and expensive to exploit, while WSI = 65% (abstraction/availability ratio).

The exploitation of Cyprus' underground water resources, due to low cost, began in the 1920s, in the aquifers of Morphou, Famagusta and Protaras, Kokkinochoria and until 1960, thousands of wells were drilled throughout Cyprus. The need to exploit surface water resources was recognized before the 1950s. At that period, a system for collecting hydrometric data, installing automatic river water flow meters, conducting surface flow measurements and conducting hydrological surveys in large aquifers began. The data gathered formed the basis for the implementation of significant projects after 1960.

In the 1960s, Cyprus was able to supply good quality drinking water to towns and villages using surface springs and new wells. Also, the construction of reservoirs for the enrichment of aquifers and irrigation began, while between 1960 - 1974, the first phase of construction of dams took place in the areas of Pomos, Agia Marina, Argaka - Makounta, Mavrokolympos, Polemidia, Morfou, Massari, Germasogeia and Lefkara. Simultaneously, government policy increased the incomes of rural areas incomes, thus minimizing the income gap between farmers and other income classes. As a result, the contribution of agriculture to GDP increased. After 1960, the systematic evaluation of water resources was decided and the first steps were taken to replenish and protect groundwater. Simultaneously, reservoirs are being built, flow to the sea is restricted and water networks are being built in towns and villages for water and industrial purposes.

Until today, significant Water, Irrigation and Sewerage Projects have been completed, and all industrial units have been connected to high-quality water, in line with European standards. More than 107 artificial lakes/dams have been constructed, while 1/5 of the State development budget (20%) accounts for water development projects.

Water is a natural resource necessary for developing any kind of activity and maintaining the ecological balance in the area. All users, such as settlements, agriculture, industry and wetlands, are entitled to this valuable resource.

A national policy aimed at sustainable water resources management must balance water supply and demand in a level of drainage basins or water compartments. Integrated management of the water resources of the drainage basins or water compartments should be sought. The protection and management of water resources, aiming to ensure sufficient quantities of good quality water for all uses, is critical in a modern, flexible and efficient state.

This chapter will analyze the current situation regarding the management of resources in agricultural production for Cyprus. It will also be examined the condition of the country's collective irrigation networks and will be analyzed the water balance. In the field of water resources management, reference will also be made to the critical immediate needs. At the same time, it will be presented the RDP of Cyprus and the legal framework applicable in Cyprus regarding water resources. Finally, the existing legislation on water resources management will be evaluated.

2.2 Current status of water resources of Cyprus

Hydrographically, Cyprus's island is divided into nine (9) hydrological areas, consisting of 70 main drainage basins and 387 drainage sub-basins. The Government-controlled area includes 47 main drainage basins. Most rivers originate in the Troodos region. The seasonal distribution of surface runoff follows the seasonal distribution of precipitation, with minimum values during the summer months and maximum values during the winter months. Because of the Eastern Mediterranean climate, which is characterized by hot summers of long duration and low average annual rainfall, there are no rivers with a continuous flow along their entire length. Most rivers flow for 3 to 4 months a year and run dry for the rest of the year. Only parts of some rivers located in Troodos have a continuous flow (rivers Xeros, Diarizos, Kargotis Marathasa, Kouris and Germasogeia). Most rivers have a rather steep slope except rivers on plains along the south coast of the island. Most sections of rivers, however, are at an intermediate altitude.

As a result of the arid Mediterranean climate, there are only five natural lakes that are brackish or salty. Other water systems have been human-made due to dams' construction on rivers or the creation of storage cisterns. All lakes in Cyprus can be characterized as dynamic systems. Natural salty and brackish lakes dry out often, but not every year. Both saline and brackish lakes include species that are typical of these conditions. The quantity of water in artificial reservoirs and storage cisterns depends on rainfall and use. Artificial reservoirs are mainly filled by the inflow of water from rivers. During winter, they fill up, but most of the water is used in summer and the water level is demoted. Therefore, the water level and the size of these lakes are variable. As all artificial reservoirs and storage cisterns are designed to provide drinking water and irrigation water can cause the lake's drying.

In total, 216 river water bodies have been identified in Cyprus and 49 of those have been characterized as highly modified, i.e., bodies that have lost their natural character due to human activities. Of these, 32% were classified as good ecological status, 35% in moderate, 7% in incomplete, 2% in low and 25% were not classified. It is pointed out that in the category of unclassified corresponds to 16% of the total length of the river bodies of Cyprus, while in the category of good condition 33%, as shown by the Technical Report for Evaluation of the Results of the Surface Water Monitoring Programs Article 8 of Directive 2000/60 / EC.

In terms of groundwater systems, most of the island's aquifers are wells developed in rivers or coastal alluvial deposits. These are the largest and most dynamic aquifers, which are fed mainly by river supplies and rainfall. Three major coastal aquifers include all the vertical riverbeds. Coastal parts of these aquifers consist of sand, silt, limestone, cobblestones, clay, and riverbeds composed of alluvial deposits, cobblestones, sand and mud. These aquifers are wells and have a depth of about 30m. Apart from the large but not so productive aquifer of the Trojan magmatic rocks, the other aquifers exist in gypsum, sandstones, limestones and chalks. These aquifers are mainly wells and, in some parts, semi-passable or under pressure. These sections are covered with layers of sludge and mud or sandy loam. It has been observed that the aquifer of Mount Troodos has generally developed in ophiolites of low permeability and locally in moderately permeable ruptured zones of magmatic rocks and for this reason, it is under pressure in some parts. All aquifers in Cyprus (66) have been grouped into 20 groundwater systems based on the lithology, hydraulic characteristics, pressures and importance of each aquifer. Ten groundwater systems are directly connected to the sea. Limassol's groundwater system flows into the sea and the outflow reaches 350 m3 / h, while the other water systems have a discharge of less than 150 m3 / h. Most groundwater systems are wells with some sections semi-permeable or under pressure. Only Maroni plasters are entirely under pressure. The Fasouri swamps (near the salt lake Akrotiri) is the only ecosystem in Cyprus that depends directly on the groundwater and specifically on Akrotiri's water system.

Rainfall, until 1997, was the unique source of water resources in Cyprus. The average annual rainfall, including snowfall, is 503 mm, while from 2000 until today, it has decreased to 463 mm. The quantity of water corresponding to the free region of Cyprus amounts to 2,750mcum. Still, only 10% or 275mcum is offered for exploitation since the remaining 90% return to the atmosphere as direct evaporation and transpiration.

Geographically, rainfall is distributed unevenly. Maximum rainfall is distributed between the two mountain ranges, while the minimum in the eastern lowland and coastal areas. Besides, there is a considerable variation in precipitation over time, with frequent, continuous droughts lasting two to four years. The average annual amount of 275mcum of water is distributed in a rough 1: 3 in surface storage and groundwater. Approximately 1/3 of the underground storage flows into the sea.

Cyprus is plagued by water scarcity over time. The available water quantities in Cyprus are unusually low, especially during the frequent, prolonged hydrological drought periods. As a result, known water quantities are not sufficient for any reasonable activity (irrigation, water supply, industry, maintenance of wetlands, recreation areas).

The reduction of natural water resources due to climate change has the following main characteristics:

• The gradual decrease in average rainfall. The recorded rainfall in the state-controlled areas during the period 1972 – 2015 decreased from 533 mm (in 1972) to 471 mm (in 2015), which means a decrease of 8%. This results in a 50% reduction in natural water resources.

• The gradual increase of the average temperature increases the plantations' irrigation needs and the losses from the evaporation from the dams. As a result, there is also a further reduction of the available natural water resources.

• The increase of extreme weather phenomena, i.e., drought periods and intense short-term rainfall, causes local floods.

Water scarcity problems are also linked to wrong anthropogenic actions such as water-consuming activities that exceed the renewal rate of readily available water resources and the waste of water resources, primarily in irrigated agriculture and secondarily in others. There are also significant water losses due to irrational management of available water resources (lack of knowledge, indifference, political costs), insufficiency of storage facilities (reservoirs), non-implementation of artificial groundwater enrichment projects and non-recycling of already used water at a satisfactory level (drainage water, processed urban wastewater). The degradation of the quality of a significant percentage of the available water resources is either due to the salinization of many overflowing coastal aquifers (poor water management practices and a disproportionate number of tourists) or surface and groundwater pollution by various chemical and industrial).

The massive increase in water needs, mainly in water supplies, was caused by the following events:

• The Turkish invasion, which resulted in the forcible relocation and settlement of 160,000 additional residents in state-controlled areas, created extra water and irrigation needs for personal use and crop and livestock production.

• After the Turkish invasion, great emphasis was placed on tourism and as a result, water needs for water supply and irrigation increased.

• The increase of foreign workers for social and industrial needs has again increased water needs for both irrigation and water supply.

• The rise of the living standard of the inhabitants significantly increased the water supply needs.

Summing up the real needs for water supply and irrigation, these are estimated at around 152mcum instead of 180mcum.

Cyprus is generally characterized by a lack of freshwater resources, limiting the possibilities of agricultural exploitation of soils and the terrestrial ecosystem's general productivity. Although for the last 40 years, the priority of the state has been the development of water resources and the promotion of saving measures, the limited availability of water remains a fact. Increased droughts – because of climate change – and a massive increase in water needs exacerbate the situation.

The use of groundwater is pervasive and perhaps the permanent source of drinking water. In the past, the absence of natural surface water bodies (lakes and rivers) made it the only alternative, the excessive use of groundwater bodies. Reduced surface water reserves have led to the over-pumping of aquifers. The over-pumping of water from the underground bodies led to the current situation. Most of the underground aquifers of Cyprus are in poor condition and considered to be in danger. The biggest problem of over-pumping among the underground aquifers of free Cyprus is observed in Kokkinochoria, Kiti, Germasogeia, Akrotiri and Pegeia, resulting in the penetration of seawater in the aquifers and the impact of water quality. In these areas, special legislation is applied, which, among other things, provides for the issuance of a permit for groundwater pumping and consequently, its groundwater level is controlled.

In recent years, significant amounts of desalinated seawater and water from the reuse of purified wastewater have been added to its water balance. At the same time, the use of Improved Irrigation Systems was promoted, reaching 95% in irrigated crops and saving 55mcum of water per year.

The rational and sustainable management of water resources over time is essential so that Cyprus can deal effectively and painlessly with water shortages during periods of drought. Every citizen must protect and save natural resources, which is so vital for life. Unfortunately, the practice of over-pumping groundwater from illegal and uncontrolled pumping continues and has the devastating effect of a permanent and irreversible depletion of groundwater aquifers and, in the case of coastal aquifers, their irreversible salinization.

The state, realizing the need to ensure adequate water supplies, proceeded to build many dams, aim to collect rainwater, which otherwise would end up at sea, and infrastructure for transporting water to areas with lower rainfall. The main project is the Southern Pipeline. In the period 1967-1974, the WDD, by the Government and technical assistance from the FAO of the United Nations, prepared the General Plan for Water Development of Cyprus, which included five major projects. The Irrigation Project of Paphos, the Irrigation Project of Chrysochous, the Water Project of Vasilikos Pentaschinos, the Water Project of South Pipeline and the Water Project Morphou Tillyria. There is also the Plan of Unified Rural Development of Pitsilia, which included projects for health, education, transport, with the primary factor the water and agricultural development of the area. The projects included dams, main pipelines, drinking water refineries, pumping stations, irrigation networks and other projects, including domestic wastewater treatment plants. To prepare these projects were taken into account the hydrometeorological data of Cyprus (period 1900 – 1967), the population data of 1970 and the economic model for agricultural, tourist, and other development was foreseen in the action projects of that period. The implementation of the assignments began in 1974. Paphos Irrigation Works 1974 – 1983, Vasilikos Pentaschinos Water Project 1980 – 1985, Chrysochous Irrigation Project 1986 – 1990, South Pipeline Project 1986 – 1995, Pitsilias Project 1978 – 1983. During 1973 – 1998, their capacity increased by 233.7mcum of water (from 64.7mcum of water to 298.4mcum of water). These projects control over 90% of the surface natural resources and cover almost the entire area controlled by the Republic of Cyprus.

Subsequently, it appeared that this was not in itself enough since water in the dams was interactive with the rainfall, which, due to climatic changes observed in the region, also declined over time. As a result, it was promoted the construction of desalination plants, which ensure the adequacy of drinking water reserves, regardless of weather conditions, but at a high cost.

To address water scarcity, which began in 1992, water-saving and waste-reduction measures were first taken, efforts were made to replenish available water resources and secure additional water resources from recycled wastewater and by the construction of desalination plants. Since the projects for recycled wastewater are time-consuming with additional obstacles to consumers' unfavorable disposition to accept them and the existing restrictions for using recycled water for food safety and hygiene, such projects' promotion was very slow. On the contrary, desalination plants' construction with good quality water for water supply purposes proved much faster and more efficient. Following the successful construction of the Dhekelia desalination plant, which was put into operation in 1997, the government's relevant department submitted a proposal to establish three additional desalination plants, one in Larnaca, which was put into operation in 2001, one in Limassol and one in Paphos. The continuous delays in constructing the proposed desalination plants, which took place after 2014, caused Cyprus to face the spectrum of water scarcity, culminating in the import of water from Greece in 2008. Simultaneously, the Government in 2008 proceeded with constructing two "mobile desalination units," one in Limassol Monastery and one in Paphos. Cyprus currently has four desalination plants with a total annual production of 73mcum of water, which will be provided in the Single Southern Pipeline Project, that supplies water for irrigation and water supply in the areas of Nicosia, Free Famagusta, Larnaca and Limassol.

Government water projects have significantly increased water availability in lowlands and coastal areas, and water competition between irrigation and irrigation has been reduced. However, the demand for irrigation water, especially in times of drought, is not always met. Water scarcity remains a crucial feature of Cyprus, adversely affecting growth, the environment, agriculture and public health. Because of the deterioration of the situation due to climate change, it is even more imperative to find and adopt water resources' reasonable use measures.

Groundwater quality is considered particularly important, as most groundwater bodies are in poor quantitative condition and their restoration is not an easy process. Droughts are also significant, given their frequency, while existing measures are not considered satisfactory.

Regarding the availability of water for irrigation, the implemented measures have not fully met so far the water demand, as agriculture is the primary water user in Cyprus (over 60% of the total demand) and within the summer period when the water supply is limited, are often imposed cuts in the irrigation water supply. In addition, recycled water is distributed through Government Water Works (GWPs) only in the lowlands and coastal areas. The construction of the necessary transport infrastructure in mountainous areas is not economically feasible. The only WFDs for irrigation water supply in mountainous regions are dams, which are of limited capacity, and their reserves are depleted during periods of drought. This has led farmers in mountainous areas to use groundwater from private wells to meet their irrigation needs, resulting in the over-pumping of aquifers.

As mentioned above, the surface water bodies in Cyprus are mainly the reservoirs, in which the supply during summer is minimal. As a result, it is not achieved a suitable dilution of the pollutant concentration and in combination with the high levels of evaporation, the water quality is threatened with degradation. However, a bent of deteriorating water quality is observed in Cyprus' groundwater aquifers due to recent urbanization, the disposal of municipal wastewater in septic tanks, the intensive cultivation and use of fertilizers, and the over-pumping of groundwater resulting in salinization of coastal aquifers.

As far as it concerns water quality, the main threat is caused by pollution from intensive crops. Through the RDP are promoting measures to protect water from agricultural activities. In particular, there are announced measures through the Regulatory Management Requirements, the implementation of GAEC and the provision of grants for the performance of other measures to reduce runoff (with the installation of pesticides) and the restriction of the use of chemicals (fertilizers, insecticides), such as mechanical weed control, integrated production or low input management systems and organic production. In addition, through the FAS, provided by the RDP, farmers can be informed about best practices for water protection.

Cyprus has prepared Programs for monitoring the water status to have a coherent and comprehensive picture of their situation following the EU WFD. These Programs continue and are strengthened continuously with new data and measurements. Based on the Monitoring Program results, it appears that the river bodies' chemical condition is overwhelmingly good. In contrast, the river bodies' ecological state is inferior due to various interventions, but also because they have no water for long periods. Similarly, while lake bodies' chemical status is outstanding, their ecological status is lagging, and measures should be taken to improve it. On the contrary, all 25 coastal water bodies were in good or high environmental conditions or good ecological potential.

Similarly, their chemical condition was good. Groundwater bodies are mostly in poor quantitative conditions. Their chemical state is similar to those of surface water bodies.

2.2.1 The state of the collective irrigation networks of the country

Recognizing the critical socio-economic role of agriculture in Cyprus, the MOA, through the WDD, provides for the allocation of quantities of water for irrigation that, as far as possible, meet the water needs of the department. Cyprus's total cultivated area is estimated at around 133,000 hectares, of which 25,200 hectares are irrigated agricultural land. About 180,000 acres are irrigated by GWP, while the irrigation needs to amount to around 73mcum of water. It is estimated that Cyprus crop's total water requirements up to 150 million sq.m. of water per year. Larger irrigated crops are potatoes and citrus fruits, which are also the main export products of Cyprus. As far as it concerns the gross value of production, potatoes occupy the first position, tomatoes, cucumbers and melons/watermelons the second and citrus fruits the third among every agricultural product of Cyprus.

With the help of various organizations, Cyprus farmers maintain and improve the existing infrastructure, regardless of how the collective irrigation networks are built (free flow-under pressure). Constant care networks will provide farmers with the necessary water supply for the irrigation of crops. The majority of Organizations operate their systems successfully by maintaining the existing infrastructure and, at the same time, by improving technical deficiencies of the network, minimizing water transfer losses, recycling a significant part of the drains and using processed effluents. Also, they adapt their programs to apply irrigation water in the field, based on the time of water distribution in each plot. The organizations' interventions are necessary, but sometimes it is problematic to deal with their networks' problems by themselves. To avoid wasting water resources, both Regions and Central Administration should undertake and promote specific actions, such as some significant construction interventions (investments of earth and worn canals, modern devices for measuring, regulation and distribution of water).

2.2.2 Water Balance

The 'Water Balance' of the aquifer is a mass balance and it is estimated by subtracting total Outflow from total Replenishment. Resulting negative values indicate depletion of the aquifer, general lowering of water levels and possible degradation of the aquifer.

Water Balance = Replenishment – Outflow, where

Replenishment = Natural recharge + Artificial recharge + Sea intrusion

Natural Recharge = Rainfall + River Flows + Return from Irrigation/Domestic + Groundwater Inflow + Dam losses and

Outflow = Extraction + Groundwater outflow + Sea outflow

The deficit in the Single South Pipeline Project, which amounts up to 60mcum due to climate change, is being replenished by desalination plants whose total production in full operation amount up to around 73mcum of water per year.

By adding to the water balance, the quantities that desalination can produce, the available water resources in the three main water projects are as follows:

- Single South Pipeline Project: the irrigation water needs are limited. According to consumers' needs, the initial requirements are 61mcum, while the water needs increasing to 70mcum in 2015. Therefore, the Single Southern Pipeline Plan's water balance is balanced and the project with adequate management could provide sufficient quantities of water. However, it should be noted that water needs will continue to grow (around 1.9%) in case the current growth rate continues. Consequently, the increase of water resources should be planned immediately, according to the rise of needs, so Cyprus won't face water shortage again. Otherwise, the quantities of water supplied to agriculture should be reduced to meet the water needs.
- Paphos Water Project: the irrigation needs are equal to those used by irrigators in recent years (12mcum) and much lower than initially planned (amounting to 36mcum). On the contrary, the Paphos project's water supply needs equal to those currently provided by the project. Based on the above, it should immediately be planned and implemented to construct a desalination plant. It should then be decided whether to increase the project's

water quantities to have more significant utilization of the projects built in the area and use this knowledge to make similar decisions for the irrigation projects of the site.

- Chrysochous Water Project: the available water resources are much less than initially planned (only 6mcum, instead of 18mcum). In this case, decisions will have to be made regarding areas that will be irrigated based on limited water resources and whether the area's water needs can be met based on current sources.

2.2.3 Required immediate needs in water resources management

The modernization and revision of the General Water Development Plan, as well as the preparation of an additional Water Development Plan, are considered necessary for the proper management of water resources. Based on the existing projects, the completed studies and, at the same time, taking into account the new data (demographic, climatic, hydrometeorological, political, social, economic, environmental, development, etc.), it is deemed necessary for the current study to be modernized and revised. First, existing water needs should be recorded, for water supply, irrigation, tourism, industry, environment, etc., so that there is a complete picture of the real water needs. The future water needs should then be assessed in the context of the current and future development plan, which will consider every factor and economic, social, environmental, energy, agricultural, industrial, and tourism data. Natural water resources should be reassessed and existing non-renewable water resources and additional effluents that could be recycled should be recorded.

Furthermore, additional water projects should be identified, combined with the existing water projects, to meet current and additional water needs. The program should include practical measures to reduce consumption and avoid or reduce waste, as well as projects for the treatment and reuse of domestic wastewater and the enrichment of aquifers. Irrigated agriculture should be restricted to those plantations with high performance per cubic meter (due to water costs). In every case, the water supply should have a reliability factor of over 90%. Economic sectors, which are entirely dependent on water, will have a continuous supply of good quality water in sufficient quantities. For the implementation of the proposed new projects, feasibility studies should be carried out and should be prepared preliminary studies and estimates of capital expenditures and annual operating and maintenance costs according to the results and schedules for the implementation of these proposed projects.

Equally important is the management of existing water resources. To manage available water resources efficiently, seawater desalination units must operate to fully meet the water needs and prioritize supplying water for domestic, tourist and commercial use, the irrigation of permanent and high-yield plantations, and the maintenance of agricultural production at the necessary levels. In addition, they should be able to minimize the existing water balance deficit. Furthermore, each dam's annual water supply should be limited to 80% of the yearly average water inflow of the last 30 years to avoid water shortages. This will ensure a continuous supply of water within tolerable limits. It should also be restored measures to save water and reduce waste and use of lower quality water. In contrast, the state's use of recycled water should be promoted by taking appropriate measures to encourage irrigators. Simultaneously, the collection of hydrological data on dams and rivers should be continued and intensified to provide the necessary information and data for the proper planning of existing projects and the planning of new additional projects.

Finally, the training of scientific and other staff of the WDD and other departments on water resources management, water-saving, and the operation and maintenance of water projects, including desalination, should be part of the proper administration of water resources.

2.3 Cyprus Rural Development Program

The RDP strategy aims to serve a General Objective: "the adaptation of Cyprus Agriculture to the new economic conditions and the increase of the environmental challenges created by climate change". This general Objective is served by three interrelated specific goals, which are:

- Improving the competitiveness of agri-food products
- Sustainable management of natural resources
- Improving the vitality of rural areas

Improving competitiveness concerns not only the economic dimension but also the environmental sustainability of Cyprus Agriculture. Therefore, it is necessary to give significant financial weight in restoring, conserving and strengthening agriculture and forestry-dependent ecosystems, and promoting resource efficiency and supporting the transition to a low carbon economy with resilience to climate change. The interventions will aim to meet biodiversity conservation targets, improve water and soil management, and more energy-efficient use in agriculture and livestock.

The RDP 2014-2020 is structured in the following six (6) Priorities:

Priority 1: Knowledge Transfer and Innovation

Focus Area 1A: Promote innovation, cooperation and foster the growth of knowledge in agricultural areas;

Focus Area 1B: Reinforce ligament between agriculture, food production, forestry, research and innovation;

Focus Area 1C: Promote agricultural and lifelong forestry learning and vocational training.

Priority 2: Farm Viability and Competitiveness

Focus Area 2A: Amelioration of the farm's financial performance and facilitation of the farm's restructuring and modernization;

Focus Area 2B: Facilitating adequately skilled farmers' entry into the agricultural sector and generational renewal.

Priority 3: Food Chain Organisation and Risk Management

Focus Area 3A: Improving the competitiveness of primary producers by better integrating them into the agri-food chain;

Focus Area 3B: Supporting farm risk prevention and management.

Priority 4: Restoring, Preserving and Enhancing Ecosystems

Focus Area 4A: Restoring, preserving and enhancing biodiversity;

Focus Area 4B: Improving water management;

Focus Area 4C: Preventing soil erosion and improving soil management.

Priority 5: Resource-efficient, Climate-resilient Economy

Focus Area 5A: Increasing efficiency in water use by agriculture;

Focus Area 5B: Increasing efficiency in energy use in agriculture and food processing;

Focus Area 5C: Facilitating the supply and use of renewable sources of energy;

Focus Area 5D: Reducing greenhouse gas and ammonia emissions from agriculture;

Focus Area 5E: Fostering carbon conservation and sequestration in agriculture and forestry.

Priority 6: Social Inclusion and Economic Development

Focus Area 6A: Facilitating diversification, creation and development of small enterprises, as well as job creation;

Focus Area 6B: Fostering local development in rural areas;

Focus Area 6C: Enhancing the accessibility, use and quality of information and communication technologies (ICT) in rural areas.

Priorities 4 and 5 contribute to the management of agricultural production resources considered in this deliverable 5.8.3.

Regarding the improvement of water quality in Cyprus, the RDP measures proposed strengthening the implementation of restrictive standards. They aim at improving groundwater aquifers in nitrogen-sensitive areas, increasing the percentage of farmers who will use environmentally friendly agricultural practices, the increase of improved irrigation systems in crops that require high irrigation needs, the possibility of utilizing water from sewage treatment plants for irrigation purposes and the spatial concentration of livestock units and greenhouses suitable for the implementation of collective investments. Also, there should be exploited opportunities through the performance of the RDPs, arising from the use of solar energy in farms, the full implementation of the Water Directive and the introduction of pricing, the possibility of utilizing investment measures to implement collective investments in water use, the joint assets of livestock units for the installation of water treatment systems, the utilization of ICT applications and the adoption of modern irrigation techniques, the climatic conditions that favor the use of RES, the spatial concentration of suitable livestock farms and realization of collective investments, the coverage of basic needs of modernization of the agricultural holdings in Cyprus. All the above will allow the better targeting of the investment measures to reduce nitrogen oxide and methane emissions from agriculture. Besides, it should be mitigated the weaknesses arising from the increased number of livestock units with lack of wastewater treatment facilities, the high consumption of groundwater resources leading to soil degradation, the limited use of closed hydroponics systems in greenhouse crops, the limited use of integrated water management information systems, the limited use of solar / wind energy in groundwater abstraction for irrigation due to the great depth of conception, the increase in energy consumption in agriculture and the food industry and the significant shortages in R&I results for the utilization of sustainable energy resources in the agri-food sector. In addition, it should be eliminated the risks expected from insufficient irrigation and the continuing depletion of available water supplies, the intensification of water scarcity due to climate change, the continued abandonment of agricultural land, the non-prohibition of drilling, the limited interest to participate in agri-environmental measures, the delay in the implementation of Management Plans' measures provided in the Water Directive and from the lack of investment interest in the performance of investments.

Regarding priority 4, "Restoration, conservation and strengthening of ecosystems dependent on agriculture and forestry," it is considered necessary to include actions that will aim at more efficient management of water resources and groundwater aquifers, which have already been degraded due to practices applied. For this purpose, there will be included actions to expand agriculture and livestock, reduce inputs to chemicals and pesticides for crops and proper management of livestock waste, especially in areas that have been identified as sensitive to nitrate pollution. The shift to more environmentally friendly agricultural practices, combined with agri-environmental measures, is expected to reverse the growing and the adverse scenario created.

Regarding Priority 5, "Promoting resource efficiency and supporting the transition to a low-carbon economy with climate change resilience," promoting the use of recycled water while constructing distribution networks is expected to reduce water demand drawn from boreholes and will contribute substantially. The adoption of innovative technology in monitoring irrigation water consumption is also likely to contribute to the more efficient use of available water for irrigation.

Through the measures of PAA 2014-2020, an effort is made to protect and properly manage the available quantities of water, aiming to reduce the effects of the phenomenon of low rainfall in agriculture as major water shortage problems are created and have an impact on both productions and in the preservation of crops.

The primary measures concerning actions for the proper management of water resources in Cyprus are presented below, as mentioned in the Cyprus Rural Development Plan.

MEASURE 1: knowledge transfer and awareness actions

The Measure aims at the vocational training and the enrichment of knowledge and experiences of farmers and foresters. The measure includes the following three schemes:

Scheme 1.1: Vocational training and skills development actions

Through the Scheme, the Department of Agriculture will implement training programs for both existing farmers and young first-time farmers. The training programs will take the form of courses, workshops, online courses, and demonstrations. They will include farm management, agricultural accounting, production planning, marketing, packaging standardization and marketing of agricultural products, and environmental protection issues. In addition to the above, training programs will be offered special topics such as organic agriculture, irrigation, and water-saving, proper use of pesticides, tackling climate change, cross-compliance and specialized programs in various industries.

Scheme 1.2: Information and demonstration actions

The Department of Agriculture carries out information activities to disseminate information on agriculture and forestry, aiming at transferring knowledge to the beneficiaries about their professional occupation. The information is provided through exhibitions, meetings, presentations and printed or electronic forms. Under the Scheme, demonstration activities present new technologies, improved machinery, new cultivation practices and crop protection. Demonstrations take place either on farms or in another suitably landscaped area.

Scheme 1.3: Short-term exchanges for the management of agricultural and forestry holdings and forests as well as visits to farming holdings and forests

Under the Scheme, exchanges and visits of farmers and foresters to farms abroad are financed to enrich the participants' knowledge of good practices used in other countries and be informed about specialized practices followed in other countries.

M1 plays an essential role in raising awareness and informing farmers about the proper and appropriate use of fertilizers and plant protection products. Through the actions of M1, stakeholders are fully informed about the obligations and benefits arising from the rational use, thus helping significantly in gaining environmental awareness and awareness about the issue.

MEASURE 4: investments in material assets

M4 is one of the essential Measures of the Rural Development Program 2014-2020 as it covers the broadest range of investments in the agri-food sector of the place. The agri-food sector is characterized by severe competitiveness problems arising mainly from the sector's structural problems in combination with the existing environmental, climatic, and geophysical constraints. The measure includes the following three schemes:

Scheme 4.1: Investments that improve the overall performance and viability of farms

The Scheme supports investment in livestock farms, aiming at modernization, improving competitiveness and environmental performance.

Scheme 4.2: Investments related to the processing, marketing and development of agricultural products

The Scheme aims to strengthen existing and new companies active in the processing and marketing of agricultural products.

Scheme 4.3.1 Spatial livestock development

The Scheme finances the creation of the necessary infrastructure for the development, modernization, and adaptation of livestock, including access to livestock land and electricity and water supply. Investments fall into the following three categories:

A. Infrastructure projects for livestock areas (exclusively cattle, sheep, and goats)

B. Infrastructure projects in livestock zones

C. Non-productive investments for landscaping within livestock areas

Scheme 4.3.2 Investments in water-related infrastructure

The Scheme strengthens the creation of infrastructure for inclusion in the water balance of recycled water of tertiary treatment to save freshwater quantities. The eligible types of investments are:

- Construction of new recycled water supply infrastructure, expansion/improvement of the existing infrastructure of the irrigation network that will supply recycled water,
- Construction of infrastructure for storage of recycled water

Scheme 4.3.3 Application of innovative technologies in irrigation projects

The Scheme will strengthen the installation on a pilot basis of an intelligent software system for monitoring/evaluating the operation of the largest water project prepared by the Republic of Cyprus. This measure concerns the Southern Pipeline Plan consisting of dams, water refineries, central drainage pipes and irrigation networks in Limassol, Larnaca, and Famagusta. The beneficiary of the Scheme is the WDD.

In this measure of investments (M4), several eligible actions have been included, used in proper water management and saving, such as, e.g., water tanks that collect rainwater. Besides, it is planned to construct recycled water diversion pipes and other projects to improve water use in specific agricultural areas. Thus, it is achieved savings in terms of water quantities in groundwater aquifers.

MEASURE 10: Agricultural and climate measures

The most crucial measure in the RDP is Measure 10 since it is the Measure with the highest budget (utilizes 24.7% of the Program's resources). At the same time, its contribution to achieving the Environmental objectives of the Program is significant. The Measure aims to fight environmental problems arising from farming activities where possible and mitigate ecological impact actions. The main objectives of the Measure contribute to the preservation of the environment and the mitigation of phenomena that intensify climate change. Measure 10 is a remarkably complex Measure that includes the following sub-categories of actions:

Scheme 10.1.1: Exclusion of the use of chemical herbicides in specific crops

Scheme 10.1.2: Application of crop rotation in the cultivation of potatoes and cereals

Scheme 10.1.3: Targeted agri-environmental actions in the cultivation of potatoes and citrus fruits

Scheme 10.1.4: Maintaining environmentally friendly banana farming practices

Scheme 10.1.5: Reduction of irrigation water requirements at the aquifer level

Scheme 10.1.6: Protection of natural vegetation and landscape features for biodiversity purposes and erosion reduction

Scheme 10.1.7: Maintenance of existing dry wells within agricultural parcels

Scheme 10.1.8: Agri-environmental obligations for conservation and sustainable use in traditional vine varieties

Scheme 10.1.9: Agri-environmental obligations for conservation and sustainable use in traditional animal breeds

Scheme 10.1.10: Management of bee colonies to maintain harmonious coexistence with insectivorous birds

Scheme 10.1.11: Environmental actions in Areas of High Natural Value

Scheme 10.1.12: Voluntary program of integrated management of pests and diseases in wine and table vines.

Scheme 10.1.13: Application of fire protection treatments in woodland areas cultivated with cereals.

Scheme 10.2: Support for the conservation and sustainable use and development of genetic resources in agriculture.

Especially important schemes of Measure 10 concerning water are:

Scheme 10.1.1: Exclusion of the use of chemical herbicides in specific crops

10.1.1A Exclusion of the use of chemical herbicides in deciduous trees

10.1.1B Exclusion of use of chemical herbicides in olives

10.1.1C Exclusion of use of chemical herbicides in citrus fruits

10.1.1D Exclusion of use of chemical herbicides in traditional landscape crops

10.1.1E & 10.1.1Z Exclusion of use of chemical herbicides and Branch net in the vineyards

The promotion of mechanical control of weeds, instead of chemical pesticides, in every significant crop, is expected to contribute significantly to the reduction of runoff from agricultural holdings while contributing to surface water conservation's good ecological status. In this context, it is included the usual practice of soil incorporation or topsoil. This can significantly reduce evaporation while also improving the ability of the soil to retain moisture.

This scheme forecast the application of any method of mechanical weed control (Soil treatment with a depth of at least 3cm – Cutting with a lawnmower or long scythe/blade – Weeding/weaning – Ground cover under the canopy of trees), the application of targeted fertilization according to the relevant table of primary nutrients of the scheme, throughout the germination cycle and the complete exclusion of the use of herbicides. Also, regarding the vineyards, it is possible to choose the action of the pruning around the perimeter of the vineyard (1,5 meter) and soil conservation around the vineyard free of weeds using mechanical means (of limited depth, soil treatment, cutting with a lawnmower or long scythe/blade, weeding).

It is also planned to keep a farmer's file for the above cultivation practices in deciduous crops (except almond trees and hazelnuts), olive, citrus, traditional landscape (almond trees, locusts, hazelnuts, agro-roses - Rosa damaskina) and vine.

The amount of aid for the implementation of the eligible actions is:

A. Deciduous – €500 / hectare

B. Olives – €300 / hectare

Γ. Citrus Trees – € 225 / hectare

Δ. Traditional landscape crops – €320 / hectare

E. Vineyards – €600 / hectare for the action of mechanical control

and €80 / hectare for the action of the branch clean

Scheme 10.1.5: Reduction of irrigation water requirements at the aquifer level

The scheme aims to replace irrigated areas with citrus trees, in their formative stage, with specific crops with lower water needs in the communities within the aquifers of Polis Chrysochous and Western Mesaoria. The obligations arising for the farmer under the scheme are:

1. Replacement of irrigated areas with citrus trees, which are in their formative stage, with specific crops with lower water needs.

2. Rooting of citrus trees that are in their formative stage. The pieces must be irrigated exclusively by licensed drillings.

3. Planting new crops with olive or locust or prickly pear plantations or other crops specified by an official announcement.

4. Existence of a water meter on the plot of land.

5. Control of the quantity of water consumed on the plot. In the case of olives and locusts, the amount of water should not exceed 4300 km/ha, while in prickly pear, the 3000 sq.m. / ha. The maximum quantity of water for new crops specified by an official announcement will also be specified in the official notification.

6. Keeping a farmer's file where the farmer's activities related to the scheme will be reported.

7. Use an improved irrigation system, with maximum possible water savings according to the type of crop, if that new crop is irrigable. Specifically, for cultivating olives and locusts, farmers can apply improved drip or sprinklers irrigation systems. In contrast, for the cultivation of prickly pear, farmers can use improved drip irrigation systems.

The amount of aid for the implementation of eligible actions come up to € 400 / hectare.

Scheme 10.1.12: Voluntary program of integrated management of pests and diseases in wine and table vines.

The obligations of the farmer regarding the scheme 10.1.12 are:

1. Awareness of the plantation's biological condition: Laboratory virological control of the vineyard for awareness of the farm's natural state. One hundred stumps/ha should be tested for GLRV-1 and 3 GLRV-3.

2. Management of the population of Eudemida (Lobesia botrana): Use of appropriate mating disruption to keep the community of Eudemida low throughout the growing season. the beginning of flowering (early March) until the end of the harvest period. The minimum number of traps/ha must be 500 throughout the above interval.

3. Maximum permissible number of plant protection product applications: The maximum permitted several applications with conventional plant protection products and sulfur powder is 6 and 4 for table and wine varieties, respectively, throughout the growing season. The restriction does not apply to plant protection products that are allowed to be used in organic farming, except for sulfur powder.

4. Use of certified propagating material: if stump replacement is required on existing plantations, it must be used as a licensed propagating material, or material falls into the ‘Standard’ category. In the case of the 'Standard' category material, the farmer must provide, within the year of the replanting, laboratory results from the Department of Agriculture or other authorized body, proving that the material is free of the following viruses: GLRV-1 and GLRV-3.

5. Controlled use of nematocide: Conventional nematocide is permitted only after laboratory soil tests have been performed to determine the presence or absence of nematodes of the genus Xiphinema, which are carriers of viruses or other phytoparasitic nematodes, and the date of application of the nematicide.

6. Prohibition of conventional plant protection products characterized as "very toxic": The use of traditional plant protection products, which are described as "very toxic," are not allowed according to the Law on Chemicals of 2010.

7. Mandatory winter spraying application with broad-spectrum fungicide and insecticide: The application of a winter spraying with a licensed copper preparation and broad-spectrum insecticide achieves populations' conservation during the overwintering season.

8. Prohibition of the combination of plant protection products: It is prohibited the variety of plant protection products in any application or spraying. Please note that this restriction does not apply to plant protection products recommended to be mixed with preparations containing oil or adhesives, or other auxiliary substances. In addition, the combination of two pesticides is allowed, meaning that one has fungicidal action and the other has insecticidal action.

9. Limiting the re-use of pesticides of the same active substance or active substances with the same mode of action:

a. The use of an active pesticide may not be used more than twice per growing season.

b. It is not allowed to use active substances of pesticides with the same mode of action more than two applications per growing season.

The amount of aid rises to € 325 / ha for wine varieties and € 565 / ha for table varieties.

MEASURE 16: Collaboration

The Collaboration Measure aims to support Rural Development through activities that promote cooperation between various factors in the agri-food and forestry sector. It works together to implement innovation projects, with particular emphasis on cooperation projects that promote competitiveness, the environment and the transfer of knowledge, experience and innovation to rural areas and agri-food companies. Through the actions of M16, it is possible to apply pilot research applications to solve problems in matters of saving and proper management of Water Resources. The measure includes the following three schemes:

Scheme 16.1 Support for the establishment and operation of Business Teams

Scheme 16.2 Creation of new quality systems

Scheme 16.4 Short chains and local markets

2.4 Legislative framework

The European Union brought forward the rational use of water resources throughout Europe as a top environmental priority. For this reason, a large number of EU legislative initiatives are related to water policy. The following Laws mainly regulate the management of the water resources of Cyprus:

1. Water Management Act of 2010. (No 79(I)/2010). Every responsibility related to water resources management is concentrated with the enactment of the Law under one body (WDD).

2. Water Protection and Management Act 2003 (No. 13(I)/2004). Constitute the harmonisation of EU WFD, setting a European level framework for the equable protection and management of the EU's water bodies and water resources.

3. Evaluation, Management and Control of Flood Risk Act (No. 70/2010). Harmonization with Flood Directive 2007/60/EC of the European Parliament and of the Council of 23 October

4. Prevention and Control of Water Pollution (No. 106/2002). Harmonization with the Urban Waste Water Directive 91/271/EC

The most critical obligations arising from the implementation of the European acquis are the Floods Directive and the Water Framework Directive, which are already implemented in Cyprus.

Floods Directive 2007/60/EC

European Directive 2007/60/EC aims to establish a framework for flood risk assessment and management, aiming to reduce the harmful effects of floods on human health, environment, cultural heritage and related economic activities. It is an extension of Community legislation on water resources and has been designed to be compatible with WFD. The new directive covers every type of flood, whether it came from rivers and lakes, whether it occurred in urban or coastal areas, or as a result of storms or tidal waves. The main stages of implementation of the Directive are the following:

Stage 1: Preliminary Flood Risk Assessment and identification of High-Risk Areas for significant damages.

Stage 2: Preparation of maps with flood risk areas and risk management plans for a potential flood.

Stage 3: Develop measures to reduce the likelihood of flooding and mitigate the effects: damage prevention, protection of these areas and emphasis on public preparedness.

Water Framework Directive 2000/60/EC

The WFD is the cornerstone of European legislation regarding the management and protection of every water resource. Its goal is to properly manage and protect water resources and prevent further degradation of water. It is considered an innovative Directive because it treats water as an ecological good and at the same time, it involves the general public in the decision-making process.

Also, it provides guidelines for the preparation of Plans and Programs, aiming at achieving "good ecological status" for water resources, with a final milestone in the full implementation of the objectives in 2027.

According to WDD estimations, nowadays, only 50% of Cyprus' water bodies are in good condition. There are serious problems such as over-pumping of water into groundwater aquifers and future threats such as the effects of climate change, tourism and water pollution from the use of chemicals in agricultural activities, livestock waste, landfills, etc. The Directive helps to address the above problems effectively as it creates an appropriate water management system, ensures pollution control from every source and requires water-pricing policies according to which the one who pollutes or over-consumes water pays the corresponding cost.

Directive 91/271

Urban wastewater is managed and processed following EU Directive 91/271 and incorporated into the Environmental Law of Cyprus. The Directive concerning biological wastewater treatment defines the minimum necessary technical infrastructure in sewerage networks and wastewater treatment plants of the EU's cities and settlements. Structures and facilities should be proportionate to the equivalent population and recipient of the processed wastewater. They should distinguish water recipients to which urban sewage ends up in three categories: standard, sensitive and less sensitive. It also sets the maximum permissible limits of processed wastewater quality characteristics to be achieved at the effluents of wastewater treatment plants. At the same time, it provides specific time limits within which the settlements must complete the infrastructure required in each case for the collection, processing and disposal of their urban wastewater. It provides for the construction and operation of sewerage networks and wastewater treatment plants in cities and settlements, depending on their population and final recipient. Emphasis is placed on issues related to waste reuse, sludge management, and energy utilization.

Directive 91/271/EEC, in addition to the provisions for collection and processing, requires the systematic monitoring and recording of the effluents' quality in wastewater treatment plants before their disposal. Through the competent Environment Agency, Cyprus is obliged to send a biennial report to the EC on the country's compliance rate with Directive 91/271/EEC requirements. Consequently, the services, which are responsible for the operation of the wastewater treatment plants, are obliged to inform the Environment Service about the achievement or not of the discharge limit values set by the Community Directive (91/271/EEC) and the corresponding

Cypriot Legislation (RAA 772/2003), as well as to plan and implement the necessary interventions for the optimal operation of the facilities.

Urban wastewater channelled into sewerage networks, before their disposal, must undergo secondary treatment. Before their removal in sensitive areas, urban sewage discharged into sewers must submit in a stricter treatment, for every discharge from settlements with Equivalent Population over 10000 inhabitants'. Urban wastewater discharged into coastal waters from territories with E.P. between 10,000 – 150,000 inhabitants or in estuarine waters from domains with E.P. between 2000 – 10,000 inhabitants can undergo less rigorous treatment if discharges occur less sensitive areas, under two conditions. The first condition stipulates that releases are subjected to primary treatment under control procedures. The second specifies that these discharges do not adversely affect the Environment, based on integrated studies. The Member States shall ensure that urban wastewater treatment plants must be designed, constructed, operated and maintained in a way that provides adequate performance under every normal local climatic condition. Also, during the designing of the plants, it must be taken into account seasonal load fluctuations.

Directive 2006/11/EC on dangerous substances

The Directive concerning the pollution caused by certain dangerous substances discharged into the Community's aquatic environment has replaced Directive 76/464/EC. The directive poses rules for protecting and preventing pollution caused by the discharge of hazardous substances into the marine environment. It also determines the water quality standards, i.e., the limit values for the concentration of importance in the water and the maximum permissible amount of a substance during discharge.

The Directive requires Member States to eliminate pollution caused by the discharge of various dangerous substances listed in Index I of the Directive and reduce water pollution caused by substances listed in Index II of the Directive.

Water Pollution Control Laws and Regulations

The Law concerning the Control of Water Pollution (No. 106/2002) provides for the elimination or reduction and control of water and soil pollution to protect natural water resources, the health and well-being of the population, as well as to protect and improve the environment, fauna and flora of the waters. Within this law framework, the state ensures a continuous and effective control of water quality to maintain them within the quality standards set by law. Penalties are assessed for those who cause or tolerate water pollution and to prevent and deal with nitrate pollution, and there are required measures. There are issued instructions for this purpose, and the Minister takes their actions for CAP’s effective implementation. Any facility that may cause pollution of water and soil is prohibited unless the operator holds a waste disposal permit following this law's provisions. The facility of the facility is obliged to comply with the terms of the waste disposal permit to ensure their safe disposal and protect the environment. Finally, within this law framework, special provisions are set for integrating pollution for specific categories of polluting installations.

The Water Pollution Control (modifiable) Law of 2005 concerns the enactment of detailed procedures for informing and consulting the public. In this context, the public can present views, which are taken into account in the final decisions.

The Water Pollution Control (Urban Wastewater Disposal) Regulations (RAA 772/2003) impose the controlled disposal of urban wastewater to minimize the effects of their discharge into water or soil. According to these regulations, municipal wastewater treatment plants must collect incoming and outgoing wastewater before their release. These requirements are more stringent in cases where sewage is discharged into sensitive areas. Through the terms of the relevant rejection permit, issued by the competent Minister, the application of legislation’s requirements is ensured. Finally, these regulations define the methods of monitoring and evaluating the unit's entire operation to ensure the achievement of the legislation's needs and protect the areas that receive the processed wastewater.

The Water Pollution Control (Nitrogen Pollution of Agricultural Origin) Regulations of 2002 (RAA 534/2002) aim to prevent and reduce water pollution caused directly or indirectly by nitrates ions of agricultural origin. These regulations set out the criteria for determining polluted or potentially vulnerable water and identifies susceptible areas. Also, there are defined measures included in CGAP, taking into account the prevailing conditions in the country's various regions to reduce nitrate pollution.

The Water Pollution Control (Use of Sludge in Agriculture) Regulations of 2002 (RAA 517/2002) aim to regulate the use of sludge in agriculture to avoid harmful effects on the soil, vegetation, animals and humans while encouraging its rational use. According to these regulations, sludge from urban wastewater treatment plants may only be used in agriculture by these regulations' provisions and only if it has been adequately treated. There are mentioned the cases in which the use of sludge is prohibited and the permitted concentrations of heavy metals that it may contain. The limited concentrations of heavy metals in the soil and the limited concentrations introduced into the cultivated soil are determined. There are analyzed the elements that must be taken into account when using the sludge. There are set producers' obligations, and it is critical analysis and sampling of the sludge and the soil in which it is used. Finally, the penalties imposed on those who do not comply with these regulations' provisions are determined.

<u>DIRECTIVE concerning the protection of waters against pollution caused by nitrates from agricultural sources (91 / 676 /EEC)</u>

The Nitrates Directive aims to protect water from nitrates from agricultural sources, which are the primary source of diffuse pollution. The Directive requires the Member States to identify already contaminated water or those who may be contaminated with nitrates. It is also necessary to designate all areas from which contaminated water flows as "vulnerable areas", to develop action plans within vulnerable zones and to monitor, evaluate and review action plans, as required, to achieve the objectives of the Directive. In order to protect water from nitrate pollution, the directive requires the Member States to adopt CGAPs to be implemented by farmers voluntarily. Action plans for vulnerable areas should include the measures needed to limit the use of nitrogen fertilizers in soils and provide information and training for farmers.

<u>CGAP</u>

CGAP aims to guide those engaged in farming activities to avoid or minimize environmental pollution with unnecessary and unnecessary amounts of fertilizers and fodder waste, in addition to setting environmentally good sludge generated by municipal waste treatment. Regarding recycled water in agriculture, the CGAP states that this should come from treatment plants, which operate by the legislative and comply with the granted permit. Simultaneously, the irrigation methods and the measures must be taken for the irrigation in tree crops, vegetables, and vegetables that are eaten cooked. Similarly, in using generated municipal waste mud, its origin must be from treatment plants, which operate following the legislation and comply with the terms of the granted permit. Besides, there is persistent storage’s mud manner of storage, the rate of its application and the soils in which its use should be avoided.

2.5 Evaluation of existing legislation for water resources management

During the last decades, at the European level, a wide range of legislation has been adopted, composing the modern European environmental model, the framework of which is reflected, among other things, in the respective ecological action plans.

Thematic strategies for specific sectors as a perception of EU environmental policy sector issues introduce a more long-term approach to setting clear ecological objectives with a particular time horizon. Water as a natural resource is no longer treated piecemeal in light of the production activities that depend on it or in dealing with specific pollutants that burden it, as a single environmental component that must be fully managed to be protected qualitatively and quantitatively. Water is not a marketable commodity but a public good of utility. In any case, access to water cannot be uncontrolled. It requires prudent management to satisfy its many and often conflicting uses. Achieving careful management requires an integrated approach that does not address the respective benefits in fragments but in interdependence.

The implementation of the aforementioned environmental policy of the thematic strategies is reflected at the institutional level in three basic Directives concerning:

a. management and protection of inland (ground and surface), transitional and coastal waters (Directive 2000/60/EC "establishing a framework for Community action in the field of water policy"),

b. in the management and protection of marine waters [Directive 2008/56/EC on a framework for Community action in the field of marine environment policy (MSFD)] and

c. in flood risk assessment and management (Directive 2007/60/EC "on flood risk assessment and management").

The Directives mentioned above are legislative tools or otherwise, the main body for dealing with water management as a whole; they operate cooperatively and are supplemented by individual Directives. The management of water resources in Cyprus is aligned with the strategic objectives of the Global Agenda 2030 for Sustainable Development insofar. The last ones reflect the goals of EU environmental legislation, emphasizing the broader purpose of European Water Policy to ensure that European citizens have access to good quality and sufficient water (Sustainable Development Goal 6).

Actions that concern management and protection of the aquatic environment are part of the Ministry of Agriculture, Rural Development and Environment's broader program of development interventions. They take into account, among other things, adaptation to the effects of climate change, tackling extreme floods and water scarcity, upgrading the quality of life (with wastewater management projects) and strengthening environmental governance mechanisms and institutions by recording and publicizing ecological information. Furthermore, water resources management incorporates practices & interventions to enhance supply through the design, implementation and optimal operation of infrastructure projects and manage demand, through water conservation and reuse measures, in close connection with environmental objectives and the protection of ecosystems related to water resources. The components of water supply and demand are influenced, among other things, by the pricing policy for the water services provided. The latter is an economic management tool introduced by the WFD and subsequently became an institutional obligation at the national level.

The rational management of water resources requires developing and implementing a coordinated and complete legislative framework to meet environmental, social and economic criteria. Such a framework is Directive 200/60 of the EU, aiming to protect surface waters, groundwater and coastal waters. Also, the Community directive's main objective is to provide the necessary quantities of water to meet current needs focusing on the sustainability of water resources without further degradation of the environment and the simultaneous prevention and response to extreme weather events such as floods and drought.

The main axes of the new framework directive on water resources are the organization for the management of water resources starting from the river basin, the strict environmental standards, the costing of water based on the real cost, the emphasis on terrestrial and aquatic ecosystems, the sustainable management and protection of available water resources through long-term acts and actions and the reduction of the effects of drought and floods.

Emphasizing managing demand for water resources through rationalizing consumption and exploiting potential for reuse and recycling combined with appropriate costing and pricing methods is now imperative to ensure resource sustainability and society access to ecosystems' services and resources.

EU water policy has successfully contributed to the protection of Cyprus' water resources. The draft water conservation plan for Europe aims to address the obstacles to slowing down Europe's water resources and builds on an extensive assessment of existing policy. It is based on a wealth of information and analysis, including the EEA report on the state of the water, the evaluation of Member States' river basin management plans and the review of water and drought policy carried out by the Commission, as well as the assessment of the adequacy of the EU freshwater policy. Emphasis is placed on vital issues, including improving land use, tackling water pollution, increasing water mass efficiency and resilience, and improving governance by those involved in water resources management.

Over the last thirty years, the EU water policy has been successful in protecting water. Pollution from urban, industrial and agricultural sources is regulated, resulting in significant improvements in European water quality. Cyprus's current legal framework for water is extensive, flexible and effectively suitable for dealing with the problems faced by the aquatic environment. However, there is a need for better implementation and increased water policy objectives into other policy areas, such as CAP. The reasons for the current insufficient levels of performance and integration are complex. They include several water management problems related to inefficient use of financial resources, lack of support for specific measures, poor governance and knowledge gaps.

3 THE ENVIRONMENT AND THE CONDITIONS FOR SUSTAINABLE MANAGEMENT OF WATER RESOURCES WITH EMPHASIS ON LIMITING ABUSE OF GROUNDWATER AND IMPROVING THE EFFICIENCY OF IRRIGATION SYSTEMS

3.1 Introduction

In the Mediterranean, and especially on the islands, water is used in an unsustainable way. The environment is ecologically fragile and the prevailing social and economic trends are dangerously testing it. The Mediterranean area's future may be threatened by the increasing pressure on coastal areas, resulting from the continual narrowing of differences between tourist and rural areas, significant interdependencies of water resources, high sensitivity to pollution, and easily reversible balance between water and soil. Soil is extremely vulnerable to erosion and the resulting problems combined with water resources development (sediment deposition in reservoirs, riverbanks' stability, etc.).

The reduction of available water reserves is due to natural and fabricated factors, which are mainly climate change, unequal and unreliable spatial and temporal distribution of water, as well as poor management of water resources and inefficient implementation of a single water policy. In addition, the growing tourism causes an intense seasonal demand for water with the result that the problems of wastewater management are multiplied by the increase of the urban population during the summer period. Furthermore, irrigated agriculture consumes large amounts of water, ranging from 60-80% of available water resources.

The rational management and use of irrigation water are of utmost importance so that the agricultural sector can meet modern society's requirements. The farm sector's primary orientation in the near future should be the improvement of the management and the rational use of available water resources to ensure the adequacy and equality to every producer. Consequently, agricultural production should increase, through the improvement of techniques, the modernization of cultivation practices and irrigation methods, which should contribute to the overall increase of farm incomes to ensure natural resources sustainability.

This chapter will analyze the environment and the conditions for sustainable management of water resources in Cyprus. Particular emphasis will be placed on reducing groundwater abuse, controlling and reducing surface and groundwater pollution, as well as improving the efficiency of irrigation systems. Also, there will be mentioned measures to promote efficient and sustainable water use, particularly those concerning demand management and support offered to farmers by creating various services to manage irrigation water properly. Finally, there will be evaluated the conditions of rational resource management.

3.2 The environment and the conditions for sustainable water resources management

Ensuring water adequacy to meet current and future water needs and balancing demand with available water requires a change of mindset and the implementation of a new strategic direction, which will recognize the limited availability of water, will reflect the real value of water, the need for economic viability and will ensure fair access to limited water resources. At the same time, it will focus on demand management and alternative water sources, will assess risk analysis and the effects of climate change and will ensure the quality of water resources and the environment. As a result, users need to use water more efficiently and in smaller quantities.

To have sustainable water resources management, the reduction and control of pollution from every source such as agriculture, industrial activity, urban areas, etc., must first be ensured. The reduction and control of pollution are achieved by strengthening Cyprus' legal framework and implementing the European provisions and directives, which concern the sustainable management of water and analyzed in the previous chapter.

In addition, water resources development projects must be designed, constructed and operated with respect for the environment. Barring to the technical and economic conditions, environmental, institutional and social impacts must be taken into account and must be carried out extensive Environmental Impact Studies. The main problems regarding water resources development projects seem to be the lack of an integrated method of approaching EIS projects, the lack of adequate technical and scientific knowledge infrastructure for the rational assessment of every environmental impact and the lack of recording and evaluation of projects during the construction and subsequent operation.

Two of the most critical conditions for sustainable water resources management are reducing groundwater abuse and improving irrigation systems' efficiency, presented in more detail below.

3.2.1 Restriction of groundwater abuse and groundwater over-pumping

Groundwater is considered a water source for domestic, agricultural, industrial, and other purposes and contributes to improving an area's economic and social conditions. They are naturally replenished through the filtration of precipitation in the rain, sleet, snow or hail, and excellent resources. Such a resource should be protected from degradation and chemical pollution, which is particularly essential for groundwater use for water supply for human consumption, groundwater-dependent ecosystems, and groundwater use for irrigation. Groundwater is the largest and most sensitive freshwater system in the European Union and a significant drinking water source for many areas.

Groundwater provides about 52% of the total water consumed in Cyprus. Thus, it is one of the principal reserves of freshwater, which has been exploiting for centuries to meet human needs and develop societies. However, groundwater is not an inexhaustible resource. Chronic water consumption at levels higher than their natural replenishment has created a significant deficit, reaching up to 40% of available groundwater reserves. The groundwater of Cyprus is under tremendous pressure and the pumping of groundwater at an intensive rate, which exceeds the quality of their renewal, can lead to their depletion. Especially during the summer season, the flow of surface water is reduced, while water requirements increase due to the greater need for irrigation crops and seasonal population growth due to intense tourism activity in the area.

Groundwater is fed by water that ends up on the surface from rainfall and manages to penetrate underground layers before evaporating. The percentage that penetrates is concentrated among rocks and moves slowly to the sea by gravity through underground paths. Along the way, groundwater can return to the surface through springs that supply surface water or remain in groundwater reservoirs. In this way, groundwater is a reservoir of water, which has been accumulated for centuries and is a renewable resource only insofar as their pumping does not exceed their annual replenishment by rainfall. Drilling wells and boreholes exploit it. In Cyprus, numerous drillings are estimated to draw more than 100 million m3 (approximately 150) per year from groundwater bodies. A total of 140million m3 per year is pumped from groundwater and springs, of which 30mcum constitute over-pumping. Three-quarters of groundwater is consumed for crop irrigation needs, while the rest is allocated for the water supply needs of the population, for livestock, tourism and industry.

The risks of groundwater depletion in Cyprus are analyzed below. First, the lack of drilling control mechanisms and the lack of coordination between services facilitate farmers' private drilling. The lack of collective irrigation systems leads to the exploitation of thousands of uncontrolled illegal wells and, consequently, over-pumping. Also, the unequal distribution of rainfall over time due to climate change contributes to groundwater depletion in Cyprus. When water comes with heavy rain, it does not manage to infiltrate the soil, resulting in a significant reduction in natural water tanks' enrichment. There is also a risk of groundwater depletion if the groundwater is exploited without prior assessment of natural water replenishment, resulting in overexploitation. Finally, inefficient groundwater management policy poses significant risks, as it results in the existence of crops with high water requirements.

In many cases, groundwater abstraction exceeds the limits of natural replenishment, and as each year, more water is pumped than replenished by rainfall, while the significant reduction in rainfall in recent years exacerbates the situation. This results in the fall of the groundwater level and thus requires water search at ever-greater depths. Simultaneously, dams' construction to retain surface water resources works negatively on the supply of groundwater aquifers below the dam, depriving the coastal aquifers of valuable water resources. The groundwater level in certain areas has dropped to 100m in the last 40-45 years, causing many wells' exhaustion and reducing the natural flow of springs and rivers.

The effects of groundwater over-pumping are the degradation of their quantitative and qualitative status, land degradation, and saltwater infiltration. When the pumping rate is higher than the aquifer's re-enrichment, the water horizon gradually descends below the sea surface, resulting in the reversal of the normal flow to the sea. In coastal areas, the reduction of groundwater's natural movement to the sea causes the inflow of seawater into the groundwater aquifers, making the water from the boreholes and wells in these areas brackish and unsuitable for use. This is the biggest problem concerning the degradation of the groundwater quality of Cyprus.

Significant groundwater problems can also be caused by overflow, which causes level rise. By surface methods using massive doses of irrigation, irrigation of this type results in an increase in the rhizosphere level and the creation of suffocating aeration conditions, salinity problems, and a reduction in production.

The effects of groundwater quality degradation concern the ecological status of surface waters. There is a reduction in the flow of rivers and springs and an indirect impact on biodiversity (e.g., in inland fish/freshwater) and the ecological quality of terrestrial ecosystems associated with the groundwater system. Soil degradation and an increased risk of desertification in some areas and an increase in nitrate concentration due to reduced natural replenishment and groundwater salinization are also observed.

Studies conducted to record groundwater reserves have shown that about 40% of the perpetually available groundwater reserves have been consumed. It has also been calculated that in order to maintain the water balance of each underground aquifer, the total water intake should be reduced to 82million m3 per year, which requires a reduction in pumping by about 40%.

The problem of over-pumping and its consequences is one of Cyprus's dominant issues and must be tackled effectively to ensure water's future adequacy. Due to the peculiarities of the island's geography and the pressures they receive from manufactured uses, the vast majority of Cyprus' groundwater systems have been characterized as critical by over-pumping. The phenomenon of salinization describes most coastal aquifers in Cyprus. The drilling of the vital aquifers' coastal zones in Cyprus has been abandoned since the water is not suitable for use.

The settlement of the groundwater over-pumping issue concerns the achievement of the WFD 's objectives. It aims at the good quantitative and qualitative condition of groundwater, the right ecological and chemical state of surface water, the excellent condition of protected areas and the adequacy of drinking water.

In order to limit the abuse of groundwater, it should be used water from renewable sources, while in case of pumping water from drilling, its use should comply with national legislation. It is recommended the use of a hydrometer for the supply of irrigation water. The water management plan should include special care for water in protected wetlands. It should also be harmonized with the national action plan to combat desertification, salinization zones, negative water balance and high erosion potential.

An important role occurs by reorganizing agriculture in Cyprus, based on the increased needs of industry in water quantities and the simultaneous issues of these quantities' availability. The process of selecting the most suitable crops is necessary. At the same time, the recent over-pumping case, on the other hand, deprives Cyprus of significant strategic water reserves, which are in danger of not being replenished. Therefore, either over-pumping should be reduced, or groundwater should be enriched with technically produced water (from sewage systems-recycled).

For better water management and savings, the irrigation of the plantations should be done with improved irrigation systems to ensure a high degree of efficiency, regularly inspect and maintain all equipment to reduce losses to a minimum and use irrigation schedules to determine the actual water needs of the plantations. The use of soil moisture measuring instruments, which will determine the time and amount of irrigation, is necessary. With proper installation and proper use, a large amount of irrigation water is saved. Irrigation should be avoided when strong winds blow and when high temperatures prevail, while open water tanks should be covered to limit evaporation. In addition, nitrogen fertilizers should be reduced to avoid wild vegetation, inefficient trees should be removed, fruit shoots should be reduced, plantations with high water needs should be avoided and the vegetation period should be adjusted where possible to reduce water needs. The collection and utilization of rainwater, especially in greenhouses, will help minimize groundwater abuse. Also, the full utilization of recycled water produced by natural urban wastewater treatment plants and the use of brackish water in durable plantations, grown on permeable and sandy soils, are essential measures. The water conditions that farmers have to deal with are among the worst in recent years, so everyone must realize that any action contributing to water-saving affects the present and the future state of affairs regarding the water balance of Cyprus.

In addition, the minimization of the waste of irrigation water can be achieved mainly by taking a series of measures. These measures concern both the training of young scientists in the rational management of irrigation water and the training of farmers in the proper implementation of irrigation with the assistance of the aforementioned expert scientists and the creation of mobile assessment units for irrigation.

The knowledge of the daily water needs of crops per region by creating networks of agro-meteorological stations is of significant importance and the experience of essential soil hydrodynamic characteristics of irrigated soils with the contribution of existing soil studies or the consultation of experts.

Waste in water will be minimized by charging for irrigation water according to the volume consumed and not based on the irrigated area or type of crop, combined with incentives for the water user to save water resources and disincentives for the waste user. Although water is a necessary commodity and therefore should be provided to citizens free of charge, evaluating and implementing a fair charging policy can give citizens incentives and disincentives to consume water. It will also provide municipalities with the necessary resources to upgrade existing and outdated water supply networks.

Also, the continuous restoration of the damages in irrigation networks, the modernization of the structures with devices for flow regulation and measurement, the application of telematics in the irrigation networks, and the conversion of open irrigation networks to closed ones under pressure will reduce waste. To alleviate the problem, leaks in the water supply networks should be reduced immediately. In several cases, the volume of water lost in the structures is about 30% of the water volume introduced into them (approximately 8mcum). IWA has established a water control accounting method that records and controls the quantities of water produced, monitors the quantities circulating and consumed in the network, and, finally, expresses these quantities in internationally recognized network efficiency factors, based on billed and non-billed amounts of water. Thereby, it is possible to effectively monitor the produced, distributed, and consumed water quantities in their network. It is also necessary to repair pipeline networks and implement practical and scientific tools for long-term and sustainable pipeline management. Any policy of renewal of old structures should be done rationally and based on a scientific approach, which considers the level of risk of leakage per pipeline, as evidenced by the channel's properties and operating parameters. The reorganization of the network structure should also be combined with the restructuring of the organizations' administrative system, with simultaneous modernization and introduction of new technology, computerization and automation of network management practices, and reduction of leaks.

Development and empowerment of water consciousness should be set as a priority by the state, the organized groups and the citizens themselves. However, citizens' awareness should be continuous and not occasional since the water issue is permanent on the island. The state has already taken several measures to develop or strengthen the citizens' water consciousness, in conjunction with the incentive policy. The systems adopted through these measures will save money and prove saviors if Cyprus's water shortage worsens and water cuts become more frequent and intense. However, strengthening or developing water consciousness can be combined with a system of "controlling" and imposing penalties, which aims to avoid wasting water to strengthen aquatic consciousness and not the punishment of offenders.

Minimizing the waste of water resources will save additional water resources for irrigation of dry areas and confront exceptional water scarcity periods. It will also be avoided the creation of saturation and salinity conditions in the root zone since the groundwater level will not rise dangerously in the valleys. Finally, it will be ensured the non-erosion of the soil surface layer, thus protecting soil productivity, reducing the cross-section of drainage ditches and flushing out agrochemicals (fertilizers) transported through ditches to the sea or through recycling of drainage water in irrigated lands.

On the other hand, a key measure is detoxification of the constantly changing climatic conditions. The main step is to remove from the "storage" strategy, followed by creating many dams and implementing a water "production" strategy. This shift should focus on increasing the volume of recycled water while increasing desalinated water to reduce Cyprus' dependence on rainfall and accumulated water reserves in dams. Particular attention should be paid to the energy consumed by a desalination plant, as well as the number of gaseous pollutants emitting into the atmosphere.

3.2.2 Control and reduction of surface and groundwater pollution from agricultural crops

Groundwater pollution from agricultural activities, in most cases, is diffused in the area. Low flow rates characterize aquifers and as a result, their decontamination time from pesticides and other pollutants is very long. Agricultural pollution levels have remained stable in recent years, in contrast to reducing pollution in other activities. There is increasing public awareness of the degradation of water resources from agricultural activities, mainly because it is associated with extremely dangerous substances to human health, such as pesticides.

Main pollutants from agricultural activities are animal effluents, salts contained in water used for irrigation, agrochemicals, which aim to increase agricultural production efficiency and protect its products from the action of harmful organisms.

3.2.3 Improving the efficiency of irrigation systems

Improving irrigation systems' efficiency in terms of quality, quantity, and cost reduction is an additional precondition for sustainable water resources management. Low efficiency of irrigation systems can be observed either at the level of water distribution or at the system level according to field studies conducted by WFO and the IIMI. Therefore, it is necessary to create a general framework for evaluating the efficiency of irrigation systems in order to improve its operation and management. In general, the evaluation of efficiency could be defined as the systematic observation, documentation, and interpretation of irrigated agriculture's relevant activities for continuous improvement. In contrast, the efficiency of irrigation programs is determined by physical, institutional and administrative factors and their interaction.

The efficiency evaluation program refers to the management of operating processes and the management and utilization of irrigation systems' available resources. It focuses mainly on causes that shape the efficiency's level and how to achieve it without considering the actions and processes that contribute to this level. The efficiency evaluation program also examines specific areas of irrigation management, such as the proper distribution of water to producers, and studies the results of agricultural production, which can affect the entire rural economy system. The ultimate goal of efficiency assessment is to develop efficient, productive and efficient irrigation and drainage systems, providing relevant management information at all levels.

The purpose of precision irrigation is the rational irrigation of crops scientifically and following the rules of precision agriculture aiming to optimize the use of water resources and the production of agricultural products. In particular, a precision irrigation system remotely controls crop irrigation. It adjusts according to available soil moisture, crop development stages, water quality and availability, taking into account current meteorological data and weather forecast. The recommendations offered are specialized per parcel, depending on the type of crop, type of soil, stage of crop development, irrigation system, quality and availability of water resources, soil moisture, weather forecast, etc. In addition, growers will receive from the system specialized alerts and instructions for impending severe weather.

A precision irrigation consulting system could provide a solution to optimize irrigation water use, which is an important input for many crops. The use of current data by local meteorological stations and the weather forecast will calculate the irrigation needs of each crop with specialized algorithms, regulate irrigation, reduce the risks of cultivation (plant damage), and use communication automatic irrigation sensors and controllers. The basic algorithm for calculating irrigation needs will be developed considering the crop's characteristics (age, stage of development, etc.), soil type, irrigation system, water quality and availability, and the latest irrigation data. Thus, users will be able to be informed via e-mails or SMS while simultaneously creating corresponding messages and giving commands to a specific solenoid valve for complete automation of irrigation.

There are observed significant losses in the water route, from the water pumping point up to the area where it will be used, depending on the network type. In Cyprus, water transport's average efficiency is estimated at 70% for water transported through earthen canals, 85% on channels lined with cement and 95% with pipes. Upgrading networks and converting them from open to closed channels can be an essential measure in minimizing transmission losses.

An irrigation system's efficiency is derived from the ratio of the water quantity consumed by a crop to the supplied water quantity. The irrigation method, i.e., the technique used to get the water to the plants' roots, is an essential factor of efficiency. For example, a drip irrigation system's efficiency reaches only 55%, of a sprinkler system 75%, while of a drip irrigation system dripping at the roots of plants to 95%. Modern irrigation systems will be able to increase efficiency up to three times. The use of such systems requires the corresponding training of users.

Additional measures that should be taken to improve the quality of raw water are the covering of tanks, the chlorination of networks, and new tanks for mixing water from different sources. It is also necessary to improve the efficiency of water treatment in Refineries. Regarding the improvement of the quantity of water, it is essential the installation of damage prevention valves in large pipelines, the reduction of leaks, the progress of the efficiency of pumping stations and the replacement of obsolete pipelines, but also the implementation of projects to serve new areas. Finally, it is vital to reduce costs by preventive maintenance of pumping stations and installing photovoltaic systems.

Modern irrigation systems have been used in the agriculture of Cyprus for the last 30 years. Due to the relatively high installation cost, the drip method was initially used to irrigate high-value crops, such as vegetables and greenhouse flowers. Subsequently, installation costs were reduced and the use of drippers, mini sprinklers and low flow sprinklers was extended to irrigate trees and vegetable fields. The new technology introduced is continuously tested by the ARI to evaluate the different systems under local conditions and select the appropriate irrigation method for each crop. With improved irrigation systems and irrigation design based on the ARI's experimental work, the overall water use efficiency at the farmer level is over 80%.

The use of improved irrigation systems has several advantages. First of all, improved irrigation systems result in significant water savings. Because transfer losses are eliminated and the area of irrigated soil is limited, it can be achieved 80% higher performances. Furthermore, productions are increasing. The crop's root always remains moist with modern irrigation methods and the plant doesn’t subject to pressure change. The necessary fertilizers can be applied with fertigation, whenever and wherever plants require it. Also, improved irrigation systems can be used on steeper slopes and problematic soils, which are otherwise unsuitable for conventional irrigation methods. Finally, with the enhanced irrigation systems, farmers' work is more manageable since they are used automatic measuring valves, electronic tensometers, computers, etc.

3.3 Measures to Promote Efficient and Sustainable Water Use

To achieve sustainable use of water resources should be launched actions that aim at a high level of environmental protection and public health, ensuring their availability for future generations and the economic and social system's prosperity. In this context, they are proposed the following:

- Crop restructuring study.
- Investigation of inclusion in the Register of Professional Farmers of all the inhabitants of the mountainous areas.
- Leakage reduction to 18% or 22% for urban areas and communities respectively in 2015.
- Promotion of water-efficient technologies in the industry.
- Preparation of masterplan of the external aqueducts of the water supply system
- Unified policy of sustainable rainwater management and implementation of the relevant proposals of WDD.
- Implementation of recycling water utilization projects promoted by the WDD to integrate recycled water into the water balance.

3.3.1 Demand Management Measures

To promote measures and targets to reduce water consumption from every use, the Republic of Cyprus pursues a demand management policy with significant benefits. Nowadays, measures have been taken, such as financial, communication, legislative and administrative, and technological, to ensure the sustainable use of water.

In this context, the WDD made a significant effort in various ways to inform consumers about water management issues, which should be continued. Also, it is suggested:

- The elaboration of a study of crop restructuring.

• The implementation of a system for measuring, recording and reporting the losses of Major Government Irrigation Projects.

• Utilization of the database of CAPO

• Addressing the issue of water network losses.

3.3.2 Creation of services for the benefit of the farmer for the proper management of irrigation water

The creation of certain services to the Cypriot farmer - irrigator would significantly improve irrigation water management with all the resulting benefits. In collaboration with Research Centers, Water Directorates and water management agencies are presented below the essential services that should be created primarily.

Initially, it is crucial to organize a program of continuous information - training users of irrigation water on issues related to its rational use, by specialized scientific staff. Equally important is creating mobile units that will evaluate the way water is applied in the field. It is also crucial to develop networks of agro-meteorological stations, which will inform (electronically) each interested body and irrigator about the daily consumption of water crops and the application right quantity of water in the field.

Quality control and evaluation of any irrigation supply's suitability should be mandatory, as it may adversely affect the quantity and quality of agricultural products, soil productivity, adjacent surface or groundwater resources, and people either as workers in irrigated fields or as consumers of agricultural products.

Finally, we must not underestimate that only a balance between water supply and demand at the level of a catchment or water body will ensure the sustainable management of water resources. A prerequisite for the sustainable management of water resources is the active involvement of all stakeholders, including non-governmental organizations and local authorities, in water management activities.

3.4 Evaluation of rational resource management conditions

In Cyprus, as in most Mediterranean countries, water is the most scarce resource of agriculture and therefore, it is necessary to manage, save it and preserve its quality correctly. It is expected the application of an innovative high-tech system for monitoring water consumption and the creation of infrastructure for inclusion in the water balance of recycled water of tertiary treatment, etc. Concerning water-saving infrastructure, the variables used to assess the ecological status and potential of surface waters (morphological conditions, nutrient conditions) may be adversely affected. The program's self-evident compliance with the strict permanent regulatory framework that protects the ecological supply of surface water will prevent possible changes at a strategic level.

The 4th Priority measures include a particular category of investments, according to which only environmental actions will be implemented in matters of management of agricultural and livestock waste, managing and saving of water resources, projects to prevent soil erosion, etc. In addition, by improving water management, it is possible to mitigate the weaknesses associated with vital livestock farms (lack of wastewater management facilities, high consumption of groundwater resources) and eliminate the threat related to the intensity of water scarcity phenomena due to climate change.

The 5th Priority measures, and in particular the increase of the efficiency of water use in agriculture, enable the mitigation of the weaknesses observed by the limited use of closed hydroponics systems in greenhouse crops and the limited use of IIS in the management of water. Furthermore, they contribute to eliminating the threats expected from the delay in implementing the Management Measures provided for in the WFD.

Nevertheless, indirect negative effects on water may occur as a side effect of changes in another environmental factor. For example, the regulations to restrain the excessive increase in fertilizer use, which are proposed in preventing effects on the soil, are also expected to avoid the occurrence of eutrophication or other alterations in water quality.

4 GAEP COMPATIBLE WITH THE CORRECT MANAGEMENT OF WATER RESOURCES OF AGRICULTURAL PRODUCTION IN CYPRUS

4.1 Introduction

GAEP is a system of guidelines to ensure minimum quality standards for the production and storage of agricultural products. GAEP is a series of methods applied in agriculture, which are linked to agronomic and environmental sustainability goals in the early stages of the food chain. Important issues managed under GAEPs are insect management and soil fertilization, water quality maintenance, crop hygiene, and control practices to collect, process, and transport products. These practices are considered particularly important for reducing food safety risks and the effective implementation of the HACCP system in the later stages of the chain.

The promotion and adoption of good agricultural practices are inextricably linked to the service of the objectives of the Europe 2020 Strategy on "Sustainable Development", the Flagship Initiative "Conservation and protection of the environment and the promotion of efficient use of resources" of the PA 2014 – 2020. In the framework of minimum agricultural activity, Cyprus preferred the strictest terms of the European framework. For all the areas declared in farmers' applications, it is foreseen that even if they are not productive, there will be annual actions, which will force the farmers to take care of their land. Therefore farmers will consider it in their interest to produce.

Since 2002, Cypriot farmers have been obliged to apply the CGAP described by the Ministry of Agriculture, Natural Resources and Environment, in the RAA 407 with number 3634 / 06-09-2002. These codes aim to guide those engaged in farming activities in order to avoid or minimize the pollution of the environment and its burden with excessive and unnecessary quantities of fertilizers and livestock waste. They also contribute to confronting problems created by the agricultural activity and the continuation of its positive functions. The CGAPs aim to establish environmentally acceptable conditions for recycled municipal wastewater produced for irrigation purposes and sludge produced from municipal waste treatment for agricultural purposes. Codes of good agricultural practice intervene in the whole range of agricultural and livestock activity and exceptional cases of areas or zones, which are part of special protection schemes. The aim of the observance of the CGAP is the dissemination of good agricultural practices and their correct implementation in the exercise of agricultural activity and, at the same time, the optimization of the use of EU resources.

Good agricultural practices respond mainly to the need to protect biodiversity, genetic resources and landscape, soil and water resources, and the provision of public goods by farmers. Biodiversity conservation is inextricably linked to agricultural activity. Farms often support wildlife, offering food, nesting sites or even hunting grounds. The survival of many fauna and flora species depends directly on the continuation of traditional forms of agriculture and animal husbandry. Biodiversity and genetic resources are proportional to the natural environment and agricultural history of each region. Cyprus, due to the variety of landscapes with unique microclimatic and topographic characteristics, the type of soil and geological substrates and the diversity of vegetation, forest and agriculture, contributes to creating a beautiful variety of habitats that meet the requirements of numerous species of wildlife.

Regulation (EC) No 1782/2003 established a framework for standards of agricultural land's good agricultural and environmental status. Based on this regulation, the Member States should develop national standards, which will take into account the specific characteristics of the areas concerned, such as soil and climatic conditions, the applied cultivation systems (land use, crop rotation, cultivation practices) and the structures of the holdings. These standards of good agricultural and environmental condition of agricultural land intend to prevent soil erosion, to preserve soil organic matter and soil structure, to ensure a minimum level of conservation, to prevent habitat degradation and to protect and manage water. Therefore, the broader scope of the cross-compliance system provided in this Regulation should include a framework within the Member States should establish national standards for good agricultural and environmental status. The EU framework should also include rules for better-confronting water, soil, coal storage, biodiversity and landscape issues, and the minimum level of conservation of agricultural land.

Through the RDP 2014-2020, a balanced allocation of resources is promoted to solve environmental problems and achieve the desired sustainability of economic and environmental systems. The interventions of the RDP 2014 – 2020 of Cyprus, among others, include the restoration, conservation and enhancement of biodiversity, in areas of Natura 2000 network, in areas facing natural or other notable disadvantages, in areas of agriculture of HNV, improving water management of fertilizers and pesticides, improving soil management and erosion prevention, reducing greenhouse gas emissions and especially ammonia, as well as maintaining and retaining carbon dioxide emissions in agriculture and forestry.

In particular, agricultural practices are aimed at the sustainable management of agricultural land and natural resources, the protection and preservation of the rural landscape and its characteristics, and the protection of farmers' and consumers' health.

CGAP that concerns the practice of agriculture exclusively focuses on specific agricultural activities: input management, soil treatment, crop rotation, fertilization, water resources protection, plant protection, wildlife management, crop residue management and waste management. The required good agricultural practices described by sector of activity anticipate, among other things, the conservation of biodiversity at its various levels. For example, concerning soil treatment, it is necessary, among other things, not to destroy the uncultivated margins between parcels, hedges, natural vegetation of ravines and adjacent forests, as well as to preserve natural streams, so that any interventions to change the course of streams will be allowed only with the permission of the competent department. About fertilization, the distance from water bodies and sources for the application of fertilizers is limited in a way that ensures public health and the health of wetland ecosystems. The CGAPs also emphasize the protection of water resources. At the same time, they focus on the safe use of plant protection products, not only for the protection of public health, directly and indirectly, but also for the conservation of biodiversity and its habitats. Some practices aim to preserve the native flora and associated fauna, while others help manage crop residues and waste in a way that is "friendly" to biodiversity.

The main axes of good agricultural practice are:

- the best water economy (protection of water resources),
- reducing soil erosion and desertification,
- limiting soil salinization and salinity of the aquifer,
- maintaining and improving fertility and soil structure,
- sustainable management of native flora and fauna (conservation of biodiversity, species and habitats),
- the preservation and improvement of the mosaic and structural features of the extensive rural ecosystems,

- reducing the residuality of plant protection products,
- reduction of pollution from agricultural fertilizers,
- proper management of crop residues, waste and livestock waste,
- the improvement of the quality and the certification of the produced products,
- the conservation of genetic resources,
- reducing greenhouse gas emissions,
- measures for protected areas (e.g., NATURA 2000 network),
- informing farmers on issues of Common Agricultural Policy and cultivation techniques.

More specifically, in terms of water resources, the increase in areas identified as vulnerable to nitrate pollution demonstrates the need to continue programs and actions that promote rational use of fertilizers and plant protection products.

Pesticides used extensively in agriculture to protect crops from insects (insecticides), fungi (fungicides) and bacteria (bactericides) and to control weeds (herbicides) pose a significant risk of groundwater pollution. Although the organic substances used as pesticides are rapidly degrading, significant quantities of them and their decomposition products are recorded in groundwater. Essential elements for the severity of agrochemical pollution are toxicity, amount and time of substance's stay in the soil, and the way they are applied in the soil.

Excessive use of fertilizers has been common in the Cypriot countryside in recent decades. Farmers, as for to intensify their crops, were using large quantities without prior investigation or study of the practicality of these actions and without the cooperation of experts. In combination with the shift to synthetic fertilizers, excessive fertilization characterized previous decades' agricultural activities. Widely used synthetic fertilizers are nitrogenous, phosphate, and potassium, which creates problems related to the soil's future exploitation and the effects on the broader ecosystem.

As an essential condition for agricultural activities that want to have sustainable development, which is also the primary goal of the CAP 2015-2020, is the rational use of fertilizers, the sensible application of sprays and the reasonable use of plant protection products. Sustainable management of agricultural ecosystems requires the implementation of best management practices, aiming to produce quality products at satisfactory yields and, at the same time, the protection of the environment. The main axes that govern this new trend are the increase of the cultivated areas' productivity, the improvement of the quality of the produced agricultural products, the minimization of the production costs and the protection of the environment.

This chapter will discuss preventive measures and alternative approaches or techniques for managing plant protection problems. In addition, reference is made to the general data for the correct application of pesticides. At the same time, they have examined the conditions for rational use of fertilizers concerning the use of irrigation water and the requirements for reasonable use of plant protection products and the rational application of sprays. Furthermore, there are presented the measures for the pesticides' safe use, concerning the transport and pesticides' storage, the user's protection and the ways of reducing the environmental imprint of the practices and the degradation of the environment. Simultaneously, methods for ensuring good quality, food safety and good agricultural practices are analyzed. Finally, it is examined the compatibility of the application of management practices about the CGAP.

4.2 Precautions - Alternative approaches or techniques for managing plant protection problems

The most critical measure of modern plant protection is the preventive actions that every farmer – grower must take in order to achieve the prevention and/or elimination of pests. Such measures are:

a) Crop rotation,

b) The use of appropriate cultivation techniques (e.g., preparation of seedbeds to break the dormancy of weed seeds and combat them, dates and sowing densities, co-cultivation with soil cover, maintenance ploughing, pruning and direct sowing),

c) use, where appropriate, of hardy / tolerant varieties and standardized/certified seed and planting material,

d) use of balanced fertilization, calcification and irrigation/drainage practices

e) preventing the spread of harmful organisms by hygiene measures (e.g., by regularly cleaning machinery and equipment);

f) protection and reinforcement of significant beneficial organisms, with appropriate plant protection measures or the use of ecological infrastructure inside and outside production sites.

Pests should be monitored with appropriate methods and tools. These proper tools should include on-site observations, Agricultural Warning Bulletins, and experts' advice.

Based on the monitoring results, the professional user must decide if and when to implement plant protection measures. The fundamental precondition for decision-making is fair and scientifically correct lower limit values. As for harmful organisms, before the application, it must be taken into account lower intervention thresholds, designated for the area, the specific locations, the crops and the specific climatic conditions, if possible.

Rational biological, natural and other methods without chemicals should be preferred instead of chemical methods, as long as they provide adequate control of pests.

4.3 General information on the correct application of pesticides

Only healthy adults should use pesticides and it should be paid special attention to the toxicity markings and instructions on the product packaging. Those handling pesticides must wear appropriate protective clothing and equipment, while long-wearing plastic aprons and goggles are also required for dense formulations. When working with pesticides indoors and when required by the instructions on the packaging of the preparation, it is necessary to use a protective mask. Protective clothing and equipment should be stored away from pesticides. In addition, the user is not allowed to eat, drink or smoke when handling pesticides. In contrast, immediately after any work with pesticides, it is necessary to wash hands very well with soap and water. Sprays and baits should preferably be used outdoors. Otherwise, there should be adequate ventilation of the area where the application took place. Pesticides mustn't be used in residential areas, stables or food or feed depots. Furthermore, the product or its packaging should not contaminate water and the equipment of the application should not be washed near-surface water. Immediately after the first symptoms of poisoning, any work should be stopped. The user should move away from the area where pesticides were applied, call the doctor immediately and remove the clothes soaked in spray liquid. At the same time, it is good to point to the doctor the pesticide packaging, indicating the antidote or treatment. In case of contact with the eyes, the user should wash them immediately with plenty of water and seek medical advice.

4.4 Conditions for rational use of fertilizers, depending on the use of irrigation water

Climate-Smart Agriculture is a prerequisite for ensuring food safety amid climate change, which is not possible without the use of fertilizers, which help increase production, adapt crops to new climatic conditions and achieve global food safety.

Proper application of fertilizers helps to adapt to new climatic conditions and reduce losses by contributing to crop growth, enhancing soil carbon sequestration rates, improving crop adaptability and water use efficiency, reducing nutrient losses to the environment, and the deforestation of forest areas.

There is a movement to a new era from indiscriminate and unplanned fertilization, where advisory fertilization plays a key role. Through advisory fertilization, it is possible to choose the right time to use the fertilizers, when the crops need it, to determine the fertilizer needs for each cultivated species more accurately and choose more accurately the kind of fertilizer. Nowadays, there is special software that helps agronomists even more to prepare fertilization-consulting programs. These programs combine the results of preliminary surveys and export various proposed fertilization models.

Advisory fertilization requires, on the one hand, an assessment of soil fertility by chemical analysis and, on the other hand, an evaluation of plant nutrient needs, mainly by foliar diagnostics. Unfortunately, the existing data of scientific research are incomplete in both cases. The analysis methods used nowadays to calculate the available soil nutrients have not been evaluated, nor have they been graded for every crop under the Cypriot agronomic environment. Thus, in many cases, the interpretation of the results is based on data from foreign literature. The same issue arises with the foliar diagnostics applied to tree crops. In the absence of sufficient scientific research data about Cypriot conditions, critical nutrient values have been adopted by foreign literature. Therefore, it is imperative and a national strategy of priority to adopt consulting fertilization, score all the analysis methods for every crop and find each nutrient's critical values under Cypriot conditions.

Soil analysis and foliar diagnostics are techniques that have been developed by expert scientists and allow them to draw up a plan for the use of fertilizers, depending on the conditions of each application.

Soil analysis provides useful information for the correct diagnosis of its fertility and productivity and can be the basis for applying rational fertilizers. The application of rational fertilization can be achieved when the concerned producer is aware of the soil's nutrient reserves, the nutritional needs of the plantation, and how to provide, anytime, the necessary amounts of nutrients to his plantation. Rational fertilization should be based on a scientific basis. The available nutrients do the fertilization in the soil and each plantation needs to regulate the fertilization tactics to be followed. The importance and significance of soil analysis are increasing due to intensification and automation of agriculture and the fact that types and forms of fertilizers are growing. Through the primary goal of analysis, which is the rational use of fertilizers, it is achieved by minimizing production costs, maximizing quality and quantity of production, the least burden on natural resources, and the maintenance of high growth rates. It is also reduced the risk of causing a severe imbalance between various nutrients and creating a competitive environment with adverse effects on the plant and the soil. Guided by the soil analysis results, it is possible to prepare a fertilization program for each plantation to achieve all desired objectives.

In response to climate change challenges, the fertilizer industry promotes crop nutrition management programs and good fertilizer application practices to encourage farmers – growers to apply fertilizers effectively and efficiently. Through these programs, the benefits resulting from the proper use of fertilizers are maximized. In contrast, the losses and adverse effects due to their reckless use are minimized. Adequate nutrition also helps increase the resilience and adaptability of plants, leading to increased adaptability to ever-increasing climate change.

Aiming at the rational application of nitrogen fertilizers, producers must apply the best quantities and types per crop and soil type, meet the nutritional needs of plants and avoid water burden with nitrate ions. The plants' fertilization needs are determined based on the instructions and the fertilization minutes issued by the competent services.

Producers whose holdings are located in vulnerable areas, they must apply by cultivation and soil type the nitrogen units (quantity of nitrogen added per unit area) defined by the Action Plans. They are specific to each area, crop and irrigation method.

The four universal principles of rational use of fertilizers are the right source, the correct rate, the right time and the right place (4Rs).

As far as it concerns the right source, the fertilizer should meet each crop's needs, while the crops should be supplied with the necessary minimum nutrients. Thus, the nutrients that already exist in the field, derived from organic sources, should be recycled and secondly, additional fertilization with inorganic fertilizers should be done. Inorganic fertilizers should be suitable each time for each crop's specific requirements and appropriate to the location of the crop. The choice of the right fertilizer must consider the cost per unit of nutrient in the fertilizer, technological developments and environmental protection. In addition to soil properties, it must be taken into account the interaction between nutrients and the irrigation way.

The application of nitrogen fertilizers must be controlled so that the total nitrogen units added do not exceed the crops' requirements. In order to calculate the required quantity, it must also be taken into account the nitrogen delivered from the soil in which the cultivation takes place. For this purpose, the farmer should keep in mind:

a. the type of crop and its needs for nitrogen depending on the germination stage of development,

b. soil properties (mechanical composition: light - medium - heavy, slope, permeability, etc.),

c. soil analysis data to obtain the nitrogen contained in the soil,

d. the method and history of fertilization of the plot with nitrogen fertilizers or livestock waste,

e. the quantity and quality of irrigation water,

f. the method of irrigation and

g. climatic conditions and especially the height and frequency of rainfall.

Increased amounts of nitrogen fertilizers should not be used "for safety". Excess nitrogen not only does not increase production but instead causes economic and environmental damage. Reducing the amount of fertilizer used can be achieved through crop rotation/crop rotation.

Regarding the right rate, the optimal recommended amounts of fertilizers should be applied based on the farmers' real needs to achieve the farmers' goals. The approximate value of the required quantity of nutrients refers to the number of nutrients received by the harvest, based on the expected performance. A fundamental tool for estimating the necessary amount of nutrients is the soil analysis for its basic properties (e.g., particle size distribution, pH, organic matter, etc.). In addition to soil properties, in order to determine the appropriate quantity, it is necessary to take into account other parameters, such as climatic conditions, cultivation techniques, expected performance, type of crop and stage of development of the crop.

Producers have to apply nitrogen fertilizers in doses according to the plants' requirements per the vegetative stage of growth. Nitrogen mainly helps the plants' vegetative growth, and not so much the reproductive (flowering, fruiting). In particular, nitrate-nitrogen fertilizers are more suitable for the observed peak period of the plants' needs for nitrogen because they deliver it faster comparatively. Concerning vulnerable zones, the Action Plans provide guidelines for the doses, method and timing of nitrogen fertilizer application.

Regarding the right time, fertilizer applications should be planned when crops need them, according to the climatic and weather conditions of each area and according to the nutritional needs of the crop over time. Fertilizers' application time, quality and type selected must harmonize to crop's seasonal requirements. Identifying plant growth boards with the highest nutrient requirements is particularly crucial for adjusting fertilizer application and crop requirements.

Producers are prohibited from applying nitrogen fertilizers from 1 November to 1 February. The plants generally have low to zero growth rates during this period, resulting in the added nitrogen, which cannot be utilized - bound, pollutes the underground and surface water, either by surface runoff or by filtration. Regarding the vulnerable zones, the Action Plans will specify by region the period of prohibition of dispersion of nitrogen fertilizers, as well as the fertilization program of the most common crops. Exemption from the above restriction of the application of nitrogen fertilizers applies in the following cases:

a. the fertilization of established winter vegetable cultivation, in which the use of nitrogen fertilizers is allowed in the already developed plants.

b. necessary fertilization, for as many crops as required, with the precondition that only slow-release nitrogen fertilizers are used.

As for essential fertilization of spring crops, no more nitrogen should be used than needed at that time, as it is in the initial vegetative development stage.

Concerning the right place of application, fertilizers must remain at the right soil depth in order to be used effectively by the plants. Ensuring the proper placement of the nutrient source near the plant roots optimizes plant absorption. The application of the fertilizer must take into account the characteristics of the root system of the crop: superficial, deep-rooted, tufted or stunted root system, as well as its development. There are two main methods of applying fertilizers to the soil, spreading over the entire surface and then integrating and applying in strips, either superficially or sub-superficially, at some depth. Sometimes, the two application methods are combined during the growing season. In some cases, especially for micronutrients, soil fertilization cannot meet crops' requirements due to their strong binding of soil components, such as organic substance.

Producers must make every effort to ensure that the application of nitrogen fertilizers in the field is as equable as possible, i.e., to ensure the availability of an equal amount per plant or square meter of arable land. It is recommended that farmers apply fertilizer by spreaders, which can be either granule spreaders for solids or fertilizer spreaders equipped with special sprinklers/injectors for liquids, which penetrate 12-15 cm into the soil. The fertilization equipment for the application of either liquid or solid formulations must always be in good operating condition and carefully adjusted, according to the manufacturer's instructions, so that the necessary quantities are applied accurately.

When applying nitrogen fertilizers, producers must pay particular attention to the rules on the packaging of fertilizers and the instructions provided by EU, national legislation and the relevant services. Special care is required to avoid their spread in cases where the risk of loss is high. In particular, producers are prohibited from spreading nitrogen fertilizers:

a. on icy or snow-covered surfaces, as well as on soils saturated with water, which is not sufficiently drained, or flooded,

b. while there is a forecast of rainfall in the next two days and

c. when a strong wind blows.

Producers are prohibited from applying nitrogen fertilizers:

a. At a distance of fewer than 2 meters from the shores of surface waters (rivers, lakes, drainage ditches) in case of a flat area and at a distance of at least 6 meters for riparian fields with a slope of more than 8%,

b. On sloping areas with a significant slope (over 8%), in case fertilizers are in liquid form, except application through the drip irrigation system or by the method of injection. In these areas, producers are advised to apply solid nitrogen fertilizers, in small quantities, which must be incorporated into the soil at the time of application or immediately after that, especially in the case of vegetation-free surfaces prepared for cultivation and

c. At a distance of fewer than 50 meters from springs and boreholes. The above safety distances delimit restraint zones, within which it is recommended to have any form of permanent vegetation that can act as a natural decontamination filter.

It is generally forbidden to spread nitrogen fertilizers in uncultivated areas, in hedges, and neighbouring lands.

Producers are prohibited from quitting at the place of application or any other site than at the specified one by the competent services, materials and means of the packaging of nitrogen fertilizers.

There are many tools and technologies available to help growers make proper fertilizer applications. For example:

- Soil analysis, a prerequisite before any fertilization decision
- Terrain mapping, field data management, GPS systems. Smart agriculture is in the spotlight.
- Digital tools for monitoring the nutritional status of the crop
- DSS
- High-tech nutrition products. Slow and controlled release fertilizers or fertilizers coated with polymer covers or various additives (e.g., nitrification inhibitors) which make the fertilizers more stable. Thus, the fertilizer industry achieves the delay in releasing nutrients or the postponement of various microbial transformations, reducing the amounts of those lost in the atmosphere or water.
- Foliar fertilizers allow the application of much smaller amounts of fertilizers (essentially microelements) whenever and wherever the plants need them. These cases of application are not being affected by the interactions that occur in the soil.
- Smart farming techniques, such as targeted fertilizer micro-deliveries, aimed at improving productivity in depleted soils, are a method that has shown significant results.

4.4.1 Fertigation

Fertigation is an innovative method of applying fertilizers through the irrigation system. Thus, it is possible to synchronize the nutrient needs of the crop, during the entire biological cycle of the plant, simultaneously with the application of the four principles already mentioned. Fertigation also has enormous potential for maximizing yields and minimizing environmental pollution. Arid and semi-arid areas in many parts of the world could be turned into rural areas.

There are several factors to consider when linking irrigation to fertilization. The available water on the farm, the quality of irrigation water, mainly in terms of conductivity and pH, and the soil's mechanical composition are the main factors, which should be combined with the climatic conditions prevailing in the area's microclimate.

Fertigation increases the efficient use of fertilizers and nutrient availability at the root level, increasing the mobility of potassium and phosphorus.

Fertigation has some specific advantages over broadcast and band fertilization:

1) a frequent supply of nutrients reduces the fluctuation of nutrient concentration in the soil;

2) there is efficient utilization and precise application of nutrients according to the nutritional requirements of the crop;

3) fertilizers are applied throughout the irrigated soil volume;

4) nutrients can be applied to the soil when soil or crop conditions would otherwise prohibit entry into the field with conventional equipment.

Drip fertigation has added advantages over other methods of fertigation:

1) application of nutrients only to the wetted soil volume where roots are active reduces the loss of nutrients by leaching or soil fixation and increases fertilizer-use efficiency;

2) the crop foliage remains dry, thus retarding incidence of pests or diseases and escaping foliage burn;

3) the wind has no effect and runoff is avoided.

Knowledge and requirements around cultivation subject and the quality of irrigation water in combination with the fertilizers that will be used, determine the degree of success of fertigation. Fertilizers, depending on their capacities, show mobility within the plant. Nitrogen, potassium and sodium are the most flexible elements in plant tissues. Phosphorus, sulfur, chlorine and magnesium offer moderate mobility and should be treated accordingly. The solution's right pH should be around 5.3 to 5.8, and the electrical conductivity should be close to 1.5 dS/m for better results during application. Regarding cumbersome elements, such as copper and iron, we need to increase the conductivity to about 2.5dS/m to make them more digestible by plants.

By combining the irrigation rules, such as time and quantity of water given to plants, crops will be led to the maximum performances. Water capacity is determined according to the mechanical composition of the soils. In this case, the irrigation rules depend on the type of soil and crops.

The water fertilization technique needs modern mechanical equipment with automated use to achieve the best results, applying modern digital technologies. The application of these techniques for the benefit of water-soluble fertilizers requires a modern field of application so that the yields reach the maximum level.

4.4.1.1 The basic parts of a modern fertigation system

The irrigation head is the heart of a successful fertigation system and is the most important component. Through this mechanism, which should be in continuous operation without problems, passes all the irrigation water.

The fundamental obligation of the user is faithful maintenance and use strictly based on its operating rules. Usually, the problems encountered by the head are related to water quality. The presence of foreign water substances creates a blockage in the irrigation system, resulting in its malfunction. Proper maintenance is an integral part of the adequate management of all components and especially filters.

The type of fertilizer mechanism that will be used is also of great importance for the irrigation system's proper operation. There are usually three types on the market—the first concerns the closed differential pressure vessel. The second is the Venturi fertilizer mechanism, and the third type concerns dosing pumps, which can also accept automation systems. The farmers' selection of the appropriate fertilizer mechanism is made mainly with economic criteria and less with technical ones.

4.4.1.2 Surface irrigation

Regarding surface irrigation, water is applied to the surface of the field either statically or by moving. In the first case, the field's surface must be practically horizontal (also called horizontal irrigation), such as irrigation methods with dormant or basins. In the second case, the surface has a minimal slope that allows the movement of water downwards (also called sloping irrigation), such as irrigation in parallel strips and irrigation in furrows.

In order to apply successfully any method of surface irrigation, the soil surface must be shaped so that the flowing water is infiltrated as evenly as possible throughout the field. Thus, the area to be irrigated must be prepared, which is primarily levelling.

The next important factor in the successful application of surface irrigation methods and consequently in the avoidance of nitrate pollution – mainly by deep filtration, is the correct dimensioning and construction of the reclining basins, strips and ditches. However, for this purpose, it is first required detailed planning and study. In cohesive soils (if the slope allows it), the basins/strips/ditches' dimensions can be larger than in light soils. If large basins/strips/furrows form in light soils, this results in uneven irrigation (depending on the slope) with deep filtration losses near the water entry point.

Furthermore, for successful irrigation, the irrigation supply must be controlled and regulated, i.e., the water intake from the supply canal and its return to the basins/lanes/ditches. Water intakes should be constructed on the canal's sidewalls, which are designed and constructed so that the received water supply corresponds to their gradual opening. Alternative, their circular pipettes are used.

4.4.1.3 Drip irrigation

During drip irrigation, water is applied to a part of the crop soil and specifically directed to the area of each plant's root system. Water is supplied to each plant in small doses, and irrigation becomes more frequent than other methods. Only the surrounding soil is moisturized, as it is close to the roots of each plant, while at the same time, every kind of irrigation water losses is significantly reduced. Using the proper equipment is possible to add fertilizer to the irrigation water and grant it to each plant together with the irrigation water. One properly installed and configured automation system provides the ability to control adequately the quantity of water administered. For the same reason, drip irrigation allows the gradual application of hydro-fertilization, with correspondingly low fertilizer losses.

In general, since the drip irrigation method moistens only part of the soil, the application of fertilizers to the entire surface is not recommended because irrigation water cannot move fertilizers in the soil's dry regions. Thus, it is more effective to add fertilizers to irrigation water, which also provides the possibility of applying the lubrication more often in smaller doses. By using this method of hydro-fertilization, the plants have at their disposal fertilizing elements, which they absorb continuously throughout the growth and yield.

As for nitrogen fertilizers, most of them are quite soluble in water (ammonia sulfate, ammonia nitrate and urea), and farmers can use them in hydro-fertilization. If farmers use ammonia sulfate combined with irrigation water with calcium above 70mg/L, insolubility problems (precipitation, microcrystalline formation and eventually blockages) can occur. Liquid ammonia is unsuitable for use with irrigation water and calcium nitrate and calcareous ammonia nitrate. Also, if farmers use ammonia phosphate in hydro-fertilization, they must dissolve it in a ratio of 1:5000 in water. In contrast, farmers can use nitrogen phosphate fertilizers in a dissolution of at least 1:100 and at a temperature lower than 45oC. They can use potassium nitrate either in crystalline or liquid form, but not in powder form.

Farmers could also use drip irrigation underground. The advantage of underground drip irrigation is the reduced losses of irrigation water and nitrates, which is vital for the protection against nitrate pollution of agricultural origin. It can also be used in crops that cover the entire surface of the soil and is the safest of every irrigation method regarding irrigation use of wastewater.

4.5 Conditions for rational use of plant protection products and rational application of sprays

Pesticides or plant protection products are compounds of organic and inorganic chemistry, high-tech products, which act and kill animal and plant organisms that harm crops.

The use of plant protection products has various benefits – mainly economic – for farmers. Plant protection products improve or ensure agricultural production and the quality of agricultural products. They also minimize work requirements. They can help reduce soil erosion by enabling cultivation without ploughing and ensure reliable supplies for a wide range of agricultural products. Plant protection products also play an essential role in meeting plant health requirements and promoting international trade in farm products. Apart from the agricultural sector, plant protection products are also widely used in applications ranging from the preservation of wood or textiles to public health protection.

Various methods for application of plant protection formulations:

1. By injections and fumigation on the ground. Soil infusions and fumes are used to treat soil pests such as nematodes, insects, mites, weeds, fungi and bacteria. They are used in high yielding crops due to their high cost.
2. By fumigation of stored agricultural products. Fumigation could also be applied to stored agricultural products to control insects, mites and rodents that can infect these products. They have the advantage of therapeutic treating the problem and penetrating products that are stored densely or in bulk.
3. By fumigation and sublimation in greenhouses. In greenhouses, because the space is closed, there is a possibility to fight the enemies through fumigation and sublimation. This control method ensures high penetration in every part of the greenhouse and reduces the risk of pesticide residues. On the other hand, the residual effect of the products used is significantly reduced.
4. By lining the propagating material. Coating the propagating material with plant protection products is a method widely used in large crops. It can be applied to the seed or to a different form of propagating material of plant protection products standardized adequately for this purpose, in order to fight insects, nematodes, fungi, bacteria that infect the aboveground or underground part of plants.
5. By irrigation water (root waterings). Using root irrigations, plant protection products are applied to the soil through the irrigation water, in the area around the base of the plant, to be absorbed by the roots. This method requires a suitable irrigation system, e.g., dropwise. The plant protection products that are commonly applied are systemic pesticides. This application method can be used to treat soil insects, nematodes and diseases of the underground part of plants. In some cases, herbicides may be used. The disadvantage of the method is the small concentrations of the active substance in the irrigation water, making its action difficult.
6. By dispersing granular formulations. Granular drugs can be applied directly to the soil or plants (e.g., corn leaf pods). They are usually used for ground operations. They act

integrated into the soil and are applied to plant lines in linear crops. When the seed germinates, the pesticide dissolves in soil moisture, is absorbed by the root and circulates in the plants' sap to fight mainly sucking insects.

7. By sprinkling
8. By spraying. The usual way of applying the chemical formulations is done with sprays and on a smaller scale with the application. Sprays and infusions fight pests, diseases and weeds. To a limited extent, they are also used for fertilization, for the regulation of flowering and fruiting (fruit thinning, prevention of fruit fall, etc.) or defoliation (mainly in cotton).

Through the misuse of pesticides, including abuse, chemicals can result in pollution of water, air and soil, with adverse effects on plants and wildlife and a loss of overall biodiversity (although several other factors also influence the latter). In particular, plant protection products released into the environment in an uncontrolled manner by spraying, rinsing or draining pollute the soil, the surface water and the groundwater. Environmental pollution can also occur after use, i.e., during the cleaning of equipment or through the uncontrolled illegal disposal of pesticides or their empty packaging. According to the EWRA, pollution of untreated water is very serious in rivers below sea level. Indeed, a large percentage of the pollution exceeds the value of 0.1μg of active substance/l of water, resulting in that water must be processed to remove the pesticide surpluses before being available as drinking water. The potential for surface and groundwater pollution requires constant and rigorous monitoring in the regulatory process, as pollution and remediation are long-term strategies.

In the field, most of the plant protection products are applied by spraying. This method gathers the most advantages over other methods of application of pesticides. The spray's effectiveness depends on the pesticides used, the method of application, the weather conditions, the growth stage of the plants, and the growth stage of the infesting pest. Spraying is based on the formation of droplets from the spray solution used to cover plant surfaces or soil. The aim is to protect the sprayed surface as much as possible with the spray liquid and consequently with the active substance. The droplets are created by passing the spray liquid through a small hole with relatively high pressure and decomposition caused by the vortex created as it passes through the stationary layer of air. Otherwise, the spray liquid is fed to a strong air stream where it is broken down into drops.

Rotating disks can also be used where droplets or electrostatic forces are formed with centrifugal force.

4.5.1 Spray drift

Effective spraying requires evenly and maximum coverage of the sprayed surface to increase the chances of encountering the target parasite. This is achieved by using small diameter droplets. On the other hand, the smaller the droplets, the more difficult it becomes to land on the target due to their air drift. The second issue is the fact that water in small drops evaporates and the active substance remains suspended. Subsequently, if inhaled by humans, it is dangerous.

The total droplet contact area of a given spray volume depends on the size of the droplets. The smaller the droplets are, the larger the contact surface. However, droplets more diminutive than a specific size are undesirable because they do not settle on the target surface but are carried away by the wind. Drops of a particular diameter are sometimes more effective against a target but are not used in practice due to difficulties in field conditions.

Spray Drift is the pesticide's movement through the air, during or after application, to a place outside the intended area of application. It is considered to be the most challenging problem faced by applicants as well as pesticide manufacturers. Although this can occur in the escape form of an evaporated chemical active ingredient from the application area, even long after spraying, dispersion is usually associated with the natural movement of the spray droplets away from the target area at the time of the application.

The main factors that contribute to the dispersal of the spray cloud are the following:

i. The size of the droplets. The size of the spray droplets is considered to be the most critical factor related to dispersion. The amount of distribution is usually associated with the percentage of fine droplets in the spray cloud. Most researchers conclude that dispersion droplets are less than 100μm. The size of 100μm is currently considered to be the most suitable size for spraying, and it would be ideal for creating droplets of exactly this size.

ii. Weather conditions at the time of application, such as wind speed, wind direction, temperature, relative humidity, turbulence and atmospheric stability. Wind speed and direction are meteorological factors that affect cloud deposition. The relative humidity and high air temperature can enhance the evaporation, reducing the droplets' size, especially the small spray droplets. As a result, their settling rate reduces and they become more prone to dispersion.

iii. Spraying equipment and application techniques. The equipment and application techniques include the type of sprayer and the condition of the sprayer regarding its maintenance and proper operation, the type and size of nozzles used, the spray pressure, the height of the spray liquid release (i.e., the distance of the spray mast from the crop or soil), the spray angle, the application volume (spray volume) and the speed of the agricultural tractor. The spray droplets' fate is affected by the working conditions, such as the application height, the sprayer's driving speed, and the distance between the nozzles. Air-assisted spraying and the use of sprayers with protective equipment generally reduce the dispersion of the spray cloud.

iv. The physicochemical properties of the plant protection products and adjuvants used, such as viscosity, surface tension, density, volatility and the presence of inhomogeneity in the spray liquid, such as emulsion droplets or solid particles.

v. The target crop and its characteristics, such as its height, type and height of the crown. Crop spraying leads to higher dispersion than spraying on the bare ground because it requires a higher droplet release height (spray mast height) and increases the effect of wind on the diffusion of the spray cloud.

vi. The care of the operator, his responsibility, attitude and ability.

Spray drift is undesirable for economic, environmental and safety reasons. Measures to mitigate spray drift can be divided into three categories and include the use of no-fly zones or even crop bans (as adopted by CGAP), the use of plant or artificial windbreaks the application of dispersion reduction technologies.

The need to measure spray drift has led to the development of various methods. Dispersion measurements can relate to either the deposition of the spray cloud on horizontal surfaces outside the application area or the airborne spray cloud profile. Measurements for potential spray drift can be performed either under controlled laboratory conditions or in the field. Air tunnels are used to measure the laboratory's dispersion, in which the spray generators are placed. The spray drift is measured by sampling or collecting the spray cloud displaced by the airflow in a designated downstream area. Field measurements are made with the sprayers operating outdoors under typical field conditions. These measurements include applying a dye detector or any other detectable material so that the plant protection product can be represented and through collectors or samplers, the quantities of the moving spray cloud could be determined during the application. Standards ISO 22866:2005 and ISO 22856:2008 describe methods for measuring spray drift.

4.5.2 Maintenance and adjustment of plant protection machinery

A properly designed and constructed sprayer must comply with specifications that ensure its proper operation and help farmers use it properly. The basic requirements that a pesticide application machine must meet are the following:

- Must have bumpers of moving power transmission guards.
- The liquid spray container must be made with smooth surfaces to facilitate cleaning, avoid operator injuries, etc.
- The liquid spray container must have a volumetric indication of continuous observation and an easily visible and suitable device for emptying the residue.
- Must have two containers of clean water, one for the operator and one for washing the sprayer.
- Have the appropriate filters for cleaning water from solids.
- Have a well-designed spray liquid stirring system.
- A pump that can support the supply and pressure needed by the nozzles.
- Have an effective system for regulating spray pressure and a suitable measuring instrument.
- The mast ensures minimal oscillations and has a suitable device for adjusting the height and locking during transport.
- Suitable nozzles, with leak prevention device (anti-drip type).
- Spray evenly throughout the width and height of the spray.

A spraying machine must be regularly inspected and maintained to function properly. In order to have effective and safe spraying, the annual, daily and emergency maintenance of the spraying machine is necessary. At the beginning of each growing season, the spraying machines must be checked for the operation of their mechanical parts, the essential repairs must be made, the operation of the pump must be reviewed, and the oils for lubrication must be supplemented or changed. Besides, the spray tank must thoroughly be cleaned, the filters that need to be in place must be checked and cleaned, while the worn ones need to be replaced. Furthermore, farmers must check the nozzles that need to be in place and have the same flow, clean and replace them if necessary, check the spray pipes for damage, cracks or tears, check for leaks and restore the tightness of the whole system. They should also check the non-return valve in the intake-suction pipe, check the operation of the safety valve, check the normal process and accuracy of the sphygmomanometer, check the operation of the agitation system, check the pressure accumulator and check – repair – lubrication of the spray tissue and the lifting and folding design.

After each use, the container of liquid spray must be thoroughly cleaned so that no residue of the spray solution remains which could clog the nozzles or wear out the components, resulting in difficulties in subsequent uses of the spray and unsatisfactory spraying, as well as damaging the crop of the next spray. A good cleaning of the container of liquid spray is essential when changing pesticides because it contributes to the crop's safety from any unwanted phytotoxicity.

Line filters and nozzles must be removed and cleaned after each use. Especially for blocking the nozzles, the operator must be vigilant and continuously observe any spray pattern changes. Leaks in pipes, valves, pumps and spray tanks must be checked after each use.

During the use of the sprayer, users must lubricate the components with lubricating oils. At the same time, they must check the manometer, bubble pressure and agitation system at regular intervals. They should also inspect every part of the spray machine to prevent any problems and repair it before it becomes severe.

Proper maintenance must be combined with appropriate adjustment of the sprayer. The sprayer's adjustment-calibration is the process of measuring and adjusting the amount of spray liquid that the machine distributes to the surface unit as it moves in the field. The adjustment of the sprayer is especially crucial for the excellent use of the sprayer and the pesticides. The setting must be precise to allow the active substance to be applied precisely to the plants or the soil. Application of doses higher than required causes a financial burden to the producer and pollution to the environment, while the application of smaller amounts does not achieve the desired pest control. Also, at the end of the spraying must remain the minimum possible quantity of spraying liquid, which must be specially handled.

Sprayers are one of those machines that require a lot of controls and adjustments for effective spraying. The settings concern the type and size of the nozzles, the spray pressure, the spray height, the propulsion rate and the amount of pesticide that will dissolve in the spray container.

Spray adjustments-calibrations must be regular. The sprayer must be calibrated:

- when the sprayer is new,
- at the beginning of each growing season,
- when the speed is changed,
- when the nozzles or the distance between the nozzles are changed,
- after any adjustments or modifications of the sprayer,
- when applying new proportions or pesticide change,
- after one week of handling under the same conditions.

The calibration process is not a waste of time, but many producers defy it because they do not know its usefulness and consider it a complicated process. They also make a lot of mistakes because the required parameters of the application are not exact. For this reason, the calibration must be reliable and straightforward so that the farmer can apply it in the field.

The key to spraying success is the stability of the spray liquid quantity for a given field area. The speed and pressure must be adjusted correctly for the machine to apply the required amount of pesticide per acre. The nozzle size must be changed when a massive change in application amounts is required. Since pressure is determined by the type of pesticide (2 – 4 bar for herbicides and 5 – 7 bar for fungicides) and the speed of movement is determined by the condition of the field and crop (4 – 8 km/h), the quantity of liquid spray is adjusted by selecting the appropriate nozzle. The precise adjustment is made with small changes in pressure and speed. The determination of the correct pressure-speed is done by trial spraying of clean water in an uncultivated field.

Thus, the correct adjustment of the sprayer includes the following steps.

- The correct choice of nozzles. The type and size of the nozzles affect the flow rate and the size of the spray droplets. First, it should be selected the type of nozzle. Suitable nozzles for soil sprays, herbicides and systemic pesticides are the nozzle type of droplet, with a reflective plate and the full cone, which produce larger droplet size and limit their off-target transport. These nozzles generally operate with small pressures of 2 – 4 bar. Suitable nozzles for foliage sprays and contact pesticides are hollow cones because the foliage's full coverage is sought as much as possible. Their operating pressure is higher, around 3 – 7 bar with a recommended 5bar. Sometimes pesticide companies recommend a specific type of nozzle on the packaging labels, which should always be followed. The next step is to select the nozzle size, and therefore it must be determined the nozzle flow (l/min). The desired quantity of liquid spray determines the nozzle flow applied to the acre, the agricultural tractor's speed during spraying and the distance between the nozzles. Based on the supply, the appropriate nozzle is selected from the lists of the manufacturing companies. The number of nozzles and the spaces between them has adjusted appropriately in order to achieve complete coverage of the soil or the plants.

- Correct pressure selection. The spray pressure affects the quantity of liquid spray ejected in the unit of time (nozzle supply) and the droplets' size. High spray pressures lead to higher flow rates and smaller droplets. The nozzle pressure must be combined with the nozzle size in order to achieve the correct outflow for the required application volume.
- Correct mast height adjustment. The mast should be horizontal and its height from the ground or the tops of the plants must be appropriately adjusted to ensure the uniform distribution of the liquid spray and the desired level of overlap of the nozzles. Initially, the entire sprayer is leveled through the three suspension points, with the tractor mounted on a flat surface. When the mast is opened, measurements of the mast’s distance are made from the ground at various points. The mast's height is adjusted with the sprayer in operation, with clean water and observing the size that ensures the desired level of overlap. Running the mast as close to the spray surface as possible (within the manufacturer's recommendations) is an excellent way to reduce the spray drift.
- The correct choice of working speed. The tractor's speed is one of the factors that determine the quantity of liquid spray delivered to the surface unit. Other factors are the size of the nozzles and the pressure that determines their flow. The amount on the surface unit is inversely proportional to the speed of movement. Adequate and constant speed ensures the required quantity of liquid spray for a given field area. Increased tractor speeds contribute to the spray cloud's dispersion and affect the stability of the spray mast.

4.6 Measures for safe use of pesticides

The use of plant protection products requires various safety measures to protect people and the environment from hazards. Measures must be taken during the use of pesticides without exception and concern the transport and storage of pesticides, the individual protection of the user and the protection of the environment and public health.

In order to ensure the quality of agricultural products and to protect the health of consumers, it is necessary to apply pesticides properly. The professional user of pesticides must minimize the spray cloud's creation and reduce human exposure to it. Some indicative measures that the user should take into account are presented below.

First of all, in order to deal with cultivation issues, they should be investigated the possibility and economics of applying pesticides with sprays that do not create a moving spray cloud. The used nozzles, in case they are nozzles of a particular type, adequately adjusted or maintained, contribute to the reduction of the spray cloud.

Spraying should be carried out on days and hours with a low probability of exposed people to a moving spray cloud, while it should be prohibited when there is a strong wind. In case the wind increases during the spraying, the spraying should stop. In the case of variable wind intensity, the spraying should start after stabilizing the low-intensity winds.

The professional user of pesticides must follow the rules of GAEP.

It should also be taken great care of the spray distances and the formation of the spray cloud. It is emphasized that the spraying of pesticides by using nebulizers (turbines) favors creating a spray cloud. Turbines are used only in the case of large farms and high crops. In addition, there should not be sprays with air that favor the transport of the cloud.

The professional pesticide user must inform residents, professionals, employees and regular visitors of the area forty-eight (48) hours before spraying, where the spray cloud may move and who may be exposed to it. In case information concerns residents, workers and regular visitors, who may be exposed to the spray cloud, it should include the estimated start time of the spray, the location of the crop to be sprayed, the plant protection products to be used, the toxicity label (Xn, Xi, etc.) on the package, as well as the corresponding risk phrases (e.g., "Irritating to respiratory system"). In case information concerns professionals (mainly beekeepers, snail farmers and stockbreeders) it should also refer to the effects on their activity, which may indicate the packaging of the plant protection product to be used.

According to current legislative, Farmer- producers are required to use approved formulations, follow the instructions on the label of the formulation, and take the necessary protective measures. Regarding the use of unauthorized formulations, pesticide users are asked to read carefully the label, which indicates in which crops it is allowed the use of each formulation. Farmers - users who cultivate different crops or that their crops are adjacent to other crops, e.g., olives – citrus, are required to rinse well their sprayers after spraying and always before the transition from one crop to another, as well as to take all necessary measures so that there is no transfer of spray cloud to adjacent crops.

Appropriate equipment for the application of plant protection products helps to reduce the effects of pesticides on human health (especially on operators) and the environment and ensure an efficient and at the same time economically viable use of these products. Successful plant protection presupposes the correct application of plant protection products. The most appropriate pesticides fail if the applicator does not work correctly and could become dangerous. The design, construction, maintenance and adjustment of plant protection machinery play an essential role in the proper application of pesticides.

4.6.1 Transport and storage of pesticides

The transport of pesticides is followed by regulations concerning the transport of dangerous goods. Only persons with experience in the transportation of such goods must carry pesticides in large quantities. When transporting limited amounts, it must be taken into account the transport vehicle and installation method. The vehicle must be in good condition, and the part where the medicines will be placed must be clean, dry and without protruding sharp objects that can pierce or tear the packaging. Pesticides should not be placed in the passenger cabin but outside the vehicle, away from food or other medicines. They can be placed in special boxes, which could lock in order to avoid the risk of displacement. Heavy packages should not be stacked on top of lighter ones. In case of an accident, all necessary measures must be taken to ensure that pesticide does not escape into the environment.

Safe storage is necessary to avoid direct or indirect contact of users and other people with pesticides. To ensure health and safety during the storage phase, specific rules must be followed. Non-compliance with storage rules often results in accidents that can be very serious if pesticides fall on people who do not have the required knowledge (e.g., children), and even create problems in pets and environmental pollution. The storage area for pesticides should be used solely for the storage of these pesticides. When choosing the warehouse location, it must be taken into account the proximity to drinking water intakes and surface water and must be observed the relevant legal provisions.

The storage of pesticides must follow each product's characteristics and properties and must always be in a covered space and, if necessary, in separate compartments. Pesticides should not be stored next to food, animal feed or flammable materials (fuels, fertilizers, etc.) and herbicides should be stored away from seeds. Pesticides need to be stored in their original packaging only so that their labels can easily identify them. Particular care must be taken to ensure that the pesticides stored and used are approved and have not expired. Solid pesticides are stored on shelves above liquids to prevent liquid from leaking into the solids.

4.6.2 User protection measures

Plant protection products must be handled carefully and controlled to avoid adverse effects on users, the environment, and other people. These effects can be minimized when users follow the pesticide labels' instructions and take appropriate protection and hygiene measures.

The hazard of plant protection products depends not only on the harmfulness of the pesticide but also on the user's exposure to it. Danger expresses the possibility of harming someone or something when exposed to the pesticide.

The exposure is influenced by the user and depends on the sprayed crop (density, height, field conditions, etc.), application techniques and application pressure, application equipment, application conditions (weather conditions, topographic characteristics, etc.), the use of appropriate personal protective equipment, the maintenance and cleaning of personal protective equipment, the duration of the application and the application dose.

Exposure to pesticides can occur in three ways: through the skin, through inhalation, through ingestion.

Using pesticides correctly, the exposure is controlled, avoiding direct exposure to high quantities and increasing the risk beyond the permissible limits. Aiming to eliminate accidents when using pesticides, there are required precautionary measures at all stages of their use, i.e., during transport and storage, preparation and application of the spray liquid, cleaning the application equipment and personal protective equipment. Healthy adults should apply pesticides and particular attention to the toxicity markings and instructions on the product packaging.

The use of personal protective equipment during the application of pesticides is a crucial preventive measure. The user must always wear personal protective equipment depending on the work performed. The choice of personal protective equipment depends on the type of preparation (wetting powder, granular, etc.), the toxicity of the preparation, and the area where the plant protection product will be used.

During the liquid spray preparation, the minimum personal protection is the use of a uniform, durable nitrile gloves, rubber boots, mask and an anti-dust mask when powdered pesticides are used. During application of plant protection products, the minimum personal protection consists of a uniform, nitrile gloves, rubber boots, a hat, a mask against liquid and solid suspended particles of dust and spray drift (e.g., when the application is made in tall crops, greenhouses, etc.). The minimum personal protective equipment is uniform, nitrile gloves, rubber boot, and a hat while cleaning the application equipment.

Personal protective equipment must be approved for protection against the use of pesticides. The uniforms should be ergonomic and should cover the whole body. Gloves must be resistant to chemicals and microorganisms. Masks can be disposable or reusable with removable filters, mechanical or chemical. Boots must be waterproof and made of durable rubber. The mask is used when mixing the spray solution and must be transparent and not cloudy. Glasses must fit snugly, must have ventilation holes and protect against liquid and solid particles. Every personal protective equipment, except the hat, must be CE marked.

The user of plant protection products must always have clean water available, incredibly when filling the tank, where he handles a concentrated amount of chemical material. Food and drink should not be consumed at work, and smoking should be avoided. When spraying, the tractor's cab (if available) must be closed airtight and must be used with suitable air filters for ventilation or air conditioning. Particular attention should be paid to moving parts of the machine.

After applying the pesticide, the sprayer should first wash the application equipment and personal protective equipment and afterwards, take a shower with soap and water, wash his hair, and wear clean clothes. The user can engage in other activities only after completing his hygiene.

4.6.3 Ways to reduce the environmental footprint of practices and environmental degradation

Over the last 40 years, the demand for the use of natural resources for the production of goods has increased. Efforts must be made to reduce the ecological footprint.

In general, the EC's natural resource requirements, while maintaining its competitiveness, can be reduced by implementing a new economy, which will integrate environmental management objectives into sectors such as agriculture, forestry, economy, transport, trade and health and will promote agricultural technologies, without the use of practices that are harmful to the environment (extensive use of water, nutrients or insecticides). In addition, high priority should be given to investments in the conservation and restoration of ecosystems as a basis for the development and recognition of forests' contribution and habitats to human health. At the same time, an approach based on proper marine ecosystem management can be adopted. Calculating economic terms the benefits of eliminating the adverse effects of chemicals on human health and the environment will contribute to further growth and innovation in this field.

Another way to reduce the environmental footprint is to introduce laws and more effective regulations, which will help Cyprus reach its sustainability levels and support citizens to live following the state's biological capacity levels. Providing more accurate information to decision-makers and the public on the socio-economic value of robust ecosystems and the development of certification schemes to ensure the sustainability of production and consumption, products and resources used are essential. The public should also be informed about the challenges and opportunities of sustainability through the analysis of issues, such as climate change, deforestation, and the destruction of vital ecosystems. Simultaneously, unreasonable subsidies, which have opposite socio-economic and environmental effects, must be eliminated.

To reduce the overexploitation of natural resources effectively and, therefore, the ecological footprint, it is necessary to maintain and increase the soil's biological capacity and protect the earth from degradation and erosion. Wetlands should be saved for drinking water, and at the same time, it is necessary to eliminate the use of chemicals and toxic substances due to the damage they cause to the environment.

More specifically, concerning the use of spraying machines and pesticides, it must be done to reduce the impact on the environment. Environmental protection measures must be taken during the manufacture and application of the spray solution and the cleaning of the application equipment and personal protective equipment. In addition, the management of packaging gaps after their use and the residue of the spray liquid, must be done without risks to humans, animals and the environment.

The spray solution's preparation requires special precautions on the part of the user and must be done responsibly by trained users. There should be no other people or animals in the area of preparation of the spray solution. Simultaneously, all necessary precautions should be taken to ensure that any mistakes or accidents would not adversely affect the user and the environment. In particular, the manufacturing site must be specific, practical, functional and ensure environmental protection. The most suitable place is considered to be the one near the warehouse of pesticides. It may or may not have a roof, but walls should not surround it. The floor must be watertight, at least where the sprayer is filled, while there should be the possibility to restrain leaks in case of an accident. When it is not possible to have a stable place, it is recommended to change regularly the manufacturing points, always keeping in mind that it should be well ventilated and away from ditches, wells, streams or another water source. In addition, the filling of the spraying machine with surface water should be avoided and should be done in organized places. The safest solution is to prepare the spray solution in the field in order to prevent the use of the same filling point and the risks of transport. However, when this is not possible and the spray machine containing the spray solution needs to be moved, special care must be taken to ensure that the lid of the container is tightly closed, that there are no leaks from the pipes and that the liquid spray level does not allow its overflow. During filling, there must be taken care not to overflow the sprayer and not create foam, which can overflow from the container. The water pipe from the intake should not be immersed in the container to avoid returning the spray solution from the container to the input. There must be a non-return valve or other device to prevent water from returning to the supply source. During the preparation of the spray solution, it must be used exclusively utensils proposed for this purpose, and the quantity of pesticide required should be accurately calculated.

The application of pesticides must be made very carefully so as not to cause problems in cultivation and environmental pollution and at the same time to protect the user from high exposure. During the spraying, it is required to adopt measures to protect the environment. The spraying machines used must work properly and there must be sought new spraying techniques (e.g., electrostatic spraying machines, low dispersion nozzles, etc.) that contribute to the protection of the environment. Excessive spraying should be avoided and unnecessary pesticides should not be used. The user must always consult the specialists and the competent Services and faithfully follow the instructions on the preparation label. It should also be taken into account weather conditions and especially air, as they are a significant factor, not only for the protection of the environment but also for the implementation of plant protection products. Suitable spraying hours are the early morning, as at that time the airspeed is low, the humidity is high and the lighting during the rest of the day increases the effectiveness of the pesticide. It should also be borne in mind that depending on the wind speed; it must be used the correct nozzles to adjust the size of the drop. In addition, only the desired spots should be sprayed. The spraying should be done keeping safe distances from neighbouring crops to avoid phytotoxicity problems from irrigation canals, surface waters and native vegetation to protect the natural fauna that exists in it. It must be used approved plant protection products with a marketing authorization. Unauthorized pesticides have not been tested for efficacy and safety, while they may contain high levels of preparative by-products and impurities. They are usually made with cheap solvents and other cheap substances, many of which have been banned throughout Europe. Illegal pesticides pose a serious risk to users' health. They potentially could damage/destroy entire crops. They could leave unknown residues in products that endanger consumers, pose environmental risks to fauna, water and soil and pose environmental waste disposal problems.

Waste management from pesticide use must be done in such a way as to ensure that every type of waste has the least possible impact on the environment. Waste resulting from agricultural activities is divided into solids and liquids. Solid waste is mainly plastic pesticide packaging voids, which if not properly managed, they are toxic waste. Liquid waste comes mostly from the excess of spray solution, from the rinsing of the spraying machines, as well as from the pesticide formulations that have passed the date for their use and are not suitable for use.

When it comes to solid waste, empty pesticide packaging should be handled properly and responsibly, while burning, burying or disposing of the packaging in residential bins are considered inappropriate practices. The proper management of empty packaging of plant protection products and especially of plastic bottles includes their triple rinsing as a necessary condition after their placement in plastic bags and their disposal in particular bins, from where they will be collected for further legal and environmental protection. The collection bins should be placed near the cultivated areas and visible places with easy access to facilitate the collection process from a suitable vehicle. The Municipality should have a fenced and locked space for the empty plastic packaging's stay from the collection of the bins until their final disposal is processed. In this way, plastic empty pesticide packaging is considered as non-hazardous waste because with their triple rinsing, the concentration of the active substance residues in them is less than 0.1%.

Empty packaging of pesticides should be cleaned immediately after emptying their contents so that pesticide residues do not dry out and become difficult or impossible to clean. The process begins with the use of the entire range of the package by their user. Since the packaging material is allowed to drain in the spray can for half a minute to minimize the pesticide residue, there are performed the following tasks. Wearing the necessary protection measures (gloves, mask, etc.) the farmer fills the empty package with water at about 10% to 20% of the package's volume and places the lid of the package tightly so that there are no leaks. Then, it must be shaken on every side to rinse the empty packaging. The procedure is repeated two more times or more until the rinsing water is clear.

Regarding liquid waste, the equipment can be washed in the field or another safe place so that the washing water containing pesticide is managed in a way that will not contaminate vegetation, animals, water or people. A big part of the liquid waste from the use of pesticides comes from the excess spray solution. A key factor in limiting excess spray solution is proper sprayer adjustment. When preparing the spray solution, it must be calculated the exact amount required. Experienced users who apply pesticides every year on the same plots can and do minimize the excess spray liquid with properly configured application equipment. Excess spray and leachate from application equipment should not end up in areas adjacent to crops. These areas could infect humans or animals, lakes, streams, irrigation or drainage ditches and sewers. The rinsing water and excess spray can be sprayed on a piece of a field with vegetation not intended for human or animal consumption, away from ditches or other water sources. They may also be sprayed in the recently sprayed field or on uncultivated land as long as there are no future phytotoxicity risks. Another technique of liquid waste management is the construction of biological substrates (bioclines). The biocline is a ditch with a layer of clay 10cm thick placed at the bottom. A mixture of straw, peat and soil in a ratio of 50:25:25 fills the rest of the depth (50cm). On the surface, there is a layer of natural or sown grass. The dimensions of the biocline are 3 x 5m and the replacement of its materials must be done every 6 to 8 years. The construction point of the biocline in the field must be at least 10m away from any water resource (stream, canal, river, lake) and 50m from any drilling, well or water source. Liquid waste during the filling of the spray liquid tank and the rinsing of the spray machine is thrown into the biocline and the microorganisms of the organic substance degrade the pesticides. Another way to manage wastewater is the Heliosec system. This system should be installed in guarded places provided that environmental requirements are met (e.g., distance from surface water, etc.) and there will be water for producers to rinse their sprayers. The Heliosec system consists of a tank whose bottom is covered by a suitable membrane, made of a special polymeric material, which has been tested for its resistance to various agrochemical products and is the only consumable of the system. A special iron grid on its entire side surface protects the tank so that there is no access of birds, beneficial insects or humans inside. A special plastic cover to prevent overflow in case of rain covers the tank at the top. Excess spray or rinsing sprays are placed inside a concrete structure, which is connected to the Heliosec via a special stainless steel pipe and enters the Heliosec tank due to gravity. With the effect of the heat from the sun and air, the water coming from the liquid waste evaporates and the pesticide residues remain on the special plastic film as a small volume solid residue. This residue is collected, placed in a special container for toxic waste and sent for disposal, while a new plastic film is placed in the tank to receive the new volume of liquid waste.

A bad practice is burying packages, either without rinsing them or after rinsing. Thus, packaging materials remain in the soil for years, the opportunity for recycling or energy recovery is lost and the environment and especially groundwater is polluted. Burning empty packaging constitutes a clear violation of the provisions on pesticides' packaging, cancel any possibility of packaging recycling. Still, it is also an unsafe practice even for user's health by inhalation of toxic fumes. Another bad method is the use of empty packaging for other purposes by the user himself, without considering the risk of the situation, such as tool cases or even pet feeders.

4.7 Methods to ensure good quality and food safety

Over the last few decades, food quality and safety have emerged as one of the critical issues of public debate in global markets, especially in the agri-food sector. Safety is an essential element of food quality and refers to the risks posed by pathogenic microorganisms, heavy metals, additives, pesticide residues, natural toxins and other elements.

At European level, food safety policy aims to protect the consumers and provide the necessary conditions for the smooth functioning of the single market. In particular, EU Member States are required by European regulations to apply standards for food hygiene, animal health and welfare, plantation and pesticide control. In contrast, controls are carried out at every stage of the chain. At the same time, food imports from third countries must comply with European standards.

In 2006, it was introduced the "Hygiene Package", which was an important development of the European regulatory framework for food safety and set the corresponding responsibilities throughout the production chain. At the same time, RASFF is a tool for exchanging information between the central authorities responsible for food regulations in cases of human health risks. EU decisions are based on scientific data provided by EFSA established in 2002.

In Cyprus, food and feed safety are implemented following the EU legislative framework. Increasing food safety through the application of the respective quality standards contributes to the protection of public health and, therefore, increases the consumer public's confidence.

4.8 Other good agricultural practices for the prevention of nitrate pollution

In case of soils with significant erosion issues, which also contribute significantly to the occurrence of nitrate pollution of surface waters, producers are advised to take appropriate measures, such as creating stable uncultivated lanes, which act as restraints and stabilizing soil surface using available organic material in quantities that will not burden the nitrogen balance of the crop. They should also take care of the presence of natural hedges on the borders of the holdings or even in between large areas with significant slopes. In contrast, during the preparation for sowing and other cultivated care of sloping areas, the ploughing should be done according to the soil's isotope curves. Where possible, the method of successful cultivation of winter legumes in sloping regions should be applied to reduce the number of nitrogen fertilizers and soil erosion, which leads to unused nitrogen in groundwater and surface water. Producers should ensure that parcels are not left without vegetation during winter, in which the risk of unavailable nitrogen's transport in the soil to groundwater aquifers is increased due to rainfall, as well as the risk of water erosion. As early as possible, swallowing should be done in as many crops as possible because late sowing favours nitrate losses. In general, the existence of vegetation even with uncultivated plants is necessary.

The agricultural use of arable land, which is revealed by the retreat of the surface of water bodies - mainly lakes - is prohibited in prolonged drought cases.

4.9 Compatibility of management practices with CGAP

The construction of infrastructure for liquid waste, the reduction of losses from water transmission systems for water supply purposes, and the utilization of recycled water to strengthen the water balance and enrich aquifers are essential applications of management practices adopted by the Cyprus State. Simultaneously, through the RDP, it promoted problems that most concern irrigation (water saving, improvement of water use efficiency, and water transport and storage infrastructure to meet irrigation needs).

Regarding interventions' management, the synergy with the CGAP is ensured since the RDP interventions aim to improve the management of the water resources, the enrichment of the aquifers, and the strengthening of the water balance. The interventions will also help achieve the goals for tackling the effects of climate change concerning water scarcity and drought. The aim is to meet the need to promote all necessary interventions for the rational management of natural resources, adaptation to climate change, and a low carbon economy transition.

Coordination of interventions, monitoring, and collecting necessary data for the impact assessment will be ensured by utilizing CAPO's integrated information systems.

The Department of Agriculture, through official controls, confirms that the practices used on a farm are following the CGAP or other equivalent practices at all stages of primary production, either during the growing season or at the harvest stage. These inspections are carried out randomly and following a risk analysis carried out by the competent authority. Upon completing the inspection in a facility, a relevant inspection report is issued, which the Inspector delivers to the producer to know the inspection results. In case that it is necessary to record specific recommendations to take corrective action on behalf of the responsible producer, it is given a reasonable time for compliance with the Inspector's instructions. At the Inspector's discretion, a plant product sample will be taken to confirm the absence of any microbial risk.

The impact of CGAP requirements is limited, as the CGAPs do not cover several important water issues. Currently, CGAP does not oblige farmers to limit phosphorus use or pesticide application in areas directly adjacent to aquatic systems, even when it is agreed that these issues need to be readdressed. Phosphorus is contained in fertilizers and is used in animal feed. It can harm water quality, causing, e.g., eutrophication. As far as pesticides are concerned, although they protect crops from damage caused by weeds, diseases, and insects, they can be harmful to human health, wildlife, and the environment. Only a small percentage of the applied pesticides reach the targeted pests, while most of them are harmful to the environment, for example, aquatic systems. Nevertheless, Cyprus could take the initiative to address these problems by adopting and incorporating new measures, e.g., restrictions on the use of pesticides in the CGAP for restraint zones.

5 APPLICABILITY OF CODES OF GOOD AGRICULTURAL PRACTICES IN LONG RANGE

5.1 Introduction

CAP emphasizes the sustainable management of natural resources and environmental protection by providing environmentally friendly farm practices incentives. These actions include systems of crop rotation, Integrated Production Management and organic farming, resulting in improved groundwater aquifers, improvement of the structure, chemical composition and soil fertility, and preservation of biodiversity.

Besides, water scarcity is one of the most severe problems faced by Cyprus over the centuries. Droughts are widespread, and it is anticipated that climate change in the Mediterranean basin will lead to further reductions in annual and seasonal water availability.

Given these challenges, the need to develop and implement measures that aim at increasing water availability and water security is a priority. The objective is to satisfy the water demand to the maximum extent possible. In this context, CGAP was implemented. In order for CGAPs to be implemented on a large scale, special attention should be paid to education, the adoption of precision agriculture, and the support of farmers by agricultural advisors.

The European Commission proposals also include robust policy integration tools and need to be further supported and enriched in implementing rules. A commitment of 20% of the EU budget to integrate the climate dimension, proposed in PAF, aims to increase support for all water-related measures concerning climate change adaptation. Cyprus should make more efforts to consolidate its policy at a national level.

5.2 The role of education/training of Cypriot farmers on the broader application of CGAPs

The structural problems faced by the agricultural sector in Cyprus, including the low level of education of those employed in agriculture, concerning the general population, are significant constraints on its development.

The role that education is called to play in the primary sector of the Cyprus economy is evident. Thus, the broad term "agricultural education" means the branch of vocational education. Education is provided, which aims to contribute to the development of the agricultural sector and the rural area.

Agricultural education refers to education for the development of the rural sector. It aims at the development of agricultural income, mitigating its differences with other sectors of economic activity, improving the standard of living and work of rural families and raising the cultural level of the rural population, the rational use of factors of production: labor, soil, capital and management, the preservation of the natural environment in conjunction with productive agriculture, the formation of environmental awareness of the rural population and especially the "Young Farmers" and the development of farm management capacity by the farmer-head of the holding.

Regarding the training programs in the context of agricultural education, their primary orientation is vocational training to achieve:

- Improving knowledge in the fields of plant, animal, fishery, and forestry production.
- The acquisition of sufficient professional knowledge by employees in the primary sector can better meet their obligations arising from their inclusion in Community Regulations of Restructuring, modernization, improvement, support, strengthening of Agricultural, Fisheries, Forest Production.
- The acquisition of knowledge in order to improve the protection of the environment in all areas.
- The acquisition of complementary knowledge to agriculture, in order to improve the family agricultural income from the exercise of non-agricultural activity (multi-employment).
- The acquisition of sufficient knowledge to improve the conditions of standardization, marketing, distribution, and cost of agricultural products.

The triptych of farmers' vocational training in the context of both initial and continuing vocational training is characterized by the following:

i. The farmer should know and understand how the agricultural policy will develop in the short, medium and long term to know the business opportunities and opportunities given to him.

ii. To know the prospects of its production in the product markets.

iii. To know the appropriate production techniques and to be continuously informed about developments and new processes.

Learning is not about acquiring information but about developing a whole process by which farmers will process and utilize information. Each educational program's thematic educational units aim to inform the trainee and provide him with professional supplies to achieve the above purposes.

The training in Agriculture includes training in technical issues of plant and animal production, qualitative and quantitative improvement of the agricultural production, protection of the environment concerning the practice of agriculture, and use of environmentally friendly techniques. Especially concerning the environment, the content of agricultural education has been enriched with unique modules on environmental protection, recognizing it as inextricably linked to agricultural activity. Farmers with higher levels of education understand better the effects of agrochemicals on natural resources. Simultaneously, according to research by Feder et al. (2004) and Larsen et al. (2002) found a relationship between the level of agrochemical use and relevant knowledge.

Nowadays, the need for agricultural education is more urgent than ever, given the introduction of numerous technologies in the production process, the management skills required by farmers, and the need to continually adapt to market demands in a highly competitive environment. In the past, formal qualifications through education were not considered a prerequisite for effective agriculture engagement. In addition, there was no serious concern for agricultural education, and no action had been taken to establish appropriate training mechanisms. Engaging in agriculture was not (until recently) an attractive career choice for young people due to social stereotypes and the prevailing standard of living. The majority of those engaged in the agricultural profession are even today, despite the signs as mentioned above of improvement, characterized by a low level of education than other sectors of the economy—the students in rural areas of Cyprus after compulsory education show comparatively higher rates of resignation. Agriculture is almost a mandatory occupation for households in disadvantaged areas, as the remaining employment opportunities in them are few and limited.

The role of education in adopting alternative and sustainable agricultural practices is essential. Sustainable agriculture is a system with low capital requirements, but it is particularly intensive in labor and highly specialized. More specifically, the adoption of sustainable forms of agricultural activity implies increased management work and adequacy needs. Educating and informing farmers is of primary importance so that farmers who adopt alternative and sustainable farming practices can cope. Thus, when it comes to promoting agricultural innovations, agricultural education will play an essential role. The peculiarities of sustainable systems lead to synchronized and organized use of agricultural training methods and farming applications. Bell and Bayley (2011) emphasize that such an approach would be beneficial for farmers and promote it as necessary, given society's changes and the agricultural sector.

5.3 The role of agricultural consultants in the broader application of CGAPs

For the proper operation of agricultural holdings, professional agronomists – consultants / agricultural implementers- must give the impetus to the farmers and teach them the necessary techniques of improving their holding and general of the upgrading of the countryside. Professional agronomist performs a complex role. He acts as a consultant who examines the local characteristics of the agricultural holding, gives guidelines, encourages and supports the farmers and aims to change the agricultural population's behavioral patterns by using appropriate communication-educational methods.

The agricultural consultant explains and promotes the various agricultural development programs to farmers. At the same time, acquiring organizational and managerial skills, with their active participation in the overall process of design and implementation of these programs and taking advantage of appropriate opportunities to modernize their farms to increase their income and quality of life.

The consultants also help to develop complementary activities, intending to boost agricultural income, in order to maintain the socio-economic fabric of the countryside and its culture, as well as to create the conditions for better living conditions, including, among other things, the organization of associations, cooperatives and agricultural organizations. The role they play in environmental actions, such as agri-environmental measures and cross-compliance, is also essential, while at the same time proposing new production methods for the production of healthy, safe products. Besides, they contribute to the proper management through the optimal use of production factors, reducing production costs, utilizing modern technology and marketing opportunities, and improving production and the operation's financial results. Finally, they inform farmers about the new institutional frameworks being developed in the EU.

5.4 The role of Precision Agriculture in the broader application of CGAPs

The purpose of the P.A. is to increase agricultural income by increasing yields, reducing production costs, and reducing the environmental impact. It could be part of a more general rational farming application system, directly related to or leading to sustainable agriculture.

Precision farming is a system of more precise management of field inputs, localized by places, based on corresponding localized outputs (yields). More specifically, precision agriculture is based on technologies and media capable of accurately recording the current situation in the field and its variability over time, manage the collected information and data, and finally apply the inputs to meet the needs of each point and time separately. These technologies apply to any type of agricultural holding.

The following is a summary of the application technologies of precision farming systems.

Geographic Information Systems (GIS). GIS is a dynamic set of tools for collecting, storage, retrieval, transformation, and rendering spatial environmental data to meet specialized requirements. They manage and combine incoming information, giving results in the form of maps and tables. Maps, called thematic maps, show the distribution in the space of any factor for which data are available (e.g., altitude, yield, nutrients, soil moisture, etc.) and are products of integration processes of a limited number of known values.

Global Positioning Systems (GPS). They are systems that make it possible to locate and record the location of any point on the surface of the globe. They use satellites' signal, received by special instruments, which calculate the geographical position and the altitude of their position and the time.

Variable-rate technology (VRT). It is a system of agricultural engineering, which change the amount of application of inputs (seeds, fertilizers, water, medicins, etc.) or change the type applied (e.g., the variety of seed or the type of fertilizer) at the same time that they use these inputs, depending on the point of the plot in which they are located.

Performance Monitoring Systems. They measure and record crop yields during harvest, as well as product quality characteristics. Measurements are recorded in tables with the respective spatial coordinates' values, taken simultaneously by G.P.S. to link the yields to the specific position.

Remote sensing is the science of obtaining and analyzing information about the environment from detectors that are not in physical contact with the environment. The remote sensing in P.A. finds particular application in irrigation. It can reduce irrigation water and a reduction in irrigation costs up to 25% of total costs. In research on remote sensing methods, they demonstrated multispectral satellite imagery's potential to evaluate irrigation management. Since then, remote sensing has played a growing role in water management and has aroused many researchers' interest.

Measurements in the Field. They are measurements of the characteristics and properties of the crops or the soil by sampling. They are performed either with analyzes in the laboratory or by sensors. Although the detailed recording of field data is considered necessary for the management of agricultural holdings, the adoption of corresponding tools is limited. They are mainly used as accounting tools. Most of them are used to enter data in the office or at home and not on the farm and in real-time.

Among P.A.'s advantages, it is the possibility provided for traceability of its products, as well as the monitoring of its environmental impact and the recording of environmental indicators, through the technological systems it utilizes

The adoption of P.A. also has moral implications. The examination of P.A. can be included in a modern framework of a comprehensive view of sustainable agriculture. It aims to mitigate climate change, water pollution, and increasing resistance to the use of chemical plant protection products and land use to be passed on to future generations, without the burden of excessive use of purchased inputs as they are used purposefully.

5.5 Limitations, disadvantages, and advantages of large-scale implementation of CGAP

The Cypriot agricultural sector presents several peculiarities about agricultural sectors of other countries. Characteristics such as the fragmented lot, the intense geomorphological relief, a large number of different crops in relatively small areas, etc., make the work of the Cypriot producer difficult and reduce its profitability.

The impact of the application of CGAPs on water issues is limited so far. Cross-compliance has led to an increase in farmers' awareness and has resulted in some changes in agricultural practices related to water, in particular concerning nitrates and pesticides. However, the impact so far is limited, due to several essential water issues which are not covered and because the sanctions under the CGAP are not calculated based on the amount of damage caused and may therefore correspond only to a part of the relevant costs.

The adoption of CGAP and consequently of the instruments that enhance its implementation, such as the PA, the education - training of farmers and the cooperation with agricultural consultants is not always easy. Indeed, while it is often assumed that the above is always socially beneficial and, therefore, will be disseminated among farmers, in practice, this is not always the case. In particular, the adoption of innovations requires a series of interpretations as well as superior support. At the same time, it must necessarily offer something new and practically applicable by the farmer in order to improve the current situation. The possibility of applying CGAP to a large scale has limitations and disadvantages, but also several advantages, which are presented below.

The socio-economic obstacles involved in the adoption of CGAP, with the support of PA, education/training of farmers and cooperation with agricultural consultants, are apparent. Costs are often very high and are the main limiting factor for farmers. In times when access to capital, own or borrowed, is difficult, such as in times of financial hardship, there are funding constraints, as it is required the supply of a high value, fixed capital.

Several of the parameters necessary for the implementation of CGAP are based on high-tech systems. While significant efforts are being made to adopt and utilize such systems, it is understandable that their growth rate is relatively low. Among other things, there are delays in the formulation of a comprehensive program of Agricultural Applications, which will provide advice and make proper use of the knowledge and information produced.

In addition, besides the cost of adoption and the need for technological progress, there are obstacles related to training programs and counselling, quality control of the necessary data, the lack of a comprehensive implementation guide of the various systems that will strengthen the implementation of CAPs to a greater extent and the environmental dimension.

On the other hand, in general terms, the benefits of implementing CAPs can be distinguished in three main areas: the economy, the environment, and society.

From an economic point of view, the introduction of more rational decision-making systems in agriculture brings significant economic benefits, offering the possibility of increasing the profit margin and overall profitability without increasing the cost of cultivation. The main goal of the CGAP's implementation on a large scale is to increase profitability, which comes from more efficient use of agricultural inputs (e.g. fuel, chemicals, labor, machinery), increasing crop yields in terms of production and the possibilities of selective harvesting, especially for high-quality products. The application of CGAP, to a large extent, can help the farmer to achieve these goals by understanding the diversity of soil and crop properties, as well as other factors related to agricultural yield variability. This will facilitate decision-making processes and the general management of crops. It should be noted, however, that increased profitability is based on the assumption that the savings realized by any relevant application significantly exceed the cost of either the additional work required or the purchase of specialized equipment. Therefore, the findings regarding increased profitability in the case of precision farming are mixed. For example, Timmermann et al. (2002) showed that the use of smart farming systems to control herbicides results in significant cost savings in the respective inputs, which, however, does not automatically translate into profitability.

These factors pose some challenges to farmers regarding the full use and utilization of precision farming systems. In addition to requiring intricate knowledge of the mechanical operation of equipment and data collection, these systems also include a high level of knowledge and experience in managing the latter, interpreting them and using them in decision-making processes to implement optimal agronomic solutions. It is clear, then, that these skills differ significantly between individual farmers, suggesting that it is not always possible to take full advantage of the benefits of implementing CGAP on a large scale. Apart from the technological factor, fluctuations in expected profitability also come from the initial investment's cost, which has decreased over time. However, it remains very high, as financial incentives and subsidies provided to farmers have not made precision farming systems affordable for most of them. As a result, the high cost of such investments often hinders profitability, at least in the short term.

In addition to benefits concerning profitability, the widespread application of CGAP offers enhanced opportunities to improve the quality and yield of a crop. A classic example, in this case, is viticulture, where the quality of the grapes reflected in the wine as its final product varies considerably between the vineyards. Similarly, the yield of grapes is not the same from vineyard to vineyard, and even in entirely uniformly cultivated areas, there are differences in yield and quality, which are due to spatial variability in terms of physical properties and soil fertility. Therefore, CGAP, at least in theory, allow better management of variable output, e.g. by verifying the requirements for foliar fertilizers, leading to increased yields on low-productivity crops, as well as to improving their quality standards, even in some plots of the same vineyard.

Regarding the environment, the implementation of CGAP on a large scale has undeniable benefits for reducing environmental impacts and risks, in addition to the possibilities of optimizing production and upgrading the quality of products. With the widespread application of CGAPs, the use of precision farming systems is increasing, and human intervention and production fluctuations due to natural factors are reduced. As a result, CGAP has become crop management practices directly linked to sustainable agriculture and sustainable rural development. Indeed, there is clear research evidence that the use of CGAP leads to a reduction in environmental degradation, including an increase in fuel efficiency resulting in a reduction in the environmental footprint of carbon. It has also been found that the adoption of these practices has significant benefits in reducing nitrate leaching in crops, proving that CGAP can reduce groundwater contamination and soil erosion. Also, CGAP makes a significant contribution to reducing the use of agrochemicals, which is a crucial objective of agricultural policy and environmental legislation both in the EU and in most developed countries around the world. The benefits in environmental terms are essential for farmers, as they facilitate their compliance with environmental legislation. Several studies have shown that such applications have the potential to significantly reduce the environmental impact caused by agriculture while improving the alignment between agricultural inputs and crop needs leads to a reduction in the use of the former, which also reduces the environmental imprint of a crop. For example, using only the required nitrogen to achieve maximum crop yield significantly reduces nitrate contamination in groundwater and pollution of water sources. These benefits are particularly important not only for the individual crop but also for agriculture as a whole, as non-point agricultural pollution is a significant cause of water pollution in large geographical areas. Overall, therefore, in addition to enhancing economic efficiency in farming activities, precision farming methods also offer environmental protection, having an undeniable economic and ecological superiority over conventional methods.

Agricultural production will be more sustainable and efficient. An increasing number of producers will be able to manage their cultivation sustainably. The results are expected to be impressive, as they will be able to produce better quality products while increasing the quantity produced. Optimized planting, the use of plant protection products and harvesting with the help of intelligent agriculture will increase yields. In contrast, accurate information on production processes and quality will help producers to adapt and enhance the unique characteristics of the products, as well as their nutritional value. With the widespread application of CGAPs, from an environmental point of view, concerns about ecological balance and the conservation of natural resources are eliminated. Environmentally responsible and sustainable production is envisaged. Natural life and biodiversity are preserved. Potential damage to the environment is prevented.

Also, the application of CGAP to a greater extent will lead to even lower water consumption, as producers will be able to adapt systems with ground sensors and take advantage of the most accurate weather forecast to their advantage. Improved water management in agriculture will help reduce energy consumption for irrigation. Also, better use of soil moisture conditions, after sowing, will improve weed control capacity and reduce the number of farms. Crop production will increase with the use of fewer chemicals. At the same time, spraying costs are significantly reduced, as well as disease problems. As a result, spraying becomes more efficient.

The products are considered healthy and reliable as they are produced according to good agricultural practices for production companies. Given that the manufacturer will have protected the earth in this way, there will be an opportunity to outsmart more products. When they need it, they can find it easier and with low credit interest. They can mainly benefit from state support. Also, competitiveness is increasing in domestic and foreign markets. In the long run, production costs decrease and production increases. As consumers increase the quality and reliability of their products, the risks associated with food safety and human health are reduced.

The implementation of CGAPs on a larger scale will also raise farmers' awareness of water degradation, as well as the environmental reasons for introducing standards to prevent its degradation. At the same time, agri-environmental measures will encourage farmers to protect, maintain and improve environmental quality.

Finally, equally important are the benefits that arise in terms of the efficiency of individual agricultural work and tasks (e.g. 18 fleet management, storage facility management, production control). For example, early detection of diseases in trees and plants through sensor technology, monitoring of field conditions (e.g. lighting, soil moisture) and effective monitoring of crop irrigation needs to offer the enhanced potential for improved production and quality of cultivation. Respectively, the reduction of working time in standard procedures (e.g. sowing), the reduction of the costs of pesticide applications and the reduction of the use of inputs (e.g. irrigation water) lead to a significant reduction of costs, and therefore, an increase in profitability. In conclusion, at the farm level, the benefits of smart farming are incredibly significant, allowing the quality and efficiency of production to be enhanced, as well as the reduction of environmental risks.

6 CONCLUSIONS

Agriculture is the largest consumer of water in Cyprus with 91.5mcum per year (70% of total consumption). Water quality data highlight the need for action as there is an excess of nitrogen (115.8 kg N/ha/y, EE - 27:50.8) and phosphorus (20.3kgP/ha/y, EE - 27:1,8) to 17.4% of groundwater samples which are classified in the low-quality category (13.3% EU - 27). The recent institutional arrangements (definition of a single water authority but also the full implementation of the Water Directive) in combination with the provisions of the CAP and the implementation of agri-environmental measures are expected to reduce the negative impacts on water quality. The promotion of collective irrigation projects for the utilization of surface runoff is also considered necessary, in order to reduce the pressures on the underground aquifers from the drillings. The total area of vulnerable zones in nitrates is 460 Km^2 (8.4% of the area of free Cyprus). There is a need to protect water in vulnerable areas, through appropriate measures to reduce nitrate pollution from the use of fertilizers and livestock waste and to introduce acceptable practices for the use of treated water and mud in agriculture to protect public health and the environment.

In order to improve water and air quality in Cyprus, the measures that will be proposed should strengthen the implementation of restrictive measures. The main goal should be to improve groundwater aquifers in nitrogen-sensitive areas, increasing the proportion of farmers who will use friendly to environment agricultural practices. Also, it is essential to increase improved irrigation systems in crops that require high irrigation needs and the possibility of utilizing water from sewage treatment plants for irrigation purposes.

Opportunities should also be taken from the full implementation of the Water Directive and the introduction of pricing, from the possibility of utilizing investment measures for the implementation of collective investments for water use, from the implementation of collective investments by livestock units for the installation of water treatment systems, from the utilization of ICT applications and the adoption of modern irrigation techniques, from the climatic conditions that favor the use of RES, from the coverage of the basic needs of modernization of agricultural holdings in Cyprus through the implementation of RDPs, which allows better targeting of investment measures to reduce nitrogen and methane oxide emissions from agriculture.

In addition, they should alleviate the weaknesses arising from the high consumption of groundwater resources leading to soil degradation, the minimal use of closed hydroponics systems in greenhouse crops, the limited use of integrated water management information systems or the limited water management energy in pumping groundwater for irrigation due to the great depth of pumping.

In addition, they must eliminate the risks expected from insufficient irrigation and the continuing decline in available water supplies, the intensification of water scarcity due to climate change, and the continued abandonment of agricultural land by non-prohibition. from the limited interest in participating in agri-environmental measures, from the delay in the implementation of all the measures provided for in the Management Plans provided for in the Water Directive and from the lack of investment interest in the implementation of investments.

Ensuring water adequacy, to meet current and future water needs, and balancing demand with available water requires a change of mentality and the implementation of a new strategic direction which should recognize the limited availability of water, to reflect the real value of water, the need for economic viability and ensure fair access to limited water resources. It should also focus on demand management and alternative water sources, assess risk analysis and the effects of climate change, and ensure the quality of water resources and the environment. As a result, users will have to use water more efficiently and in smaller quantities than before. Everyone will have to pay according to the water service offered at a price, which will be reviewed and revised accordingly.

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