CLIMATE CHANGES IN NORTH AFRICA AND THE POSSIBILITIES OF ADAPTING TO IT WITH ECOSYSTEM APPROACHES

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Abstract
Climate changes in North Africa and the possibilities of adapting to it with ecosystem approaches
The article deals with geographical characteristics of North Africa with the focus on climate changes which are reflected in particular by the increase in the average temperatures and decrease of precipitation. These conditions have a direct impact on the reduction of agriculture and on the changes in land use. Further on, this has a direct impact on the way of life of people. The use of ecosystem technologies (imitation of nature) can be an easy and effective way to contain water in the region. Water also has a significant role in survival. Therefore, the use of ecoremediation (imitation of nature) in North Africa could mitigate climate changes.
Key words
North Africa, climate changes, ecosystem technology, ecoremediation

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1. Introduction

For the period 2020-2030, experts predict a decrease in rainfall for most of the area. Considering the year 2012, the lowest precipitation is predicted for south of Egypt (more than 20% lower), Morocco, central and coastal areas of Algeria, Tunisia and the central of Libya where they predict that the annual precipitation will lower for 5-15 %. In some areas, it is expected that the precipitation will increase (0-20 %). The lowest precipitation for this period is predicted for Morocco, the central and north part of Algeria and for Tunisia (Terink, Immerzeel, Droogers 2013). It is expected that the annual precipitation will lower for about 4 to 27%. Even though, it is expected that there would be more torrents. A huge issue will be a water shortage mostly because of the increase in the evaporation level. Therefore, these areas will be most affected by the lack of precipitation (Radhouane 2013).

North Africa has specific natural and social elements that have a significant effect on the abilities of adaptation to climate changes. With the aim to determine the types of areas for adaptation to climate change, we have typified North Africa to similar areas as those areas. In North Africa, the average annual precipitation is low since some areas like Libya and Egypt receive less than 25 mm of rainfall annually. Desert areas receive less than 200 mm of rainfall annually. More rainfall, up to 1000 mm a year, is received in the coastal areas of Morocco, Algeria and Tunisia (Radhouane 2013, Terink, Immerzeel, Droogers 2013). The countries in North Africa receive on average 25-1000 mm of rainfall annually. Deviations are caused by geographical location, closeness to the sea and orographic barrier. The most drought months in North Africa countries are the summer months (June, July and August). In these months, the precipitation is very low, for example, in West Sahara falls only 1,6 mm of rainfall. Precipitation is mainly concentrated in winter time (December, January and February) in the form of rain that falls mostly on the coastline. The only exception is Sudan, which receives the most rainfall during the summer months. The average monthly precipitation decreases towards the east and the hinterland area (The World Bank 2015).

2. Methodology

The purposes of the typification are to recognize similar areas in North Africa and to plan similar measures to adapt to climate changes. We have developed a new criterion for the typification. The criteria consider the current conditions of natural resources and social process. The typification takes into account the following parameters:

- Common physical-geographical characteristics
    - The reduction of the average precipitation
    - Raising of average air temperature
    - The increase in consumption of freshwater
- Common social-geographical characteristics
    - The decrease of attachment of the economy on agriculture
        + Gross domestic production
        + Workforce
    - Land use
        + Cultivable areas
        + Irrigation agriculture.

We gained the information about North Africa from African Development Bank (2015), Central Intelligence Agency (2015), Radhouane (2013), Terink, Immerzeel and Droogers (2013) and United Nations Environment Programme (2014).

3. Climate changes in North Africa

A major part of North Africa receives a low level of precipitation and that has an impact on the poor water conditions. The average total annual precipitation in North Africa is estimated at 1503 m^3/annually, which is equivalent to 7 % of total annual precipitation in Africa. However, the distribution of the precipitation varies in Africa. The most rainfall, almost 7,5 %, falls in Sudan and only 3% falls in Egypt. 5,6% of precipitation falls in river networks or it is used for filling ground water. The rest is lost by evaporation, transpiration and disappearance. Availability of water per capita was 26 m^3/annually in 2000 in Egypt and up to 1058 m^3/annually in Morocco for the same year (United Nations Environment Programme 2014).

There are even more differences if we compare North Africa countries to countries of Sub-Saharian Africa. Total of internal renewable fresh water resources in North Africa present 2,5% of the total in Africa, but the withdrawal of it presents 46% of the total in Africa. This difference partly reflects harsh climate conditions. Renewable fresh water sources are supplied with water from hinterland river flows (alluvial aquifer Nil) or from the rainfall (coastline of the Mediterranean Sea (United Nations Environment Programme 2014).

This region heavily depends on rare winter rainfall and short rainy seasons. Agriculture has adapted to this weather conditions. Drought areas on the South of the region entirely depend on irrigation (Radhouane 2013). Climate changes and population growth will push people to marginal dry lands that are already sensitive for desertification (United Nations Environment Programme 2014).

North Africa is located in the subtropical zone, an area of constant variation of polar and tropical air masses and thus dry and wet periods (Medved 1978). Summer drought is prolonged, the more we are heading south. North Africa countries have the highest temperatures in summer months and the lowest temperatures in winter months. Data from the year 1990 to 2009 show that the average monthly air temperature rarely falls below 10°C. What is more, in the summer the average monthly temperature rises even over 30°C. In comparison to the period from 1930 to 1960 the average monthly air temperatures have increased in every country. The only exceptions are Egypt and Libya, where the average monthly temperature has decreased in some months, but only for 0,1°C (The World Bank 2015).

An annual temperature increase from 2,2°C to 5,5°C is expected for North Africa by the end of the 21st century. The temperature increase will be higher in the hinterland than by the coastline and it will be more noticeable in the summer months (2,7°C - 6,5°C) than in winter months (1,7°C - 4,6°C).

North Africa is an extremely dry country. The drought increases on the account of climate changes, in particular, due to lack of precipitation. North Africa received in average more rainfall in the period from 1930 to 1960 than in the period from 1990 to 2009. As it is shown in Tab.1 the average annual precipitation of North Africa has decreased in average for 26,3 mm in the last 20 years. During the period from 1930 to 1960, there was less precipitation in Sudan (24,4 mm/annually), Morocco (15,2 mm/annually) and West Sahara (1,3 mm/annually) in comparison to the period from 1990 to 2009. Even though, this is a small amount considering average annual precipitation the differences indicate that global climate changes are noticeable also in North Africa.

Tab. 1: The variation of rainfall amounts across North African countries in the years 1930–1960 and 1990–2009.

Country	Change of precipitation (in mm)
Western Sahara	-1,3
Morocco	-15,2
Algeria	1,6
Tunisia	8,9
Libya	2,2
Egypt	1,9
Sudan	-24,4
Northern Africa	-26,3 mm

Source: The World Bank 2015.

The position of North Africa in subtropical zone influences on the temperature of the atmosphere. North Africa is a region of extreme records. The highest air temperature in the world was 57,8°C and it was measured in 1922 in Libya (The World Bank 2015). Global climate changes also have an effect on the increase of average annual and monthly air temperature during the period from 1930 to 1960 and from 1990 to 2009. During those periods, the temperature increased the most in Sudan (1,11°C) and Tunisia (1,02°C). The temperature increased the least in Morocco (0,32°C) and Egypt (0,4°C).

3.1 Regions with increased consumption of freshwater

A total of annual consumption of freshwater in billions of cubic meters is increasing. The largest consumption of fresh water was in 1977 and 2013 in Egypt and the lowest in Tunisia. In the last 35 years, the consumption of freshwater in Africa has increased by more than 28 %. Moreover, in Libya, it has increased by 72%. Though, Tunisia has the lowest consumption of freshwater that does not neglect the fact that freshwater consumption in Tunisia has increased by 62,5% from 1977 to 2013.

Every year, the number of population is increasing and due to that the need of food and more cultivated land is also increasing. Since the few fertile soils are already cultivated, more dry soils are also being cultivated. This demands irrigation for which freshwater is used. Another issue that comes along with this is a significant water loss before water comes to the cultivated land because of old irrigation systems. Many current issues of North Africa countries are also connected to the urban wastewater treatments and industrial sewage that are being removed inappropriately. The need of renovation and water supply systems also present an issue.

3.2 Regions with the decrease of attachment of the economy on agriculture

The North African economy depends on natural conditions. Most of the cultivated land is concentrated in the coastal areas. Due to physical-geographical and socio-geographical changes like global warming and the impact of human activities on the environment, the North Africa countries have decreased the dependence on agriculture. “The gross domestic production is the value of all the finished goods and services that are produced within a country’s borders in a year” (Finančni slovar 2009-2011).

In 2013, the most significant contribution to value added were service activities, followed by industry. The least value added was provided by agriculture. The contribution of services to the total gross value added was the largest in Tunisia (61,0 %) and Morocco (53,2 %). Services add the lease value in Algeria (28,0 %). A significant contribution of service activities to GDP of a country is an indicator of technological progress, foreign investments, globalization, successful trade links and structural changes. Industry contributes the biggest share of gross value added in Algeria (62,6 %) and Libya (58,3 %), where the industry is strongly depended on and connected to oil and its derivatives.

The smallest part of agriculture production is in Libya (2,0 %). The biggest part of the agricultural production is contributed by Sudan because of the good climate conditions and the river Nile that enables irrigation. Agriculture in Egypt also contributes 14,5 % to GDP, this is possible in Egypt because of irrigation by the Nile river.

Agriculture requires workforce. The highest percent of persons employed in agriculture has Sudan (80,0 %), west Sahara (50,0 %) in Morocco (44,6 %). Of all North African countries, agriculture is the largest part of gross domestic production in Sudan. This is due to good climatic conditions and the river Nile that enables irrigation on the droughty north part of the country. West Sahara and Morocco also have favorable climate conditions, especially along the coastline where the Mediterranean climate allows to grow olives, wine, citrus fruits and vegetable. These are cultivated on huge fields that require workforce. Most of the harvest is exported. The exported harvest presents 33% of all exports. A vast amount of surfaces is irrigated with modern systems.

The lowest share of people employed in agriculture is in Algeria (14 %) and Libya (17 %) where they devote more attention to industry and services since they base their economy and export on oil.

Tab. 2: Percentage of employed in agriculture in 2004.

Country	Percentage of employed in agriculture (%)
Algeria	14
Egypt	29
Libya	17
Morocco	44,6
Sudan	80
Tunisia	18,3
Western Sahara	50

Source: Central Intelligence Agency. (2015). The world Factbook. Accessed February 15 2015 from https://www.cia.gov/library/publications/the-world-factbook/.

3.3 Regions with significant changes in the proportion of cultivated land

Cultivated land and fields in North Africa are mostly by the coastline and on the areas where irrigation agriculture is possible. The percentages of cultivated areas were the highest in 2011 in Morocco (17,79 %) and in Tunisia (17,35 %) because these two countries have the most appropriate physical-geographical and socio-geographical conditions. The cultivated areas are mostly by the coastline and in the highlands where irrigation is possible. In the last ten years, the percentages of cultivated areas have been increasing at the expense of increased number of population and the increased demand for food.

Tab. 3: The percentage of cultivable areas in North African countries in the year 2011.

Country	% of cultivable areas (1977)	% of cultivable areas (2011)	% change of cultivable areas between the years 1977 and 2011
Algeria	2,9	3,15	0,25
Egypt	2,51	2,87	0,36
Libya	0,99	0,99	0
Morocco	16,69	17,79	1,1
Sudan	5,18	6,76	1,58
Tunisia	22,7	17,35	-5,35
Western Sahara	No information available	0,02	/

Source: Central Intelligence Agency. (2015). The world Factbook. Accessed February 11 2015 on https://www.cia.gov/library/publications/the-world-factbook/.

Agriculture demands adjustments because of extreme weather conditions and rare fresh water supplies with the exception of the Nile in Egypt. We can find irrigation agriculture in all countries of North Africa. In Sahara water is available only deep under the surface and it can be accessed only in the oasis. In the oasis, the underground water is near the surface and it comes to the surface in springs or it is retained in hollows. However, in many places, people have to dig wells (Krušič 1992).

Tab. 4: Off irrigation farming areas.

Country	Off irrigation farming areas (km^2)
Algeria	5694
Egypt	34220
Libya	4700
Morocco	14850
Sudan	18900
Tunisia	3970
Western Sahara	No information available

Source: Central Intelligence Agency. (2015). The world Factbook. Accessed on 11. 2.2015 from https://www.cia.gov/library/publications/the-world-factbook/.

Common physical geographical characteristics have shown that the average precipitation is decreasing and the average air temperature is increasing in the countries of South Africa. Freshwater sources that get water from rainfall are additionally overloaded and their use is increasing.

In North Africa countries, the common social-geographical characteristic show that economy is less depended on agriculture than other economy sectors. The share of gross domestic production and employment shows that agriculture contributes only a small percentage of gross domestic production and that agriculture employs only a small amount of workforce considering other economy sectors. The main reason for this is because of foreign investors that see an important basis for future development in countries of North Africa. In some places, there is also a low-cost workforce and well-educated workforce. This shows that North African countries are in postindustrial period and that they invest in research and development. The main investments of foreign investors are services, trade, traffic infrastructure, education and medicine. Therefore, the economy does not need to depend on agriculture and the after-effect is that there are fewer people employed in agriculture. It can be said that North African countries are successfully introducing western management standards of the economy.

Nevertheless, countries in North Africa are still very attached to the land. Percentage of cultivated land has increased in all North African countries from 1977 to 2011. The number of population is increasing and with it, the need for food is increasing and the need for new land for cultivation that are expanding to droughty areas.

Cultivated lands are overloading and polluting coastline areas. This, along with big population density, the increasing number of population and the use of fertilizers or pesticides are some of the reasons for catastrophes. Some of these catastrophes are disease, social problems, desertification, soil erosion and torrential downpour. Expansion of cultivated land effects biotic diversity reduces soil coverage and influence on larger and more intensive environmental issues.

At the same time, the expansion of cultivated land is burdening irrigation systems. The cultivated lands are expanding to drought areas that need moister and fertilizers for cultivation. This overloads irrigation systems and freshwater sources. Moreover, the irrigation systems are old and that causes unnecessary water loss. Extreme use of fertilizers and other chemicals to increase the fertility of sandy soils and to maximize the harvest are overloading and polluting the soils, underground water and freshwater sources.

Moreover, freshwater sources have been the reason for fights and disorders in the past. They could be caused because of unequal access to water or because of pollution. Current political disorders in North Africa are beginning to be a regularity. Mostly, because of diverse nationalities and the ancient people that still live there. The cause of the Arab spring was corruption, social problems and other economic factors and it took place in all countries of Northern Africa. The number of victims is enormous, but the positive consequences will not be visible for a long time.

4. The use of ecosystem technologies for adapting to climate changes

The concept of ecosystem technology or ecoremediation (ERM) means the usage of natural processes for restoration and protection of the environment (eco + remediation = »natural renewed revival«). Using ecoremediation methods we can decrease and abolish the consequences of agricultural pollution, tourism, traffic, industry, dumping grounds and settlements. Ecoremediations mean returning to nature, aiming to save and restore natural balance, where these kinds of areas can give an opportunity to develop new working places and additional activities. Ecoremediations have already been recognized as perspective and continual approach, where natural and conatural processes and systems are being used in favor of the restoration of degraded environment and protection of natural environment. In practice ERM are used as constructed wetlands, conatural sanitations of deposits, riverine vegetation zones – balancing areas, side branches, artificial lakes, noise and/or dust reducing barriers, phytoremediation of polluted sediments, purifying soil and drinking water, tertiary purifying and purifying dangerous sewage water. By using ERM methods, less money is spent on sanitation of already threatened areas and continual protection of these is emphasized, which is a big advantage in a financial sense. ERM is entirely adjusted to the newest programme documents and strategies. Using ecoremediations also opens the possibility to save energy and even gain it (usage of renewed energy sources). We only list some of the benefits of ecoremediation methods: to introduce and implement them does not require pretentious financial investments; these are environmental friendly methods, that are natural from functional and aesthetical point of view; they have multipurpose effects, include simple, understandable and nature-friendly and acceptable procedures, that work as an addition to existing systems for preventing pollution etc. ERM are methods for integral environment handling, therefore additional studies to current environment managing plans need to be made.

Tab. 5: Systems and methods for retaining water in agriculture areas.

Water resources	Systems and methods
Surface retention (habitats)	Systems that form an appropriate structure of land use with the help of: – Systems of tillage fields, meadows, forests, ecological areas and ponds, – Afforestation, planting protection belts, bushes, arrangement of terraces – Escalation of wet surfaces (peat bog and swamps)
Retention of soil	Systems of cultivation influence on the effect that waters have on soil: – Improvement of the soil structure, agriculture drainage, liming, appropriate agriculture technics, appropriate rotation, increasing organic matter in soil
Soil and underground water	Cultivating and systems for drainage are restricting surface flow: – Restriction of surface flow – Increasing of filtration abilities of soil – Measures against erosion, fitodrainage and agriculture drainage measures – Regulations for a flow from drainage systems – Ponds and infiltration wells for containing rainfall
Surface water	Hydrotechnical systems for sorting and preservation of water – Small water ponds – Regulation of water in the system of drainage and ditches – Water retention from the drainage systems – Increasing of water retention in river valleys with building dams.

Technical measures. Under this category, we can place most of hydrotechnical and drainage measures that try to slow down the water moving from the surface. Technical measures include building small water containers, dams for lakes, watercourses, ditches and drains, drainage water retention, the use of appropriate methods of drainage from closed surfaces (roofs, squares and streets) that allows water decanting to another open surface, restoration of small watercourses and flooded valleys with the use of technical measures.

Methods of planning (non-technical). Appropriate spatial planning for water catchment areas has an important role in water management. These measures focus on spatial planning that can limit the flow of rainfall and water when the snow melts. Under this category, we can place restoration of ecological areas, including small ponds, making of appropriate structure of fields, meadows and forests and planting of protection belts.

Agrotechnical (agriculture) measures. These measures depend on land use, including the use of the appropriate methods for cultivation on fields in the catchment areas of the rivers. The main measures in this category are to improve soil structure in the fields and forests, measures against erosion, protection of appropriate forest habitats that can prevent the flow of the water into the forest and maintain infiltration surfaces in urban areas.

On the contrary, it is not desirable that the agricultural areas are intended for retaining water all thought many agrotechnical measures can improve the structure of water balance in the reservoir.

Measures like the increase of organic matter in the soil, to stop making the closed layers that are the result of tillage and to improve the structure of hard soil can cause a better ability for the soil to retain water. Even a small increase in the capacity to retain water can retain a considerable amount of water. For example, the increase of the capacity to retain water for 10mm (10 l on 1 m^2) can retain 100 000 m^3 of water per hectare. From a water use point of view, this amount is not significant but it is a significant amount from the perspective of water retaining since this can limit the occurrence of floods.

All of the measures that are related to the increase of water retention in the river catchment area are a consequence of the changes in spatial planning and in the manner of land use and they can be a part of a non- technical form of natural water retention. These are the manners that are most similar to natural water retentions. With the limitation of surface flow of we increase the potential of retention of water in the region, the storage of water in the region and the ability to restrain water in the soil. The ability to restrain water in wetlands and forests is described below.

Wetlands. In regard to the ability to water retention of wetlands, we distinguish:

- The ability to retain soil water in the wetlands means the ability to retain water in the air parts/zones (pores in the soil);
- The ability to retain water in the wetlands means the ability to retain water on the surface of the wetlands
- The ability to retain water in levels occurs as the result of limiting the flow of the water from the surface with the formation of peat bogs on the ridge of the aquifer.

It is possible to retain rainfall in the soil pores (Air parts/zones; between the level of the land and water). The higher the water level is there is a lower ability to retain water (defined as the ability to be filled with water as the result of flood or plenty of rainfall)

Forests. Forests also have the characteristic of water retention. Many of science publications are dedicated to the role of forest on the structure of water balance in the catchment area. It is well known that forests balance water cycles with the help of water retention when it rains and with the increase of river level between the periods without rain.

Forests have a positive role in limiting floods when it rains often and when the snow is melting in the areas where there is a lot of snow to melt and where the soils are poorly drained. On the contrary, it is hard to prove that the role of the forest in the evaluation of the degree of the river flow. Forests have a significant role in the areas with a diverse surface and with weakly absorbing grounds. With water retention in the soil, we can limit the fast flow of the water from the surface.

The measures that involve building of devices and construction are causing an increase in the amount of water retention in catchment areas are called technical measures for water retention.

Water reservoir. Water reservoirs have an important role in the economy and in the environment. Depending on the role the water reservoirs have, we can divide them into the following categories:

- Water storage reservoirs for economic purposes: water retention for agricultural irrigation and for forestry, for human and agriculture water needs, water for aquaculture, flood protection, electricity (small water power plants)
- Water reservoirs for recreation and aesthetic purposes: swimming pool complexes, aesthetic areas (parks), fishing ponds (non-commercial aquaculture);
- Ecological reservoirs: enclave of water flora and fauna, biofilters (constructed wetlands) or reservoirs that serve as the filtration for water treatment;
- Water reservoirs that are used for the improvement of water balance structure: a supply for aquifers, flood protection, limitation of erosion, retention of surface flows in closed areas.

Drainage systems. A significant number of small aquifers were designed and deepened because of intensive agriculture. Moreover, many valley drainage systems were built and as a consequence of this, a thick network of drainage systems was made. The level of underground water has decreased in the areas of wetlands. In many cases, it is a possibility and a need to increase and restore the level of underground water without damaging agriculture. The drainage system shift water when there is too much water because of field crops and usually the level of underground water decreases more than it is necessary. In general, a sufficient drainage for the purposes of agriculture production is a drainage that can provide 6-8 % of the ventilation zones in a layer of the soil. There are technical solutions that enable the excessive flow of water from the drainage. This effect can be achieved with the use of so-called regulated spill from the drainage system or with building dams (dam constructions) on the drainage ditches. Devices that can be installed in the drainage fountain allow controlling the level of the dammed water and adjust to the current weather conditions. Dam constructions with the permanent threshold are built on ditches. The level of the ditch is normally located approx. 40-60 cm below ground level.

The results of several studies suggest that limiting the amount of runoff water from drainage systems or from the trenches does not cause negative effects on agricultural production. On the contrary, this type of regulation of run-off water causes that the stored water in plants can be used in the vegetation period. In general, water conditions can improve from the perspective of agriculture. In addition, the water that outflows from the drainage system is less loaded with nitrogen and phosphorus. Therefore, the regulation of the outflow contributes to the improvement of water quality in the rivers.

Drainage systems with regulated drains can be made on relatively flat surfaces. If the landscape is more diverse (a significant denivelation of drainage pipelines), is a more efficient construction of small reservoirs for water retention on outflows of drainage systems. The water in these reservoirs can be cleaned and used for irrigation or other commercial purposes. Similar solutions can be used in the system of drainage ditches.

4.1 The importance of adapting to climate changes

The most important benefit of adopting is water retention. Water retention plays an important role in limiting the negative effects of drought. The elevation of the

groundwater level and water retention of the soil profile due to the demands of agriculture and the environment increases the groundwater sources.
The most important benefits of the water retention measures are:

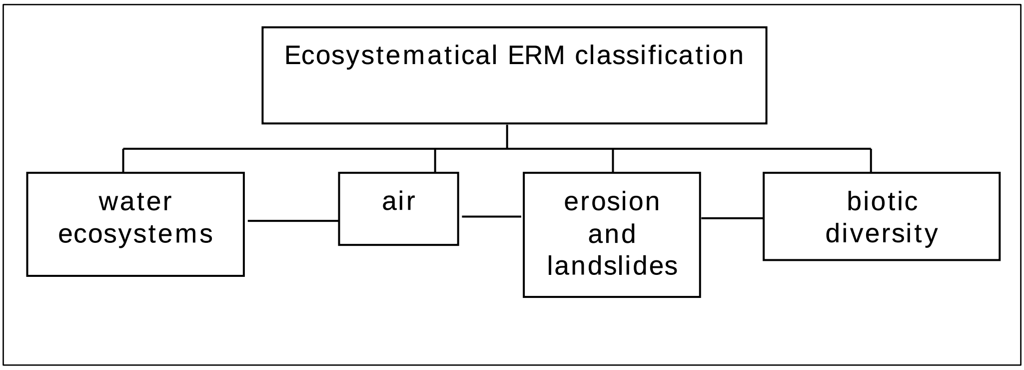
- Changes in the structure of water drainage in rivers, reducing flood wave and in some cases the improvement of low-flow conditions.
- Meet the needs of the forest and swamp ecosystems that depend on water, and improving the state of the environment as a result of the increase in the level of underground water.
- An increase in supplies of groundwater aquifers, which causes an increase in the sources of groundwater.
- To meet the need of economy. For example: water reservoirs can be used as a pumping station for firefighters, spas, extensive ponds, pumping stations for irrigation, etc.
- The improvement of the natural values of the environment, the improvement of biodiversity in the agricultural landscape by rehabilitating wetlands, small ponds, creating natural aquatic habitats for animals and plants, creating a human-friendly micro-climate.
- Protection of the quality of surface water, retention of suspended particulates, removal of nutrients (nitrogen and phosphorus) from the rainwater.

Solutions involving high technology can be effective, but they require a huge input of energy, are operationally too complex and often do not meet the goals of sustainable development. With the increasing development and knowledge of natural processes, ecology, and the relations in the ecosystems we discover the unexplored potential in nature. These are very effective for the protection and restoration of the already degraded and deprived areas. The concept of ecoremediations refers to the use of sustainable systems and processes for the rehabilitation of the environment and its protection. Ecoremediation technologies include the principles of nature, the phytoremediation (phytostabilization, phytoextraction, phytostimulation, phytodegradation, phytotransformation, and phytovolatilization) and bioremediation to restore pollution in the environment. Natural (green) approaches increase biodiversity and are returning the ecosystem to balance. Ecoremediation methods have the potential for the reduction, prevention and elimination of natural disasters (floods, droughts, avalanches), nonpoint sources of pollution (agriculture, transport) and point sources of pollution (public utilities, industrial sewage). High efficiency can be achieved by protecting habitats, in particular, water sources, streams, rivers, lakes, groundwater and sea. The basic functions of ecoremediation are the high buffer capacity, self-cleaning ability, enhancing biodiversity and water retention. With ecoremediation (phytoremediation, buffer areas and constructed wetland) we can revitalize degraded areas (quarries, periphery of roads), remove excessive levels of nutrients and clean waste water.

Ecoremediation of aquatic ecosystems during climate change is becoming more and more visible. We have some of the water at our disposal and the pressures on the use of the available water are increasing. In order to gain additional sources of water from the channel of water courses that would otherwise not have the economic, environmental or social role, we are contributing to the conservation of cultural landscapes and life in them. Although watercourses represent a small proportion of surface they significantly contribute to the well-being of the population.

Ecoremediation (ERM) are more and more used as systems not only for protection and renewal of environment but also as the way of living – symbiosis of human being with nature in underdevelopend coutries. People recognize all the benefits of ERM as multipurpose, long duration, applicability, social views, economical views, but above all the fact that many problems that we have caused ourselves, can be solved only using ERM – ecosystematical technologies (Zupančič, Vrhovše, Bulc 2002). Multipurposefulness is shown and can be a great help at decreasing climate changes, lack of energy and preservation of rare and endangered species. In practice all these ecosystem characteristics can be adjusted according to needs and consequences of needs.

In North Africa ERM are used for protection of environmental components:



There is an increasing need to use ERM systems for protection environmental components.

The most important benefits of the water retention measures are:

- Changes in the structure of water drainage in rivers, reducing flood wave and in some cases the improvement of low-flow conditions.
- Meet the needs of the forest and swampy ecosystems that depend on water, and improving the state of the environment as a result of the increase in the level of underground water.
- An increase in supplies of groundwater aquifers, which causes an increase in the sources of groundwater.
- To meet the need of economy. For example: water reservoirs can be used as a pumping station for firefighters, spas, extensive ponds, pumping stations for irrigation, etc.
- The improvement of the natural values of the environment, the improvement of biodiversity in agricultural landscape by rehabilitating wetlands, small ponds, creating natural aquatic habitats for animals and plants, creating a human-friendly micro-climate.
- Protection of the quality of surface water, retention of suspended particulates, removal of nutrients (nitrogen and phosphorus) from the rainwater.

Depending on the physical geographical features and climate change, countries could use the following ERM systems.

Tab. 6: Ecoremediations systems in North Africa countries.

Country	Systems of ecoremediation
Algeria	Afforestation, planting protection belts, bushes, arrangement of terraces Restriction of surface flow Increasing of filtration abilities of soil Measures against erosion, fitodrainage and agriculture drainage measures Regulations for a flow from drainage systems
Egypt	Systems of tillage fields, meadows, forests, ecological areas and ponds Afforestation, planting protection belts, bushes, arrangement of terraces Escalation of wet surfaces (peat bog and swamps) Improvement of the soil structure, agriculture drainage, liming, appropriate agriculture technics, appropriate rotation, increasing organic matter in soil Restriction of surface flow Increasing of filtration abilities of soil Measures against erosion, fitodrainage and agriculture drainage measures Regulations for a flow from drainage systems Ponds and infiltration wells for containing rainfall Regulation of water in the system of drainage and ditches
Libya	Afforestation, planting protection belts, bushes, arrangement of terraces Increasing of filtration abilities of soil Measures against erosion, fitodrainage and agriculture drainage measures Regulations for a flow from drainage systems
Morocco	Systems of tillage fields, meadows, forests, ecological areas and ponds Improvement of the soil structure, agriculture drainage, liming, appropriate agriculture technics, appropriate rotation, increasing organic matter in soil Restriction of surface flow Measures against erosion, fitodrainage and agriculture drainage measures Regulations for a flow from drainage systems Ponds and infiltration wells for containing rainfall
Sudan	Systems of tillage fields, meadows, forests, ecological areas and ponds Afforestation, planting protection belts, bushes, arrangement of terraces Escalation of wet surfaces (peat bog and swamps) Improvement of the soil structure, agriculture drainage, liming, appropriate agriculture technics, appropriate rotation, increasing organic matter in soil Restriction of surface flow Increasing of filtration abilities of soil Measures against erosion, fitodrainage and agriculture drainage measures Regulations for a flow from drainage systems Ponds and infiltration wells for containing rainfall Regulation of water in the system of drainage and ditches

Tab. 6: Ecoremediations systems in North Africa countries (cont.).

Country	Systems of ecoremediation
Tunisia	Systems of tillage fields, meadows, forests, ecological areas and ponds Afforestation, planting protection belts, bushes, arrangement of terraces Escalation of wet surfaces (peat bog and swamps) Improvement of the soil structure, agriculture drainage, liming, appropriate agriculture technics, appropriate rotation, increasing organic matter in soil Restriction of surface flow Increasing of filtration abilities of soil Measures against erosion, fitodrainage and agriculture drainage measures Regulations for a flow from drainage systems Ponds and infiltration wells for containing rainfall Regulation of water in the system of drainage and ditches
Western Sahara	Afforestation, planting protection belts, bushes, arrangement of terraces Restriction of surface flow Measures against erosion, fitodrainage and agriculture drainage measures

Ecoremediation of aquatic ecosystems during climate change is becoming more and more visible. We have some of water in our disposal and the pressures on the use of the available water are increasing. In order to gain additional sources of water from the channel of water courses that would otherwise not have the economic, environmental or social role, we are contributing to the conservation of cultural landscapes and life in them. Although watercourses represent a small proportion of surface they significantly contribute to the well-being of the population.

5. Conclusion

Common physical-geographical features emphasized in the research have shown that the amount of rainfall during the period of 1990-2009 reduced according to the period 1930-1960. Moreover, in the countries of North Africa, in the same period of time increased the average annual air temperature by more than 0,5°C. At the same time, the effect on freshwater sources has increased. Annual consumption of freshwater in total was higher in 2013 than in 1977. It increased the most in Libya since it has increased to 72,3 %. All of this does not bring anything positive to the countries of North Africa. If annual consumption of freshwater will increase, the absence of precipitation and high temperatures will cause increased evaporation and reduce the level of water in water sources. In addition, the consequences will be disastrous for the environment. The deserts will continue to spread, biological diversity will be reduced and the soil erosion will increase. In the analysis of data, we also identified some common socio-geographical features of Northern Africa countries.

In the countries of Northern Africa, economic attachment to agriculture has decreased, which is also reflected in GDP by economic sectors. The lowest share of GDP is contributed by agriculture and the dominated share is contributed by service activities. The share of persons employed in agriculture is the lowest in the light of other economic sectors. Sudan stands out, due to a favorable climate and other influences of the favorable climate and has the biggest shares of the population employed in agriculture. This also brings it the greatest share in the gross domestic product. In 2011, according to the data from 1977 there is an increase of the proportion of cultivated land in the countries of North Africa. With this, the impact and pressure mainly on the fertile coastal areas have increased. The cultivated areas are increasingly extending in semi-desert and desert parts of the countries, which not only overload irrigation systems, but also overload soil and biodiversity. Due to the additional cultivated areas they are overloaded with chemicals and fertilizers which also pollute water sources. For a long time, the fight for fresh water and water sources has been causing disorder and conflicts in the countries of Northern Africa.

Ecosystems have a big buffer capacity and can retain, treat or neutralize many organic and inorganic pollutants with natural processes. Ecoremediation uses natural processes in natural and partly artificial ecosystems to ensure better usage of water sources, for the elimination of harmful pollution impacts and preservation of biotic diversity.

Renewal of devaluated ecosystems using ecoremediations means, along with a more stable natural systems, also a better state of natural elements in the living environment, which improves human's and other living creatures' lives. Above all, they offer an important educational and pedagogical possibility, which is perhaps more important than technical effect. Natural sources are already exploited and because they are limited we are obliged to protect and mend them as long as it is possible.

Knowing the sustainable concept and dimensions of sustainability in local communities is essential because climate change will cause significant changes in the quality and availability of water resources, in a number of sectors, including food production, where water plays a crucial role. More than 80% of agricultural land is dependent on rainwater. Food production also depends on available water resources for irrigation.

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CLIMATE CHANGES IN NORTH AFRICA AND THE POSSIBILITIES OF ADAPTING TO IT WITH ECOSYSTEM APPROACHES

Summary

North Africa has specific natural and social elements that have a significant effect on the abilities of adaptation to climate changes. With the aim to determine the types of areas for adaptation to climate change, we have typified North Africa to similar areas as those areas.

A major part of North Africa receives a low level of precipitation and that has an impact on the poor water conditions. The average total annual precipitation in North Africa is estimated at 1503 m^3/annually, which is equivalent to 7 % of total annual precipitation in Africa. However, the distribution of the precipitation varies in Africa. The most rainfall, almost 75 %, falls in Sudan and only 3 % falls in Egypt. 5,6 % of precipitation falls in river networks or it is used for filling ground water. The rest is lost by evaporation, transpiration and disappearance. Availability of water per capita was 26 m^3/annually in 2000 in Egypt and up to 1058 m^3/annually in Morocco for the same year (United Nations Environment Programme 2014).

There are even more differences if we compare North Africa countries to countries of Sub-Saharan Africa. Total of internal renewable fresh water resources in North Africa present 2,5% of the total in Africa, but the withdrawal of it presents 46 % of the total in Africa. This difference partly reflects harsh climate conditions. Renewable fresh water sources are supplied with water from hinterland river flows (alluvial aquifer Nil) or from the rainfall (coastline of the Mediterranean Sea (United Nations Environment Programme 2014).

A total of annual consumption of freshwater in billions of cubic meters is increasing. The largest consumption of fresh water was in 1977 and 2013 in Egypt and the lowest in Tunisia. In the last 35 years, the consumption of freshwater in Africa has increased by more than 28 %. Moreover, in Libya, it has increased by 72 %. Though, Tunisia has the lowest consumption of freshwater that does not neglect the fact that freshwater consumption in Tunisia has increased by 62,5 % from 1977 to 2013.

The North African economy depends on natural conditions. Most of the cultivated land is concentrated in the coastal areas. Due to physical-geographical and socio-geographical changes like global warming and the impact of human activities on the environment, the North Africa countries have decreased the dependence on agriculture.

Cultivated land and fields in North Africa are mostly by the coastline and on the areas where irrigation agriculture is possible. The percentages of cultivated areas were the highest in 2011 in Morocco (17,79 %) and in Tunisia (17,35 %) because these two countries have the most appropriate physical-geographical and socio-geographical conditions. The cultivated areas are mostly by the coastline and in the highlands where irrigation is possible. In the last ten years, the percentages of cultivated areas have been increasing at the expense of increased number of population and the increased demand for food.

Common physical geographical characteristics have shown that the average precipitation is decreasing and the average air temperature is increasing in the

countries of South Africa. Freshwater sources that get water from rainfall are additionally overloaded and their use is increasing.

The concept of ecosystem technology or ecoremediation (ERM) means the usage of natural processes for restoration and protection of the environment (eco + remediation = »natural renewed revival«). Using ecoremediation methods we can decrease and abolish the consequences of agricultural pollution, tourism, traffic, industry, dumping grounds and settlements. Ecoremediations mean returning to nature, aiming to save and restore natural balance, where these kinds of areas can give an opportunity to develop new working places and additional activities. Ecoremediations have already been recognized as perspective and continual approach, where natural and conatural processes and systems are being used in favor of the restoration of degraded environment and protection of natural environment. In practice ERM are used as constructed wetlands, conatural sanitations of deposits, riverine vegetation zones – balancing areas, side branches, artificial lakes, noise and/or dust reducing barriers, phytoremediation of polluted sediments, purifying soil and drinking water, tertiary purifying and purifying dangerous sewage water. By using ERM methods, less money is spent on sanitation of already threatened areas and continual protection of these is emphasized, which is a big advantage in a financial sense.

Depending on the physical geographical features and climate change, countries could use the following ERM systems.

Tab. 6: Ecoremediations systems in North Africa countries.

Country	Systems of ecoremediation
Algeria	Afforestation, planting protection belts, bushes, arrangement of terraces Restriction of surface flow Increasing of filtration abilities of soil Measures against erosion, fitodrainage and agriculture drainage measures Regulations for a flow from drainage systems
Egypt	Systems of tillage fields, meadows, forests, ecological areas and ponds Afforestation, planting protection belts, bushes, arrangement of terraces Escalation of wet surfaces (peat bog and swamps) Improvement of the soil structure, agriculture drainage, liming, appropriate agriculture technics, appropriate rotation, increasing organic matter in soil Restriction of surface flow Increasing of filtration abilities of soil Measures against erosion, fitodrainage and agriculture drainage measures Regulations for a flow from drainage systems Ponds and infiltration wells for containing rainfall Regulation of water in the system of drainage and ditches
Libya	Afforestation, planting protection belts, bushes, arrangement of terraces Increasing of filtration abilities of soil Measures against erosion, fitodrainage and agriculture drainage measures Regulations for a flow from drainage systems
Morocco	Systems of tillage fields, meadows, forests, ecological areas and ponds Improvement of the soil structure, agriculture drainage, liming, appropriate agriculture technics, appropriate rotation, increasing organic matter in soil

	Restriction of surface flow Measures against erosion, fitodrainage and agriculture drainage measures Regulations for a flow from drainage systems Ponds and infiltration wells for containing rainfall
Sudan	Systems of tillage fields, meadows, forests, ecological areas and ponds Afforestation, planting protection belts, bushes, arrangement of terraces Escalation of wet surfaces (peat bog and swamps) Improvement of the soil structure, agriculture drainage, liming, appropriate agriculture technics, appropriate rotation, increasing organic matter in soil Restriction of surface flow Increasing of filtration abilities of soil Measures against erosion, fitodrainage and agriculture drainage measures Regulations for a flow from drainage systems Ponds and infiltration wells for containing rainfall Regulation of water in the system of drainage and ditches
Tunisia	Systems of tillage fields, meadows, forests, ecological areas and ponds Afforestation, planting protection belts, bushes, arrangement of terraces Escalation of wet surfaces (peat bog and swamps) Improvement of the soil structure, agriculture drainage, liming, appropriate agriculture technics, appropriate rotation, increasing organic matter in soil Restriction of surface flow Increasing of filtration abilities of soil Measures against erosion, fitodrainage and agriculture drainage measures Regulations for a flow from drainage systems Ponds and infiltration wells for containing rainfall Regulation of water in the system of drainage and ditches
Western Sahara	Afforestation, planting protection belts, bushes, arrangement of terraces Restriction of surface flow Measures against erosion, fitodrainage and agriculture drainage measures

The most important benefits of the water retention measures are:

- Changes in the structure of water drainage in rivers, reducing flood wave and in some cases the improvement of low-flow conditions.
- Meet the needs of the forest and swampy ecosystems that depend on water, and improving the state of the environment as a result of the increase in the level of underground water.
- An increase in supplies of groundwater aquifers, which causes an increase in the sources of groundwater.
- To meet the need of economy. For example: water reservoirs can be used as a pumping station for firefighters, spas, extensive ponds, pumping stations for irrigation, etc.
- The improvement of the natural values of the environment, the improvement of biodiversity in agricultural landscape by rehabilitating wetlands, small ponds, creating natural aquatic habitats for animals and plants, creating a human-friendly micro-climate.
- Protection of the quality of surface water, retention of suspended particulates, removal of nutrients (nitrogen and phosphorus) from the rainwater.