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Ivan ŠIMUNIĆ[1], Marija VUKELIĆ-SHUTOSKA[2], Velibor SPALEVIĆ[3], Goran ŠKATARIĆ[4], Vjekoslav TANASKOVIK[2], Mile MARKOSKI[2]

AMELIORATIVE MEASURES AIMED AT PREVENTION/MITIGATION CONSEQUENCES OF CLIMATE CHANGE IN AGRICULTURE IN CROATIA

SUMMARY

Climate change can be represented as a change in climate elements (temperature, precipitation, humidity, wind, insolation) relative to average values, or as a change in the distribution of climate events relative to average values. Climate change causes more frequent occurrences of floods and droughts, which can cause major damage to agriculture and the environment.

Ameliorative measures in hydrotechnical amelioration include protection from flood and catchment waters, drainage of surplus water land and irrigation (Soskic et al, 2001). Protection of a certain area from flooding and catchment water implies hydrotechnical measures and solutions aimed at preventing or diminishing harmful effects and consequences of surface runoff of large amounts of precipitation or torrents water from higher elevations to lower parts, as well as consequences of flooding events from watercourses and other water bodies in the riparian and a wider area. Drainage of surplus water from a land area can be achieved by designing an adequate drainage system (hydro–ameliorative drainage system) consisting of different technical solutions and structures: pumping stations channels/pipes for various purposes, of different dimensions and shapes, additional structures/equipment and infrastructures (roads, bridges). For the purpose of preventing or mitigating droughts as a natural occurrence that causes a shortage of water in the soil (rhizosphere), an amelioration measure of irrigation should be provide favourable soil moisture condition for plant growth and development where there is lack of precipitation in an area. Successful agricultural production can be achieved if there is a favourable water-air ratio in

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[1]Ivan Šimunić (corresponding author: simunic@agr.hr), University of Zagreb, Faculty of Agriculture, Department of Soil Amelioration, CROATIA.
[2]Marija Vukelić-Shutoska, Vjekoslav Tanaskovik, Mile Markovski, Faculty of Agricultural Sciences and Food, Ss. Cyril and Methodius University, Skopje, NORTH MACEDONIA.
[3]Velibor Spalević, University of Montenegro, Faculty of Philosophy, Geography, Danila Bojovica bb, Niksic, MONTENEGRO.
[4]Goran Škatarić, National parks of Montenegro, Podgorica, MONTENEGRO.
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the soil during the growing season, as excess or shortage of water in the soil causes a decrease in yield.

At aimed preventing/mitigation the consequences of climate change in agriculture and the environment, existing (built) hydro-technical facilities, surface and underground drainage systems as well as irrigation systems should be adequately used and maintained, and continue with activities for the construction of new hydro-technical facilities and drainage and irrigation systems.

Keywords: Ameliorative measures, climate change, agriculture

INTRODUCTION

Potential impacts of global climate changes may include the change in hydrologic processes and watershed response, including timing and magnitude of surface runoff, stream discharge, evapotranspiration, and flood events, all of which would influence other environmental variables (Simonovic & Li, 2004). Changes in precipitation are the prime drivers of change in the availability of both surface water and groundwater resources (Beare and Heaney, 2002). The trends of precipitation extremes in Europe vary greatly and depend not only on region but also on the indicator used to describe an extreme (Groisman et al., 2005). More frequent and severe extreme weather events are anticipated to cause greater damage to ecosystems and agricultural systems (Choi et al., 2015; Wigley, 2009). Precipitation distribution in the territory and their changes within a year have a huge impact on hydrological phenomena, soil formation and plant growing seasons (Bukantis and Rimkus 2005). Amount and distribution of precipitation has impact on state the moisture in soil (Šimunić et al., 2013). As a consequence of climate change, the rise in frequency and intensity of extreme weather events, such as drought, heavy rain, gales and storms, among others, have a negative impact on yields and their quality (Mađar et al., 1998; Parry et al., 2005; Fischer et al., 2005; Šimunić et al., 2007; Kovačević et al., 2012; Marković et al., 2012; Kovačević et al., 2013; Šimunić et al., 2013; Šimunić et al., 2014; Kovačević and Josipović, 2015; Dokić et al., 2015). Agricultural production is very risky and almost impossible in agricultural areas where there are dangers from flooding, retention of surplus water in soil a longer time during year or if often is appear drought and not built hydrotechnical objects for protection from flood and catchment water, drainage and irrigation. In such conditions agricultural production and hence yield are dependent on weather conditions, making yields and their quality highly variable. The highest yields are obtained, if is during of vegetation period favourable air-water ratio in the soil (Šimunić, 2016).

AMELIORATIVE MEASURES

Already according climatic characteristics and catchment area characteristics are seeking hydrotechnical solutions and constructing hydrotechnical structures for flood protection, drainage and irrigation, water accumulation and watercourse regulation. Ameliorative measures can include hydrotechnical and cultural technique activities.

Protection from harmful flood and catchment water

Protection from harmful water activity is conducted by undertaking different measures and intervention, the most important ones being regulation of watercourse and construction of hydrotechnical facilities. Even though the basic function of hydrotechnical facilities is protection from harmful water activity, their impact on temporal and spatial water distribution in a certain area is significant in that it enables more effective water management and protection. There are different solutions for protection from harmful water activity, such as regulation of watercourses, accumulations and retentions, protective embankments, unloading channels and peripheral or lateral channels.

Regulation of a watercourse implies development of its bed and increase of its ability to take up larger amounts of water. The method of regulation depends on natural characteristics of the watercourse, notably on its size (river, stream), its bed (straight or meandering) and mechanical stability of the waterside. Watercourse regulation can involve simplest action, from cleaning, deepening and widening of the bed, bank reinforcement to straightening of meanders. In Croatia, there are a total of 3,935 km of national watercourses, of which 1,436 km (36.5%) are completely regulated, 1,672 km (42.5%) are partially regulated, and 827 km (21%) are not regulated (Marušić, 2007).

Accumulations are usually parts of watercourse systems that include dams. The size of the accumulation, that is, volume of collected water, depends on several parameters, such as climate characteristics of the area, downstream flow capacity, intended use and geomorphology of the area. During high water events, surplus water is collected in the accumulation, water flow in the watercourse is stabilized and this way flooding of the downstream area is prevented. Accumulated water can be also used for other purposes. Mountain retentions are parts of watercourse catchment areas where water from the watercourse is accumulated only during high water events and this way flooding of downstream is prevented and accumulated water are not used for other purposes. Up to now built 58 multipurpose accumulations and 43 mountain retentions (Marušić, 2007).

In lowland areas is smaller water flow velocity in watercourses and hence the danger from flooding higher and therefore are build other hydrotechnical structures, such as embankments and unload channels. Protection from flooding events which can follow after longer and heavy rain period is achieved by earthen embankments, which are built along watercourses. In Croatia, 2,415 km of embankments were built along larger (state) watercourses, and 1,642 km along local watercourses (Marušić, 2007). Besides embankments in lowland areas can be built unloading channels which purpose is to unload the main watercourse from a part of high water inflow and in this way protect a certain area from flooding. Unloading channels divert part of the inflow from main watercourse up to recipient. Three large drainage channels have been partially built on the Sava River Basin. Unloading the main watercourse from a part of high water inflow because of danger from outflow and flooding, water from watercourse can be diverted to lowland retentions which can hold large volumes of water, but after the flooding danger is over, water is discharged from the retention back to the watercourse. There are several retention areas in Croatia and are located in the central Posavlje region. The retention area for the river Sava and it is tributaries is the Natural Park Lonjsko polje, which, owing to it is size and natural characteristics, is the largest protected wetland area not only in Croatia but it he entire Danube region. Besides their role of natural retention in watercourse regulation, wetlands are important because of their ecological value, since they have a positive effect on the water environment. Besides appearance of unusually large amounts of water on certain area, which are caused heavy rain, break of embankments and dams can cause flood, as was in eastern part of Croatia in year 2014 (Figure 1).

Fig. 1. Flood in eastern Croatia after water is broke embankment along Sava river (area of flooding is marked blue colour)

Flat lowland areas from possible flooding events, which can be caused by surface water from higher elevation, can be protected by peripheral channels. Peripheral channels are constructed at the foot of a hilly area. Surface water from the elevated catchment area is collected in these channels and they divert collected water to the main recipient. The total is built 916.8 km peripheral channels (Marušić, 2007).

Surface water runoff can cause soil erosion, and erosion severity in a certain area dependents on the precipitation amount and intensity, soil structure, terrain slope and slope length, slope coverage with vegetation. In inclined terrains are more exposed to erosion, land management in such areas involves certain protective measures and biological, biotechnical and technical procedures to prevent or mitigate erosion effects. Effective measures for erosion prevention include grassing of the terrain, planting of bushes and forests, erection supporting walls.

Fig. 2. Soil erosion caused by heavy rain

Drainage of surplus soil water

Drainage of surplus water is an ameliorative measure that involves collection and removal of surplus water from soils intended for cropping or some other activity. Surplus soil water in an area adversely affects the productivity of agricultural production because it restricts the growth and development of plants or prevents the use of the area for another purpose. The removal of surplus water from the soil creates favourable water-air relations in the root zone of the plants, equilibrium of water in the soil-plant relationship, improves the structure, temperature and aeration of the soil, positive chemical processes occur in the soil (Šimunić, 2016; Dragovic et al, 2012). Types of drainage can be surface drainage, subsurface and combined drainage and choice of way drainage it dependent on more factors, such as origin of surplus water, type of soil, kinds of plants which will be growing, etc.

An ameliorative drainage system consist of different drainage structures, such as basic and detailed channel network, pumping stations, drainage pipes and some additional structures. The basic channel network is made up of ameliorative structures of the 1st order, namely main drainage channels, which can be natural watercourses or artificial channels and ameliorative structures of the 2nd order channels (main drainage channels) with additional structures on the channels and a pumping station if gravitational transport is not possible (Figure 3). These hydraulic structures within the drainage system collect water from the 3rd and 4th order channels, detailed channels, and transport it to the recipient. Detailed surface drainage is directly connected with surplus water on a plot (table) and the efficiency of the entire system most commonly depends on the functionality of ameliorative channels of the 4th order or detailed channels. Detailed channels network consist of ameliorative channels of the 3rd order (colled collector channels) and of channels of the 4th order (detailed channels). Pumping stations of the drainage system enable transfer of surplus water from the ameliorated area to the recipient.

Pipe drainage consists of underground drain pipes, which collect and drain surplus water from soil. They can be classified as lateral drains and collector drains.

Combined drainage is usually surplus water drainage by means of a combination of channels, pipes and agro technical measures, but it can also be a combination of pipe (lateral and collector drains) and agro technical measures.

The total area in Croatia with the need for surface drainage is 1,673,792 ha. Surface drainage systems were built on 724.749 ha (43.3%), structures and surface drainage systems on 324.662 ha (19.4%) were partially constructed, and surface drainage facilities and systems on 624.381 ha (37.3%) were not constructed. The total area with the need for underground drainage is 822.350 ha. Combined drainage systems (surface and underground drainage with agro-technical measures) were built on 121.484 ha (14.8%) and partly on 27.169 ha (3.3%) (Marušić, 2016).

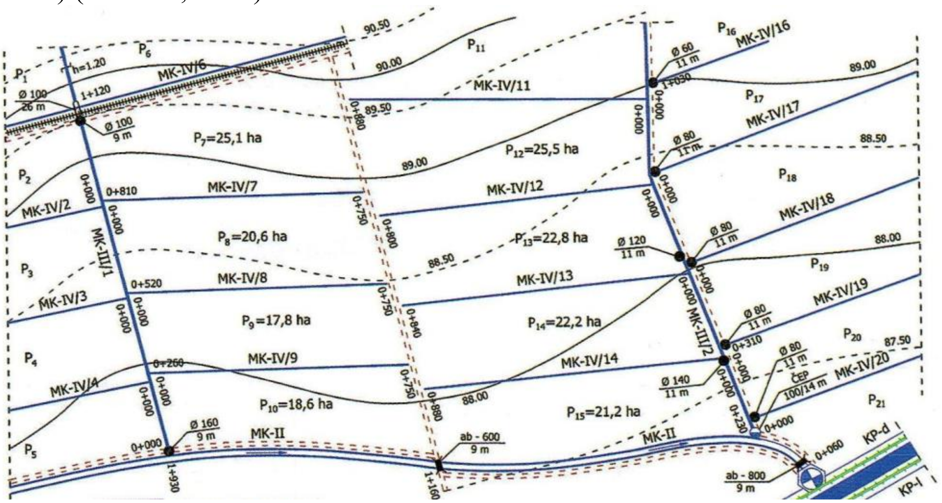

Fig. 3. Surface drainage system with a travel network (Marušić, 2007)

Irrigation

Irrigation is an ameliorative measure that provides a certain area with water using an appropriate hydrotechnical system in such way ensures soil moisture necessary for plant growth (Šimunić, 2016). Bearing in mind that irrigation is used to artificially compensate for the lack of precipitation necessary for water supply to plants; the irrigation requirement of an area depends on the precipitation amount and its dynamics during the growing season. It important to say that irrigation as ameliorative measure in Croatia had not tradition and is very small used regardless on natural riches such as land and water. Riches of soils lay in the fact that there is 244,151 ha favourable soils for irrigation or 9,4% from total agricultural land and 588,164 ha moderate favourable soils or 22,7% from total agricultural land (Husnjak, 2007). Riches of water are in the fact that there are many watercourses, natural and artificial lakes, accumulations, fish-pond, and ground water. According to Mayer (2004) Croatia disposal on 32,800 m^3 water/capita/year and belongs in group of countries with the most riches on water on the World. But then after due to the occurrence of frequent and prolonged droughts, that is, risky agricultural production, in 2005 the Government of the Republic of Croatia approved the project national project, name “National Project for Irrigation and Management of Agricultural Land and Water”. The project provides guidelines, short-term and long-term goals and states that by 2020 irrigation will be applied to 65,000 ha or about 6% of arable land. From year 2004 until 2016, new irrigation systems for 13,000 ha of agricultural land have been built (Đuroković et al., 2016). With previous irrigation systems from 9,264 ha (Tomić et al., 2007) and newly constructed systems, it is possible to irrigate 22,264 ha or about 2% of arable agricultural land.

Fig.4. Consequence of drought in year 2003 (www.agroklub.com)

CONCLUSIONS

At aimed preventing/mitigation the consequences of climate change in agriculture and the environment, existing (built) hydro-technical facilities, surface and underground drainage systems as well as irrigation systems should be adequately used and maintained, and continue with activities for the construction of new hydro-technical facilities and drainage and irrigation systems.

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