IRRIGATION
STRATEGY
OF SERBIA

SUPPORTING THE DEVELOPMENT OF AN IRRIGATION STRATEGY FOR SERBIA

Brief: Economic opportunities, value drivers and key risks of public and private investment in irrigation

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Prepared by
Dr Steve Goss and Luis Dias Pereira for FAO

Economic opportunities, value drivers and key risks of public and private investment in irrigation

Key messages

- Irrigation can enable a transition to higher value-added crops and increased crop yields (both on new irrigated areas and in areas where irrigation is improved) with positive impacts on the gross agricultural product of the country and exports.

- Irrigation, however, is not a panacea and the materialization of the opportunities for transition through irrigation depends on a number factors. Adoption of irrigation will be a measure of the incentives and risks each farmer perceives regarding such change. Reviewing the financial feasibility of irrigation under different contexts and scenarios and implement agricultural policies that address identified market inefficiencies, may be necessary to optimize adoption.

- Three value drivers for investments in irrigation in Serbia have been identified: (i) intensifying current arable crops systems, (ii) accelerating the transition towards higher value agriculture, (iii) adapting to climate change, particularly mitigating risks related to extreme whether events.

- Different possible drivers for adoption of irrigation will play differently depending on the context. A strategy for the development of opportunities in irrigation needs to consider the main options in terms of investment (water source and technology) as well as the scenarios on a set of agricultural and irrigation conditions for each option.

- Investment in systems serving high-value crops are likely to have high returns, even when the investment is high. **The increase in income from irrigating small fields of arable crops may not provide enough incentives for high uptake**, making systems with high capital and O&M costs financially unsustainable. In between these two extremes lays a number of systems which require moderate capital and O&M costs and serve a mix of arable crops. Section two categorizes the main opportunities for irrigation in Serbia and provides a framework for their analysis.

- Selecting lower cost and simple technical and water management options that provide flexibility in terms of water supply may also enable a larger uptake. Irrigation may bring about small increases in average gross margins (see section two) for arable crops. In regions where arable crops are predominant, it is important that water can be supplied on demand and at a low cost as to ensure that benefits outweigh its costs and therefore promote uptake.

- Whereas, in areas of the country, benefits from investments in irrigation may outweigh the costs, in other cases enabling economically sound investments in irrigation may require complementary policies. The strategy should map out and give priority to investments with higher potential for success in the short run. Likewise, it should identify complementary investments (e.g. improved roads) or new institutional arrangements that may be necessary to make these investments work. This does not mean that investments which are currently deemed unfeasible (e.g. due to current farming systems or land size) should be discarded in the long-term. Policies that can produce structural reforms can contribute to make investments irrigation progressively economically viable. Some examples of such policies are those that result in land consolidation or on market opportunities for higher value-added crops.

Contents

1 Introduction

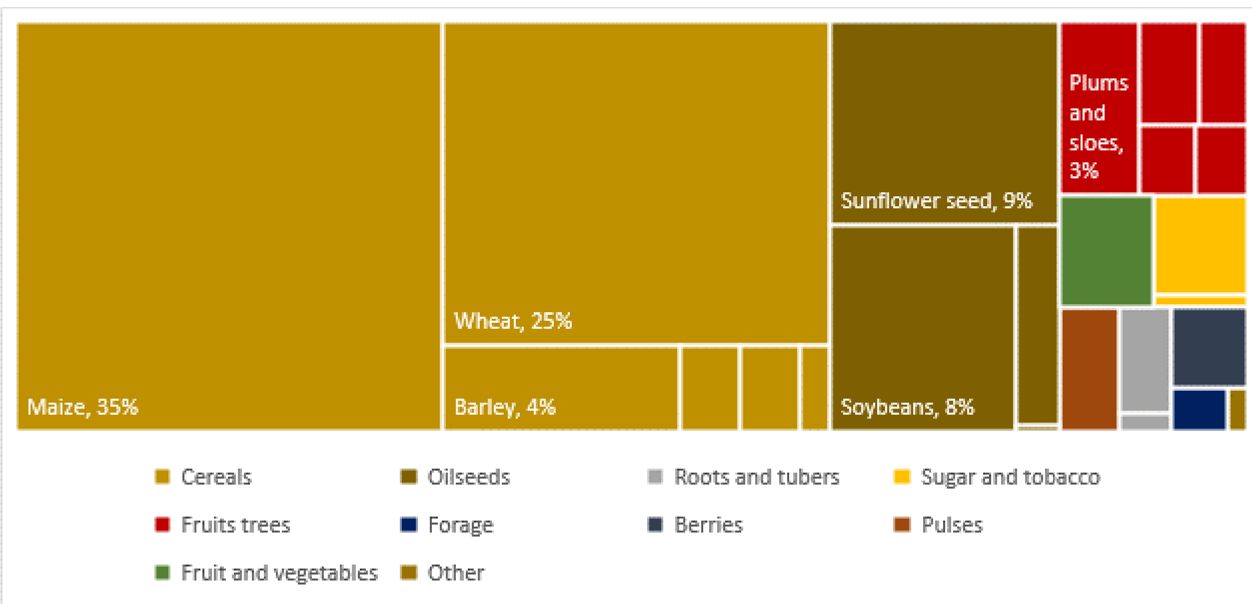
1.1. Aim of the brief

This brief provides an overview of the potential economic value of key opportunities for irrigation development in Serbia. It does not provide a detailed economic analysis of the different options for irrigation in Serbia, but seeks to identify the key value drivers, the rational and the main risks for a number of main types of investment options. This brief builds on inputs from other briefs, particularly in terms of agronomical and hydrologic potential for irrigation, governance and management structures, as well as possible technology options.

1.2. What changes can improved irrigation bring to Serbia

As described in detail in brief 1 – Water resources availability – the surface of agricultural land under irrigation in Serbia is rather limited. In 2018, 90% of Serbia's harvested area was dedicated to arable crops – cereals, oilseed, roots and tubers, pulses and forage crop. In the same year cereals and oilseed crops alone occupied about 85% of the harvested area[1] and oilseed. However, according to CENSUS data (2012) less than 5% of the arable crops area is irrigated[2]. Regions with a tradition to grow fruit and vegetables also show limited irrigated areas. In 2012[3], only less than 8% of the country's 187 thousand hectares of fruit plantations were irrigated. A larger share of the area dedicated to vegetables was irrigated: about 20 thousand hectares of a total of 57 thousand hectares sown (35%) in 2012.

Figure 1 – Distribution of harvested area in 2018 (authors elaboration from FAO Stata, 2020)



Irrigation can enable a transition to higher value-added crops and increased crop yields (both on new irrigated areas and in areas where irrigation is improved) with positive impacts on the gross agricultural product of the country and exports. For example:

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[1] FAOSTAT, 2020

[2] Irrigated surface has not increased significantly in the last decade.

[3] Census data

(i) In the plateau of Fruška Gora, in Vojvodina, farmers who have recently converted rainfed cereal land to irrigated fruit plantations have reported good returns and an interest in fruit plantation expansion should water for irrigation be available. Additionally, famers reported an overall investment of 25 million Euro in cold storage alone since the region started converting land use from field crops to fruit trees.

(ii) Serbia is also an important plums producer – production value was of USD 163 million and occupied 77,000 ha in 2014. However, plums face quality, productivity and competitiveness issues partially due to inter-year weather variations[4] (and due to agricultural practices). In Italy, in 2016, plum and sloes average yield was 17 tons/ha compared to 6 tons/ha in Serbia. Whereas irrigation would only be justified for commercially driven medium-sized fruit plantations – which are not the norm in Serbia – should future agriculture and territorial management strategies promote the intensification and professionalization of agriculture, irrigation could contribute to the development of fruit value chains in the longer term.

(iii) The company with the largest investments in agriculture in Serbia - MK group – has invested 50 million Euro in irrigation equipment in 9000 hectares of vegetables, apples, sugar beet and seed maize in Vojvodina. Average yields in sugar beet can move from 35 tons/ha to 80 tons/ha from rain-fed to irrigated systems.

In addition, improved drainage and irrigation can decrease losses due to extreme weather events and smoothen farmers' cash flows. Combined economic losses due to extreme climatic events averaged USD 78.7 million/year for 8-year moving average between 2005-2013[5]. In 2014, economic losses from floods damage in Serbia were estimated at around Euro 1.7 billion, of which Euro 228 million were in the agriculture sector[6]. In the summer of 2012 Serbia suffered its worst recorded drought[7]- for more than 50 days temperatures exceeded 35ºC. Total economic losses were estimated at USD 2 billion[8], including about one million hectares of lost agricultural production and more than USD 141 million in agricultural damages.[9]

In 2017, Serbia suffered a major drought, which reportedly cost up to 1% of the country's GDP (about Euro 410 million) mainly through lower yields, lost agricultural production and a fall in electricity output. Some estimates (Serbian Grain Association) put total economic losses at between Euro 600 million and Euro 1 billion.

Figure 2 – National reported economic losses in Serbia from 1990 to 2014

[4] FAOSTATA (2020) data on plus and sloes average yields in Serbia, shows that inter-year variation can be often be as large as 30%.

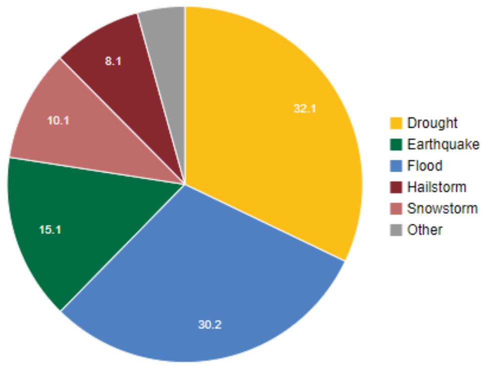
[5] https://www.preventionweb.net/countries/srb/data/

[6] http://documents.worldbank.org/curated/en/830671468184737730/pdf/105096-WP-Country-Note-Serbia-April-2016-PUBLIC.pdf

[7] https://www.climatechangepost.com/serbia/droughts/

[8] https://www.reuters.com/article/us-balkans-drought/balkan-drought-highlights-years-of-farm-neglect-idUSBRE87J0MX20120821

[9] https://www.climatelinks.org/sites/default/files/asset/document/2017_USAID_Climate%20Change%20Risk%20Profile_Serbia.pdf



Source: prevention web https://www.preventionweb.net/countries/srb/data/

Irrigation, however, is not a panacea and the materialization of the opportunities for transition through irrigation depends on a number factors. For example, in small farms the irrigation of arable crops may not be financially feasible. The low share of overall income that comes from agriculture for many farm owners, may provide little incentive to adopt irrigation and move to higher value crops. Hurdles to increased productivity may also come from value chain inefficiencies and not from lack of access to irrigation. Raspberries an important export from Serbia (annual production of over 60,000 tons) are mostly sold frozen. Issues such as insufficient road network, the prevailing use of conventional agricultural practices and lack of well-organized producer organizations may be what conditions the capacity to increase value addition. This may explain why recently investments in irrigation have materialized in regions with farms of larger size (e.g. ex-kombinats) or with a significant number of farmers who have invested in high-value added crops (e.g. Leskovac), where there are opportunities for efficiency gains, economy of scale, professional farm management and vertical integration of value chain.

It is therefore clear that not all land with technical potential will be irrigated in the short/medium term as farmers need to have the right incentives in order to change their production systems. The following section summarizes some of the main possible value drivers and economic rationale for the adoption of irrigation.

1.3. Value drivers and rationale for investment

Three value drivers for investments in irrigation in Serbia have been identified: (i) intensifying current arable crops systems, (ii) accelerating the transition towards higher value agriculture, (iii) adapting to climate change, particularly mitigating risks related to more frequent extreme whether events. Irrigation can produce different outcomes in these three areas depending on the context. For example, transition to high value added crops may not occur just by introducing irrigation in cases where income from agriculture is too small a share of the overall income to incentivize farmers to invest in new cropping systems. Some crops are more sensitive to weather variations than other crops are; those which are less sensitive may not justify an investment in irrigation.

Selecting lower cost and simple technical and water management options that provide flexibility in terms of water supply may also enable a larger uptake. Hence, options that leverage on existing infrastructure containing investment and additional maintenance costs and allow individual water intake may prove to be more efficient and successful. Section 2 provides some examples.

This section describes more in detail the main drivers and rationale for investment in Serbia. The next chapter provides a framework for the identification and analysis of concrete opportunities.

1.1.1 Adapting to climate change

Irrigation and drainage may be instrumental in preventing losses caused by extreme climatic events and in transforming potential risks into opportunities. Changes in temperatures (Minimum and Maximum) and rainfall distribution across the year are well documented in literature and, especially for temperature, also factored in practices by farmers that – especially in some areas of Vojvodina - have started anticipating the growing season for grains.

- Research results in the literature are not unambiguous and impacts are reported both as positive and negative like. Some [10] suggest that "*key crop average yields in Serbia (winter wheat, and soybeans) will increase on average under current climate change scenarios, with the exception of maize in non-irrigated conditions and under the A2 scenario"*[11] while others reports that these results have a major shortcoming as they do not account for possible increases in pests and fungal diseases as a result of climate change[12]. Regardless, there is agreement among researchers and institutions that temperatures (MIN and MAX) are increasing steadily (0.3 C per decade) and that rainfall pattern is becoming more variable with tendency to concentrate precipitations in winter months. Therefore, as also communicated by the country to the UNFCCC[13], impacts on agriculture are already reducing its potential and constitute a major risk for the next coming years (2050 horizon). A recent report published by UNDP and the Ministry of Environment of Serbia reports an already evident decrease in yields for all the grains but wheat that will further decrease in the next decades.

- Climate change is expected to increase the probability of Serbia suffering from more intense droughts, reduced yields of maize, soybeans and sunflower as well as wildfires and increasing extreme rainfall days in winter months[14] - as well as increased losses due to pests and diseases.

- The future should bring an increase (relative to data from 1986-2015) in the number of consecutive dry days by 11 to 18 percent and a 21 to 31 percent increase in total annual precipitation on extreme rainfall days (annual total precipitation that occurs on days in which precipitation exceeds the 99th percentile)[15]. Finally, since 1970 the number of heat days (T > 30 C) have increased by almost 7 days per year while frost days (T < 0 C) have decreased by about 11 days per year. Similarly, projections for the period 2020-2050 show a further increase of heat days (T > 30 C) of 8 days per years and a further decrease of frost days (T > 30 C) of about 4 days per year.

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[10] http://onlinelibrary.wiley.com/doi/10.1002/joc.4209/abstract

[12] https://www.researchgate.net/publication/346419599_Vulnerability_of_agriculture_to_climate_change_in_Serbia_-_farmers'_assessment_of_impacts_and_damages

[13] https://unfccc.int/documents/39803

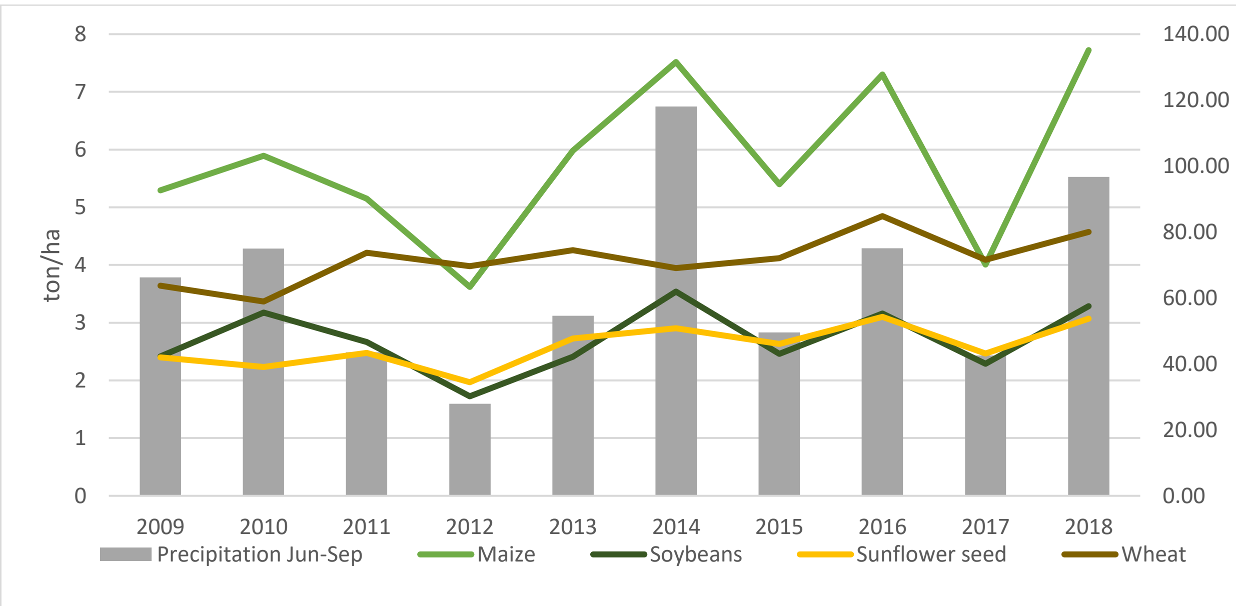
[14] https://www.researchgate.net/publication/280157382_Social_and_Economic_Impact_of_Drought_on_Stakeholders_in_Agriculture

[15] https://www.climatelinks.org/sites/default/files/asset/document/2017_USAID_Climate%20Change%20Risk%20Profile_Serbia.pdf

- **As demonstrated in the graph below some crops may be more sensitive to weather conditions than others.** Despite the short time series, a statistical analysis made on some climate variables and yields for the crops in the graph below suggests that: (i) for maize and sunflower, there seems to be a strong correlation between accumulated rainfall from June to September and yields, meaning that complementary irrigation could guarantee higher yields in dry summers; (ii) the slope is steeper for Maize than sunflower, suggesting that the impact on yields of complementary irrigation would be stronger for maize; (iii) none of the climate variables that were studied showed significant correlation with the yields of soy or wheat (a longer time series might have been needed for this).

- **Decisions on investments in irrigation to mitigate extreme weather events effects need to be made based on solid projections of land use change, expected yields changes, and frequency of droughts and their effects on yields.**

- *Figure 3 – Inter-year variation in yields for selected crops in Serbia*



	Maize	Wheat	Soy	Sunflower
Pearson correlation coefficient	0.889	0.068	-0.143	0.908
corresponding p-value	0.001	0.852	0.694	0.000
Regression - Adjusted R-squared	0.765	-0.120	-0.102	0.802
Regression - Intercept	2.819	4.036	5.745	1.502
Regression - Slope	0.046	0.001	-0.001	0.019

Source: Authors' compilation from FAOSTAT (2018)

There is an opportunity to increase O&M capacity for flood prevention and drainage as well as investment in irrigation as more intense droughts and floods will hit the country while temperatures will possibly reach a + 2.49 Celsius by 2060. Such systems will decrease risks in agriculture (promoting private investment) and reduce agricultural losses caused by climate change and natural disasters. This however may not be always financially interesting in all cases and requires a case by case analysis (see next section)

Further assessment needs: Yields variations due to inter-year weather variability need to be carefully assessed and monitored for different crops and regions as to evaluate irrigation vs. crop insurance/budgetary reserves costs.

1.1.2 Intensification of current arable crop systems

Irrigation can secure higher average yields for Serbia's key arable crops, thus increasing farmers' revenues and promoting investment in area expansion.

- A review of empirical evidence of irrigation impacts in Serbia shows that average arable crops yields can increase significantly under irrigation. The Institute of Agricultural Economics estimated for Svilajnac, an area of fertile land in Central Serbia, that irrigation would double maize yields from 6 to 12 tonnes/ha. This would increase output value by around € 1,100/ha and gross margin by around € 770/ha, before taking account of the fixed and variable costs of irrigation. If that could be replicated across the whole country, then irrigating the entire maize area would increase annual agricultural output by around € 100 million and Gross Value Added by some € 70 million.

- Most importantly, irrigation reduces inter-year variability caused mostly by variations in precipitation and may lead farmers – with a lower risk exposure – to increase the use of inputs and therefore intensify their cropping systems. Shifting rotations in addition to investment irrigation to include more value added field crops, such as soybeans, sugar beet or cereal seeds, may also lead to higher returns per hectare.

- The census data show that large farms prefer crops that are easy to mechanize and easy to manage, so if a large arable farm were provided with irrigation, in most cases it would continue to grow arable crops. However, the arable cropping mix would tend to change. Projections made by the Institute of Agricultural Economics for Sviljanac, based on discussions with local farmers, were that irrigation would lead to a decrease in the area of grain maize, and an increase in the area under high-value crops and under fodder crops, including maize silage.
- Things look different for medium and small farmers. Average yields are already interesting for rain-fed field crops. For example, farmers from the district of South Banat reported maize yields above 10 ton/ha in years with average rainfall. Given that maize is a low-value crop, irrigation systems for maize must have low overall costs (capital cost, regular operations and maintenance, and the volumetric costs of water and pumping), and the uptake must be high to spread the capital and recurrent costs over as many hectares as possible. Even then, uptake is not guaranteed as even individual borehole systems feeding "Tifon" hose-reel sprinklers – usually preferred option – are likely to produce small marginal results for maize production, and in practice farmers tend only to make such investments it order to grow high-value crops. This is probably why nationally, only 3 % of maize is irrigated and of the 630,000 holdings with irrigation, only 2.5 % (15,700) irrigate maize. On the farms that do irrigate maize, on average only 40 % of the maize area is irrigated.
- Hence, uptake by small farms not envisioning a shift to high value crops is likely to be quite low and they would be reluctant to pay the tariff levels needed to cover full operating costs, let alone capital recovery, as many of them will consider that the increased output from irrigating field crops is not worth the extra work and investment cost of on-farm irrigation equipment.

Further assessment needs: Investments in irrigation targeting arable crops with no major changes in farming systems need to be carefully assessed, depending on the prevalent farming systems and market outlets, improvements in yields may not be sufficient to ensure positive economic returns for investment in irrigation. Financial instruments such as crop insurance or reserve funds may be a more efficient alternative when the benefits from irrigation are more about stabilising cash flows, rather than significantly increasing average yields. However, disaster risk finance is underdeveloped in Serbia with existing catastrophe risk insurance largely underutilized and few other options to hedge against clime risk are available.[16]

1.1.3 Accelerating transition towards higher value agriculture

Irrigation can enable land use shifts from lower valued added crops to higher valued added ones. In addition, in cases where some form of irrigation already takes place, improvements to irrigation systems and the resulting increase in quantity and quality of delivered water can support farmers attain optimal levels of irrigation throughout the year.

- Some of the crops currently grown in Serbia show larger value addition and returns on investment than the country's key export crops which occupy most of its agricultural area. According to national experience and also international evidence, fruit crops such as apple or sour cherry have higher value added and provide better returns to investments in irrigation than maize or wheat[17]. Extension of fruit and vegetables areas also creates opportunities for new private investments in grading, storage and processing units.

There is an opportunity for lowering costs of irrigation and modernizing irrigation systems used for fruit and vegetables (to increase production quality and competitiveness) in Sumadija and West Serbia and in South-Eastern Serbia, as well as to create new irrigated areas for land use conversion into fruits and vegetables in the highlands of Vojvodina (as described above for Fruska Gora).

Further assessment needs: Higher value crops often expose farmers to new risks and require a different level of technological sophistication if they are to achieve their potential. Investments in irrigation targeting a conversion to fruits and vegetables or improving productivities of fruits and vegetables should be assessed for market risks. Market risks include for example: (i) drop in market prices for specific commodities in case Russia changes its trade policy, (ii) technical and financial capacity and feasibility for the necessary changes in agriculture and post-harvest technologies and practices (e.g. apples may require large amounts of water concentrated around a short blossoming season for frost damage prevention).

1.1.4 Leveraging existing infrastructure and containing investment costs

Serbia has invested in a complex and large drainage and flood prevention network[18]. With limited investment in new infrastructure (see section 2), such network can be adapted for irrigation purposes. Existing irrigated areas in Sumadija and West Serbia and in South-Eastern Serbia can become more efficient if they are provided with electric energy sources and improve their on-farm technology and

[16] http://documents.worldbank.org/curated/en/830671468184737730/pdf/105096-WP-Country-Note-Serbia-April-2016-PUBLIC.pdf

[17] According to the 2012 CENSUS, in Serbia, 50 percent of the land under vegetables, melons and strawberries is irrigated versus less than 5% for arable crops.

[18] Serbia operates 400 drainage systems benefiting an area of about 2.2 million ha. There are 210 pumping stations with an installed capacity of about 545 cub.m/s, and over 22,000 km of drainage network including main, secondary and tertiary channels. Most of the drainage systems are in Vojvodina benefiting a service area of about 1.8 million ha.

practices. Overall investment costs for expanding irrigated areas can be moderate in an international perspective.

- The existing irrigation systems and the wide network of drainage and flood prevention infrastructure provide opportunities to contain investment costs:
    - flood protection and drainage systems can be adapted for irrigation during dry seasons – mostly in low lands in Vojvodina;
    - existing flood containment dams and reservoirs can be used for irrigation with an investment in replenishment infrastructure (pumping stations and conveyance)[19];
    - Irrigated areas served by surface or groundwater can benefit from conversion from diesel to electrical pumps, possibly powered with renewable energy.
    - Investment in off-farm systems in Serbia vary between Euro 2,500 and Euro 7,000 per hectare depending on the type of investments (pumped, gravity, dams, rehabilitation, modernization or new construction), and are at around Euro 2,500 per hectare for on-farm systems. Source?

Given that such investments would be made on pre-existing infrastructure for drainage, there is an opportunity to significantly increase irrigated areas with infrastructure investment costs below those of other countries in the region. *O&M should also be efficient in cases where irrigation would contribute to the maintenance of flood protection and drainage systems, and vice-versa.* However, these investment options require capacity to *operate and maintain multi-purpose infrastructure, i.e. water users may be dependent on the maintenance of drainage infrastructure.*

Further assessment needs: The economic and financial feasibility of the solutions will largely differ case by case and a good characterization of the main typologies needs to be made. The following chapter establishes a framework for analysis.

2 Setting the analysis framework

2.1 Mapping out investment opportunities

As seen above the different possible drivers for the adoption of irrigation will play differently depending on the context. Each zone or sub-zone represents a set of agricultural and irrigation conditions that can be subject to a preliminary feasibility and risk analysis. Key agricultural and irrigation conditions shaping each sub-zone's potential for investment in irrigation include water source, distance to water source, topography, farm/plot sizes, soil type and prevailing farming systems.

Table 1 – Main zones and sub-zones of the Serbian territory in terms of potential for irrigation

Zone: Lowland plains	
Sub-zones	Adjacent to rivers & overlying alluvial aquifers
	Already served by drainage canals
	Above reasonably shallow available groundwater
	Fruska Gora lower slopes supplied by flood control dams

[19] The country has over 3,500 km of protection dykes and a number of reservoirs for flood containment that can be used for irrigation

	None of the above sources but could be supplied by canals
	Not irrigable at reasonable cost
Zone: Hilly areas - m*osaic*	
Sub-zones	Land close to rivers and streams
	Land over reasonably shallow and plentiful groundwater
	Not irrigable at reasonable cost

The agricultural and irrigation conditions of each sub-zone will in turn condition the options in terms of possible (on- and off-farm) technology adoption, governance, and possible changes in farming systems as briefly described below. For more complete accounts of governance and technology adoption options/scenarios, see briefs 2 – *Water Governance* – and 6 – *Technology and infrastructure needs*.

2.1.1 Lowland plains:

Adjacent to rivers & overlying alluvial aquifers

These areas exist not only in Vojvodina, but also along the Danube in central Serbia. Irrigation can be made through **direct pumping from the river or canal** for individual or a small group of farms or through individual **boreholes**. This enables the most flexibility for farmers, but requires strong **governance** to monitor and control individual water abstraction, especially in international rivers. **Public investment** in this type of systems would mostly consist of providing electric infrastructure for pumping and increasing capacity to gauge water levels and monitor abstractions.

Farming systems may change considerably in this case, comprising medium to large farms (ex-kombinats) with cereals, seeds and sugar beet, fruit and vegetable producers, and small scale arable crop farmers.

Given the topography and access to water in these areas, most on-farm **technology options** are possible: centre-pivot (on large arable farms), tifon sprinkler (on small arable farms), permanent drip (for fruit trees), single-use drip tape (for field vegetables)

Already served by drainage canals

Public investment in converting drainage infrastructure to dual-purpose systems has been identified for two well-defined areas: the Danube-Tisa-Danube (DTD) and the Macva (Sava River) systems. The proposed investments would include **reversing water flow** using subsurface drains and **farm pumping out of the canals** with possible construction of secondary and/or tertiary **(last mile) canals**. However, drained areas usually have shallow groundwater and **boreholes** could be a more economic efficient option.

The former option would require some **adaptation** for irrigation of the current **governance** of drainage systems.

Most of the **farming systems** in this sub-zone consist of arable crops with some sizeable farms and fields. However, some small farmers in the DTD system have already converted to vegetable production and it would be interesting to understand the potential and interest for farmers for conversion.

Technological options would therefore be the same as for the previous case, except that perennial crops with permanent drip irrigation would probably not be present.

Above reasonably shallow available groundwater
The mapping of groundwater availability (at affordable piezometric levels and with quality for irrigation[20]) is paramount to understand the potential scale of this option. Groundwater is normally the preferred source of water for farmers as they do not rely on the operation of irrigation systems and the costs are often lower (no conveyance or distribution costs).

In terms of **on-farm technology options**, they can be the same as for the previous cases, but fruit and vegetables may play a more significant role in these areas, which means that drip irrigation may be the most common choice.

In terms of **governance**, individual boreholes will require monitoring of abstraction by users or at least of piezometric levels. Additionally, should forecasted demand be higher than the estimated water availability from the onset, abstractions will need to be controlled. In those cases, it can also be considered the investment on multi-user pressurized system from boreholes (as it is planned for Resavska Celina in Svilajnac). This is usually not a preferred option for farmers, but may be prove to provide a better means to control abstraction.

Fruska Gora plateau supplied by flood control dams
Fruska Gora is a raised area within the Vojvodina plain protected from flood by 12 dams. There are a few options in terms of **public investment** for these dams: (i) dredging of sediments and wall repair to increase capacity and enable direct intake by surrounding farms, (ii) building pumping and conveyance systems from the river for increased direct intake, and (iii) providing water under pressure to farmland downstream the dams. All the options are incremental. i.e.: option (ii) would imply (i); option (iii) would imply (i) and (ii). These options differ greatly in costs and in the number of farms and hectares that they can benefit. Hence, they will need to be well assessed in terms of economic sustainability, as well as in terms of distribution economics – Investments for direct intake may only benefit a few large farmers with a heavy investments made with tax payers' money.

Governance would also change significantly depending on the options. In case there is only direct uptake from the lake, water abstraction can be **managed** directly by the group of beneficiary farmers through ad-hoc contracts. Vode Vojvodina would continue charging a fixed fee for dam maintenance. If water is serves farmers downstream either Vode Vojvodina or a newly created water users association should be responsible for management.

Downstream the dams, **farming systems** are usually composed of small farms with arable crops, but some close to the river have started converting to vegetables. Some large farms with irrigated high-value crops (apple plantations and cereals seed production) can be found in around the lakes on the Fruska Gora the plateau.

On-farm **technology** would mostly consist of centre-pivot (on large arable farms irrigating high value arable crops such as certified seed for export) and permanent drip (for fruit trees). Single-use drip tape (for field vegetables) could be used in smaller farms further downstream.

Lowland Supplied by canals

[20] Some aquifers in Vojvodina contain arsenic, which makes it unsuitable for irrigation without previous treatment.

This is option is very similar to invest in areas already served by drainage canals in terms of farming systems and technology options. However, it implies new **investment** in canals networks (making it possibly the less efficient option in lowlands). Additionally, new **governance** arrangements would need to be defined for these areas. The new canal proposed under the Abu Dhabi Fund would fit into this option.

2.1.2 Hilly areas - mosaic

Land close to rivers and streams

This sloping or at altitude land is more likely to grow fruit than arable crops. Irrigation potential in this areas will be conditioned by the distance and difference in altitude of the water source (conveyance costs) and the existence of rivers with sufficient summer flow to support irrigation. Such zones can be found in a large part of the national territory in the regions of Sumadija, West Serbia and South-East Serbia.

Most existing cases consist of individual pumping from rivers or boreholes – when farms are close to rivers or there are alluvial aquifers. In the future, systems with a small reservoir to serve a few farms downstream could be considered. Some of these systems in Serbia are **governed** by farmer groups who decide on water allocation to the different users and manage its operation and maintenance. Some ex-kombinats acquired a license for private pumping from the river into a private reservoir in order to irrigate fruit trees.

Most **farming systems consist of** areas under grass or forest with irrigated patches that can be used for fruit or vegetables. Hence, **on-farm technology** would consist of permanent rip (for fruit trees), single-use drip tape (for field and greenhouse vegetables) or fixed sprinkler systems (for vegetables and potatoes).

Public investment could comprise new water reservoirs, abstraction, conveyance and distribution systems, farm electrification, as well as subsidies for the installation/modernization of on-farm irrigation systems.

Land over reasonably available shallow groundwater

In this case, water would be abstracted from **individual boreholes**. The cost of boreholes and pumping for small farms means this solution would only be used for fruit and vegetables, including greenhouses (drip irrigation). **Farming systems** would mostly be as described above.

Public investment would be limited to farm electrification and subsidies for the installation/modernization of on-farm irrigation systems, but in, terms of **governance**, groundwater levels would have to be monitored and abstraction would possibly need to be controlled.

2.1.3 Crosscutting enabling investments

In addition to investment in irrigation related infrastructure and on-farm equipment specific to each sub-zone, the success of any intervention in irrigation will depend on the effectiveness of a number of enabling investments at central level. These necessary investments include: (i) improved legislation and regulations, as well as zoning, licensing, monitoring and control of groundwater use; (ii) legislation and regulation on Water Users' Associations; (iii) a new "Irrigation Support Unit" to assist Municipalities, Water Users' Associations and other operators of multi-user irrigation systems; (iv) tools, training and guidance on tariff-setting and efficient operation; and (v) training, advice and information services to improve irrigation and crop production practices.

2.2 Scenarios and main variables to be considered

Once the subzones described in the previous section have been mapped out in the irrigation Atlas, it will be possible to select a number of concrete examples on which to build scenarios for analysis. The return on investment in each of the sub-zones identified above will vary greatly, both from technological option to technological option and from place to place depending on the farming context. As such, and in order to better understand where the best economic opportunities and the greatest risks lie, the strategy needs to be informed by scenarios on possible economic returns to investment in irrigation.

A number of scenarios should to be constructed for each main type of water source and conveyance and distribution system, as these will ultimately define the level of investment in each case. The main variables that will define each scenario are the farming systems (with and without investment) and the projected level of irrigation uptake by farmers.

The table below provides a first overview of the scenarios that can be considered to inform the irrigation strategy. Although not explicitly mentioned in the table below, all scenarios will need to project not only changes in cropping systems, but also possible changes in governance and tariff structures, as well as the effect of climate change over the years of analysis.

Table 2 – Factors determining financial and economic feasibility of possible investment scenarios

Water source and conveyance and distribution system	Key factors determining economic feasibility (investment costs do not include on-farm equipment)
Low land	
<u>Direct pumping from river</u> (areas adjacent to rivers) *Analyze three different types of farming systems and levels of uptake*	**Investment**: 500-1000 Euro/ha in pumps, but most important public investment could be in electrification. **Cropping systems**: (i) large, medium and small farms of perennial crops, (ii) small fruit and vegetables farms, (iii) arable crops. **Level of uptake**: (i) and (ii) small investment compared to possible gains and possible high uptake (in some cases, e.g. Timok rivers in Zajecar where modernization and expansion of existing systems is possible, uptake can be high), (iii) possibly low except for large farms.
<u>Boreholes</u> (areas with shallow aquifers) *Analyze three different types of farming systems and levels of uptake*	**Investment**: 1000-2000 Euro/ha per borehole, but most important public investment could be electrification. **Cropping systems**: (i) small fruit and vegetables farms, (ii) large arable crops farms, (iii) medium to small arable crops farms. **Level of uptake**: (i) small investment compared to possible gains and possible high uptake (in some cases, e.g. Leskovac where modernization and expansion of existing systems is possible, uptake can be high), (ii) there is an appetite for irrigation from large arable crop farms (e.g. Vojvodina sugar beet and seeds farms), (iii) but otherwise uptake should be low as it has been so far.
Dual purpose systems + pumping from canals (areas already served by drainage canals)	**Investment**: 600-800 Euro/ha **Cropping system**: arable crops with a mix of small and large farms and fields with a number of vegetables producers in the DTD system. **Level of uptake**: probably high amongst larger farmers, but for smaller farmers depends on their appetite and capacity to change to higher value crops. Irrigation of arable crops may only occur in dry years and with subsidized equipment.
Dual purpose dams + pressurized system (*such as Fruska Gora*)	**Investment**: 5000-7000 Euro/ha

	Cropping system: (i) fruit plantations and high-value arable crops around the lake, (ii) also smaller farms with arable crops and some with vegetables in case water is distributed downstream **Level uptake**: very high around the lakes, but lower downstream. Uptake downstream depends on their appetite and capacity to change to higher value crops. Irrigation of arable crops may only occur in dry years and with subsidized equipment.
New canals system + pumping from the canals	**Investment**: 3000-5000 Euro/ha **Cropping system**: arable crops with a mix of small and large farms. Larger farms may plant higher value arable crops such as certified seeds or sugar beet. **Level uptake**: probably high amongst larger farmers, but for smaller farmers depends on their appetite and capacity to change to higher value crops.
Highland	
Direct pumping from river (land close to rivers and streams)	**Investment**: 500-1000 Euro/ha in pumps plus costs of conveyance, but most important public investment could be in electrification. **Cropping system**: Fruits and/or vegetables. **Level of uptake**: Depends on the appetite of farmers to intensify their farming systems. May require ad-hoc complementary policies to incentivize change.
Boreholes (land over reasonably available shallow groundwater)	**Investment**: 1000-2000 Euro/ha per borehole, but most important public investment could be electrification. **Cropping system**: Fruits and/or vegetables **Level of uptake**: 1000-2000 euro/ha may be costly for small farmers. May need incentive schemes for crop intensification and installation of irrigation..
Reservoirs + pressurized system	**Investment**: N/A **Cropping system**: (i) fruit trees plantations such as the case of existing systems in Leskovac, (ii) fruits and vegetables. **Level of uptake**: Could be high in regions where irrigated crops already exist. May require incentives to modernize cropping systems otherwise.

Source: author's elaboration based on costs ranges of investments from previous projects, Vode Vojvodina investments and interviews with stakeholders.
Note 1: Investment does not include possible needs for ancillary infrastructure, training of stakeholders. No O&M costs were considered in this snapshot of possible investment scenarios, although it is fundamental to estimate then when analysis their economic and financial sustainability.
Note 2: In the irrigation Atlas, these main zones defined by water source and conveyance and distribution system would be mapped out. For each zone, when relevant, different subzones would be delimited for which costs of conveyance, water losses, etc. would be estimated depending on their distance to the source.

In the addition to the options for new systems listed above, the country can also invest in the rehabilitation of existing systems. In order to understand where the main opportunities would lie in terms of rehabilitation, for each existing system, it would be important to understand what costs it would imply and what additional benefits the rehabilitation could bring. For example, in some cases, the electrification of pumps of reservoir and canal systems can imply very contained investment costs and larger benefits in terms of energy and maintenance costs.

3 Expected results and next steps

3.1 Investments yielding good results in the short term and major risks

The analysis of the scenarios identified above will enable understanding what farming systems, value chains, and regions can benefit from investments in irrigation with high returns and relatively low risk. The following paragraphs provide examples of what the results from the analysis can look like for four types of water source and conveyance and distribution systems[21]:

A – Two examples of **boreholes for individual irrigation**: (i) serving a 3 hectares farm with a walnut plantation, and (ii) serving an ex-kombinat in Republika Srpska, which renewed its network of boreholes and pump stations to supply a large linear-move irrigation machine covering 300 hectares of cereals and oilseeds.

B – **Dual-purpose drainage and irrigation systems** such as those linked to the Danube-Tisa-Danube canal and around Macva serving small and medium arable crops farms. This example assumes (a) the canal already exists and only needs renovation, (b) water flow is by gravity rather than pumping, and (c) application is by low-cost surface irrigation.

C – **Dual purpose reservoir with direct intake from the lake** by surrounding farms serving large intensive apple orchards of a small number of farmers in Vojvodina.[22]

D – **Two examples of local pumped systems**: (i) one serving with small farms of arable crops (Negotin) and one serving farms with a mix of crops including alfalfa (Svilajnac). Two uptake scenarios where considered for each of them.

Although, at the moment of the elaboration of this brief there was no information on costs and benefits for the other investment options listed in the previous section, it can be assumed that:

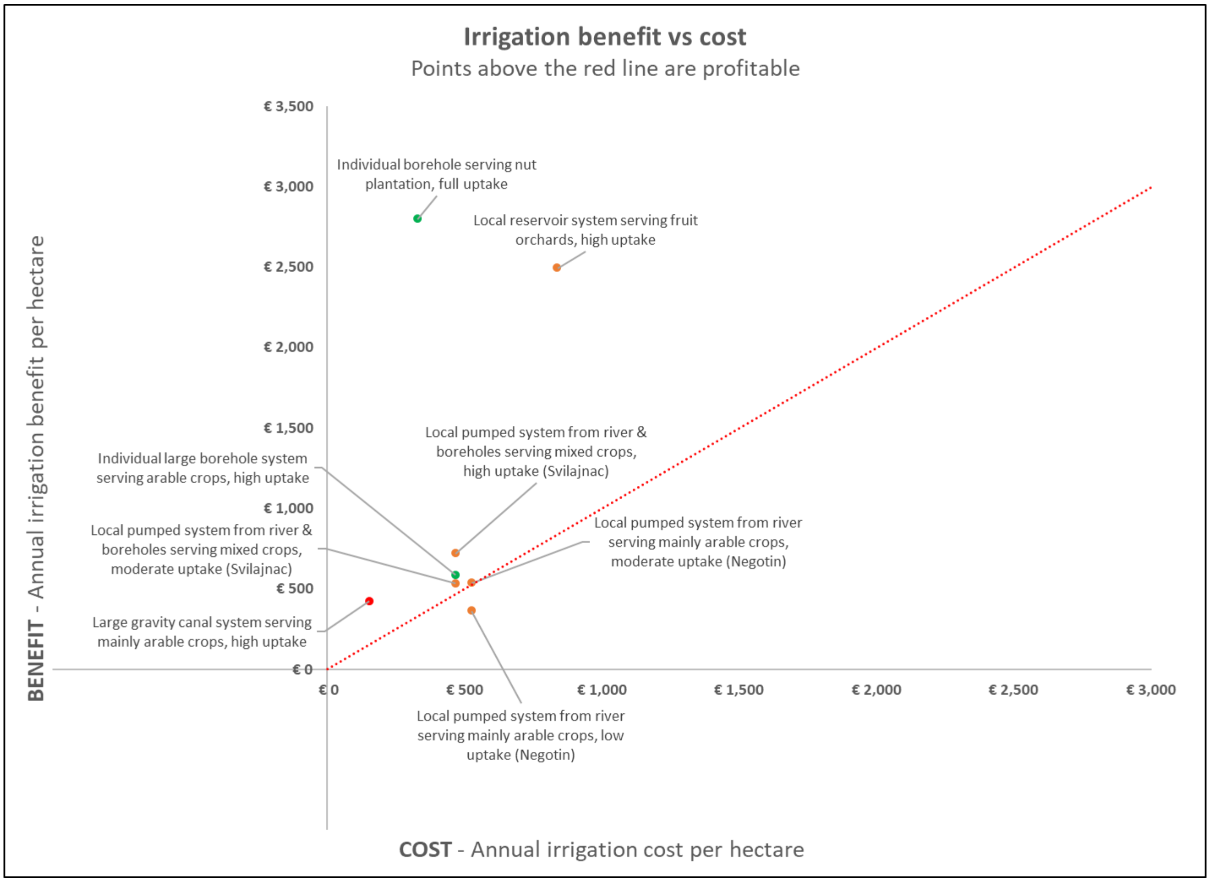
- The construction of large new canal systems to irrigate arable crops may have low economic efficiency as the investment is significantly higher than for the conversion drainage and flood protection systems, but the benefits should be similar. Additionally, O&M costs cannot be shared between irrigation and flood protection beneficiaries.

- Investments in existing systems that irrigate fruits and vegetables – in low lands through boreholes and direct intake from the river or perennial crops in highlands through a network of small reservoirs – should have a high return and present a small risk of low uptake. Such investments would lower the irrigation costs and enable expansion in irrigated surface in regions with organized value chains for high value crops.

Figure 4 - Irrigation benefit vs cost for selected examples of investment in irrigation

[21] The choice the examples is due to the limited information available on other cases. None of the examples considers the effects of climate change.

[22] Costs are approximate.



This preliminary analysis suggests that systems serving high-value crops are likely to have high returns, even when investment is high. It also supports the assumptions made before in this brief that the increase in income from irrigating small fields of arable crops many not provide enough incentives for high uptake, making systems with high capital and O&M costs financially unsustainable.

Likewise, the main financial incentives for farmers are for the adoption of individual irrigation. Multi-user irrigation systems tend to be risky in terms of adoption rate given the high share of farmers with small land plots and with agriculture only representing a small share of their income. This means that: (i) expansion of irrigated agriculture may require expedite licensing (as well as control) of **areas suitable for sustainable** individual irrigation from boreholes or direct intakes, (ii) in most cases investment in irrigation schemes that benefit a large number of small will need to be planned together with policies that promote the adoption of more intensive farming systems.

There is considerable uncertainty attached to all these scenarios, both in how much it will really cost to build, maintain and operate the irrigation system, and in how many farmers will use it and what they will grow. Hence, the scenarios that will be constructed to inform the irrigation strategy and that meet basic criteria for technical, legal, institutional, social and environmental viability should be complemented by a sensitivity analysis for key variables.

3.2 Next steps for the strategy

Despite the uncertainty involved, this preliminary analysis already identifies large categories of investment that can be classified as (i) having positive returns at a manageable risk, (ii) investments that will be inherently risky given that require assumptions of high uptake where this may not occur, (iii) investments that require detailed case by case analysis to determine their financial and economic sustainability.

The strategy should hence map out where opportunities for investments with low risk and interesting returns in the short term may be located and identify what complementary investments or what new institutional arrangements may be necessary to make these investments work in a sustainable manner. For example, making use of the full (sustainable) potential of existing water sources through boreholes or direct intake from the river may require expedite licensing processes that do not shy farmers away from seeking permits for water abstraction and thus enable fair law enforcement on illegal water abstractions.

Likewise, expanding areas producing fruit and vegetables may imply: (i) a careful review of legislation and law enforcement mechanisms on the use of chemicals along with incentives and technical assistance on their rational use; (ii) coordination with the ministry of mining and energy as well as municipalities for the expansion of the electrical grid.

Risky and/or for the moment unfeasible investments should also not be discarded in the long-term. As the Serbian society becomes increasingly more urbanized and industrialized, there is an opportunity to for land consolidation through long-term territorial planning and to support the development and organization of strategic agricultural value chains in particular regions. Such developments mean that what are immediate unfeasible investments, can become increasingly more interesting due to progressive increase of farms size and the development of markets for higher value added crops. The strategy should provide directions on policies that may enable successful expansion of irrigation in the future.

All the remaining options should be analyzed regarding the relevance and importance of public investment or policy support for their development. The analysis should include the identification of risks and their possible mitigation strategies alongside the analysis of the investments in irrigation infrastructure and on-farm equipment.

In order to ensure a comprehensive economic analysis, the team working on irrigation economics advises the strategy working groups to:

1. Map out all the zones and sub-zones with potential for irrigation and respective climate change scenarios.
2. Identify sub-zones and schemes that could provide examples for analysis of all the possible scenarios identified in this brief.
3. Agree on possible scenarios for shifts in farming systems brought about by climate change and irrigation water availability for each of the examples.
4. Conduct a detailed cost-benefit analysis for scenarios on the different investment (public and private) examples that were identified – this would include agreements on what type of off and on-farm technology to consider for each example.
5. While conducting the analysis, identify key social, environmental and governance and management risks that may compromise the sustainability of the investments, as well as necessary mitigation measures.