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APPENDIX: Long version of good practices

GP 3	Binomial fee estimation for a rational use of water in agriculture

Project Partner:
Regional Agency for Rural Development of Friuli Venezia Giulia (ERSA)

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1. Abstract

This best practice is concerned with the evaluation of both economic advantages and water savings which can be achieved when a "sprinkler irrigation system" instead of a "surface irrigation system" is adopted

This practice is aimed at providing a reference scheme for the irrigation consortia so as they can evaluate the consistency of a binomial fee to be applied to the farms adopting a "on demand water supply" as well as to demonstrate the farmers the advantages and the profitability coming along with this irrigation pattern.

The evaluation takes into consideration a reference sprinkler irrigation plant, realized and put into action in summer 2011, consisting of an underground network of pipelines flowing water kept at the target pressure and regarding the Pascat district managed by the Land reclamation consortium Ledra Tagliamento.

This plant can improve the irrigation technique performances enabling remarkable water savings compared to the surface water irrigation system.

Different levels of binomial fee and scenarios could be explored through PC simulations. The "binomial fee" can be split into two components: one component refers to a fixed quota related to the management costs of the plant, the other component is directly related to the water consumed for irrigation by the individual farm. The binomial fee is aimed to advantage the farms which adopt a "on demand irrigation pattern" instead of a

"scheduled irrigation pattern" as the former pattern foresees water supply only when it is really necessary for the crops requirements. The "on demand irrigation pattern" has also a positive impact on the overall balance of the plant as it enables a reduction of the energy costs to maintain the target water pressure of the system.

2. Introduction: the Friuli Venezia Giulia context

Irrigation is one of the crucial issues for the rural development of the region Friuli Venezia Giulia, a well organized and viable rural community also promotes the land conservation and the ecosystem protection.

In the recent years the concern for water availability for agriculture irrigation has increased because of a more intensive competition for the use of water resources, lack of precipitations for longer periods during growing season, higher air temperature, lesser storage of water in the snowfields in the mountains during winter, being this latter the main source of water for the streams and the rivers which supply the irrigation network of the regional territory.

Maintenance of the irrigated agricultural land and of the related environmental benefits require the implementation of specific actions for the conservation and the protection of water bodies as well as for the transformation and the modernisation of the irrigation network system, especially for what concerns water storage capacity, water supply rationalization and water savings.

In the region Friuli Venezia Giulia many of the agricultural land is provided with a surface irrigation system which requires remarkable water availability, moreover the "extraordinary irrigation pattern" is still practiced and wide-spread. These facts suggest the need for the modernisation of the irrigation system.

According to the statistics the total area managed by the Land reclamation consortia corresponds to 338,562 ha and the related area covered by irrigation is 145,400 ha of which 38,976 ha served by sprinkler irrigation systems, 29,634 ha served by surface irrigation, 3,070 ha served by other systems and 73,900 ha interested by extraordinary irrigation interventions pattern.

Since 1989 the plain territory of Friuli Venezia Giulia is managed by four different Land reclamation consortia (namely Bassa Friulana, Cellina Meduna, Ledra Tagliamento and Pianura Isontina) which are in charge of the protection of the agricultural land, of the collection and use of water for irrigation purposes in agriculture and to project and realize irrigation infrastructures, to carry out the land reclamation and the irrigation works, to assure the efficiency of the irrigation system as well as the water supply for the agriculture and the prevention of water excess in the wet areas of the region. Modernisation of the irrigation network and conversion from the surface irrigation system to the sprinkler irrigation system, aimed to optimize and rationalize the use of water in agriculture, is another task of the Land reclamation consortia.

In the region Friuli Venezia Giulia over the recent years, being aware of the need to promote an increased efficiency in the water resources use, remarkable efforts have been effected for the modernization of the irrigation system. At the present time, as it is shown in Fig. 1, the "sprinkler system" is the main irrigation system adopted in Friuli Venezia Giulia, however it is noteworthy that in 20.38% of the agricultural land covered by irrigation is served through surface irrigation systems, moreover the "extraordinary irrigation pattern" is still practiced and wide-spread.

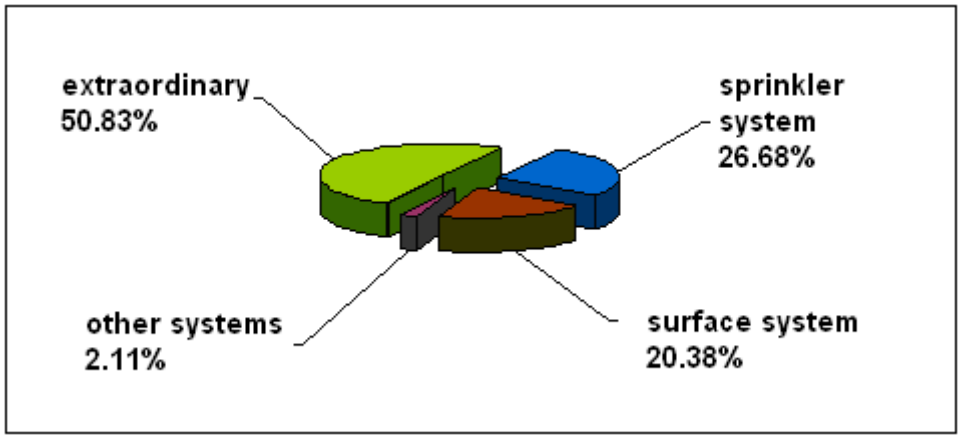

Fig. 1: Irrigation systems adopted in the agricultural land covered by irrigation in the Region Friuli Venezia Giulia.

3. Water savings potential

Droughts occurred in 2003 have made evident the need of a rapid conversion from the surface irrigation system to the sprinkler irrigation system due also to the consideration of the water savings that could be achieved through the latter technique.

In fact on the basis of a theoretical average water consumption of 2.2 and 0.9 l/(s*ha) respectively with the surface technique and the sprinkler technique, with the conversion from one system to the other an average water savings of 1.3 l/(s*ha) could be estimated.

Studies carried out so far from the competent authorities have identified the areas of the regional territory where the conversion of the irrigation system can be regarded as suitable both in terms of technical feasibility and economic costs.

Tab. 1 lists, for each of the Land reclamation consortium, the areas regarded as suitable for the conversion of the irrigation system which are mostly distributed within the territory of Bassa Friulana and Ledra Tagliamento consortia.

Tab. 1: Areas of the region Friuli Venezia Giulia suitable for the conversion to the sprinkler irrigation technique and water savings potential.

Land reclamation consortia	Concerned area	Water savings potential
Cellina Meduna	1,500 ha	1,950 l/s
Ledra Tagliamento	6,935 ha	9,015 l/s
Bassa Friulana	7,750 ha	10,075 l/s
Pianura Isontina	0 ha	0
Total	16,185 ha	21,040 l/s (21.04 m^3/s)

Bearing in mind that the conversion to the sprinkler technique could lead to an average water saving of 1.3 l/(s*ha) and taking into account the areas where this conversion could be applied, then a theoretical water savings of 21,040 l/s corresponding to 21.04 m3/s can be computed (see Tab. 1).

At the present time the Government of the Region Friuli Venezia Giulia has financed the conversion of the irrigation system for 5,200 ha in the areas managed by the four Land reclamation consortia which, at the work completion, could assure a water potential savings of 6.76 m3/s.

Tab. 2 shows the figures of the possible water savings that could be achieved after the completion of the conversion of the irrigation systems already financed by the Government of the Region Friuli Venezia Giulia.

Tab. 2: Irrigation conversion works already financed and water savings potential

Land reclamation consortium	Concerned area	Water savings potential
Cellina Meduna	2,420 ha	3,146 l/s
Ledra Tagliamento	1,870 ha	2,431 l/s
Bassa Friulana	770 ha	1,001 l/s
Pianura Isontina	140 ha	182 l/s
Total	5,200 ha	6,760 l/s (6.76 m^3/s)

Having in mind that most of the water derivations have a different purpose use (i.e. irrigation, electricity and mechanical energy, public and civil use), regulated by specific regulations and regional concessions, the potential water savings that could be achieved from the conversion of the areas irrigated with the surface technique, when this conversion is feasible, could lead to the following results:

1. reduction in the number of derivations used for irrigation purposes so that the water spared could be used for other purposes (electricity, public or civil use, etc.);
2. an increase in the areas served by irrigation that could lead to a reduction in the practice of the “extraordinary irrigation pattern”.

On these basis a reduction trend of water savings could be progressively achieved as a result of the extent of irrigation system conversion and of a larger portion of the agricultural land served through sprinkler irrigation technique.

Water savings could show an increasing trend over the time taking into account on one hand the larger amounts of water available because of the savings achieved in the previous period, on the other hand the lower water consumption due to the introduction of more efficient irrigation techniques in the following years, leading to a cascade effect that could have a significant impact in terms of cost benefit analysis.

4. The conversion of the irrigation system

The conversion of the irrigation system from the surface technique to the sprinkler technique is necessary to achieve significant water savings so as to limit the possible conflicts among different water purpose utilization

and counteract frequent lower amounts in water resources availability. Moreover such a conversion could also be of some benefit to the environment to reduce nitrate and other substances leaching in the areas most sensitive to the pollution risk.

The conversion to the sprinkler irrigation technique should be strictly connected to a specific restructuring of the individual networks which supply water so as to avoid water waste especially when droughts occur. This restructuring could also be realized through the adoption of high efficiency irrigation techniques, such as drip irrigation to be adopted with cultivations having high profitability, like horticulture, orchards and vineyards.

The Region Friuli Venezia Giulia, having in mind the importance of water savings issues, has adopted some planning instruments which have defined objectives, criteria and priorities to be taken into consideration when it comes to realize public investments.

Among these instruments, the "Ten-year programme for the public investments in land reclamation and irrigation for the period 2004-2013" (*"Programma decennale per le opere pubbliche di bonifica e di irrigazione afferente al periodo 2004 – 2013"*), approved with Deliberation of the Regional Government no. 3495/2004, which provides a general view of the real needs of the territory, being this latter a prerequisite for an efficient use of financial resources made available by the EU, the State and the Region. This ten-year programme describes the public investments needed for the agricultural sector so as to assure the regular control of water flows, as well as of the works to be effected for irrigation and for the maintenance of the public works already operating. Moreover this programme describes the characteristics of the works to be effected, the possible or the given financing source for the works, the costs foreseen for the individual work and the costs to be borne by the Institution which will finance it.

Irrigation strongly affects the agricultural production. The present climate changes, showing lesser rain precipitations in Summer, with shorter duration and higher intensity, coupled to higher temperatures leading to increased water consumption by the crops, marks more and more the difference between irrigated areas and non-irrigated areas.

The adverse effects of droughts, represented by remarkable reduction in crops yield and additional costs for the extraordinary irrigation interventions have reached very high levels; for instance the droughts occurred in 2006 in the Region Friuli Venezia Giulia have resulted in overall losses of 51 MEuro.

Bearing in mind that costs for the realization of a new irrigation plant could be estimated in 7,000 – 8,000 Euro/ha depending upon the works for the water derivation, the degree of fragmentation of the farm agricultural land in scattered parcels, the shape of the parcels and type of construction material used, while the costs for the conversion from the surface irrigation technique to a sprinkler irrigation technique can be estimated in 8,000 - 9,000 Euro/ha, in 2006 the overall losses in agriculture for the adverse effects of the droughts could have financed the irrigation of 6,800 ha, or alternative achieve overall water savings of about 8 m^3/s.

5. The works in the PASCAT district

These works are concerned with the realization of an irrigation plant served by a sprinkler irrigation system consisting of an underground network of pipelines flowing water kept at the target pressure in the Pascat

district managed by the Land reclamation consortium Ledra Tagliamento. Over the recent years the need of a rational irrigation system has become apparent because of a reduction in water availability, due to climate change, as well as for the reorientation in the agricultural activity, i.e. more specialized crops cultivated.

At the present time the district is served by non permanent irrigation infrastructures used especially for extraordinary irrigation interventions that with the new works will be replaced by a rational plant that will be able to serve all the agricultural parcels.

The water will be taken up through the channel "Roggia di Udine" and the individual plots will be provided by derivations connected to the underground pipelines network supplied by the central water pump station.

The new system will allow:

- to rationalize the water resources exploitation pursuing to the plan of the concerned irrigation district;
- enhancement of the irrigation techniques and conversion of the crops cultivated in the district from arable crops to horticulture cultivations and orchards;

6. Irrigation technique adopted

As for the irrigation technique to be adopted in the new plant, the feasibility analysis has considered three different options:

- sprinkler system;
- drip system;
- Ranger or Central Pivot equipment.

In areas with frequent rain precipitations in Spring, as it occurs in the Pascat district, drip irrigation system is not suitable neither for arable crops nor for orchards. The sprinkler system allows to prevent damages from late frosts in Spring. Equipment such as Rangers or Central Pivot exhibit high costs for management and maintenance.

For the realization of the irrigation plant the sprinkler system technique has then been chosen, which, on the other hand, has always demonstrated to be more convenient than the surface technique.

Having regard of the type of soil in the concerned area, previous experiences suggest to adopt an irrigation intervention every 7 days with at least 40 mm of water supplied. On monthly basis this means a minimal water supply of 1,600 m^3, amount that assures the best growth conditions for the cultivations. To assure the administration of such amounts of water a continuous flow of 0.8 – 0.9 l/s/ha should be adopted on average.

With the new plant the water distribution to the plots of the individual farms is managed through indwelling or mobile pipelines. This new irrigation plant should be regarded as innovative especially for what concerns the flow meters (Fig. 1) which regulate the water supply to the final users. The automatic control can be managed through a remote control system (radio or cable connection) or through an in situ control which foresees some scheduled activities while the flow meters are managed through memory electronic cards.

Fig. 1: Flow meter installed.

In this plant the installation of an ultrasound flow meter on the input derivation is foreseen, which coupled, with the flow meters installed on the plant network will enable the automatic control and supervision of the two main pumps of the irrigation plant.

7. Pilot project for the "binomial fee"

At the present time the fees paid by the farmers for the irrigation services are simply based on the extent of agricultural land served by irrigation with an average rate of 150.00 Euro/ha.

Most of the irrigated areas are managed according to a scheduled irrigation pattern. For about 70% of the irrigated areas, given the type of soils (sandy or pebbly soils) and climate conditions (Summer with few precipitations and high temperature), 10 – 15 irrigation interventions are required (about 30 – 40 mm of water every 7 days).

This new irrigation plant, which foresees the installation of an individual flow meter for each of the user served, makes possible the adoption of a "binomial fee" where it could be taken into account:

- the extent of agricultural area irrigated, for the fixed quota related to the plant maintenance costs;
- the amount of water really consumed (water consumption measure by the flow meter).

The potential advantages from the application of a "binomial fee" are:

- reduction in water consumption;
- equity in sharing costs among the district partners;
- energy savings;
- opportunity for the district to benefit from the application of "expert systems" based on the water balance and the relationship soil-plant-climate;
- opportunity for the district to benefit from a "guided irrigation".

The possible difficulties that could be encountered with the new organization of the plant are the following ones:

- high degree of fragmentation of the farm agricultural land in many scattered plots;
- specific structure on the derivation systems and of the distribution network;
- landscape impact (i.e. one flow meter for each hectare);
- management of the overall irrigation schedule;
- management costs for data collection for consumption reporting purposes.

At the present time economic analyses are ongoing to evaluate whether the costs for the data collection and water consumption reporting are counterbalanced by a reduction in the energetic costs of the system.

Different fees schemes can be considered. The volumetric fee system takes into account the measurement of the water consumed and the rate of the fee is proportional to the volume of water consumed. This system considers the volume of water used by each farmer which can be measured by the individual flow meters. Costs for the implementation of the volumetric system are quite remarkable. An indirect method can measure the volume of water flowed over a given timeframe and a rate related to a minimal amount of water which has to be paid regardless that it has been consumed or not.

The binomial fee scheme foresees that farmers pay a marginal price per each unit of water consumed (MCP, Marginal Cost Pricing) and a fixed annual quota (or alternatively the payment of a quota to get the right to effect the irrigation) which is the same for all the farmers.

Binomial fee at discrete levels are based on the volumetric method. Once the flow meters have been installed the costs are very simple to be shared.

8. The real structure of the "binomial fee"

The Water Framework Directive, WFD (2000/60/EC) has identified the conservation and the protection of water quality, the rational and efficient use of water as main objectives in the public management of water resources; it provides some suggestions on the pricing of the water, which should be related directly to the volume of water consumed by the final user: this pricing criterion, in fact, should promote an efficient use of the water resources.

As for the level of the fee to be applied to the water, the total cost recovery concept is recalled. The WFD suggests that in the total cost should be computed not only the costs related to water distribution (management and fixed costs) but also the costs of the resources and various external costs such as the social and the environmental costs.

As for the structure of the "binomial fee" the following principles should be considered:

1. the discrimination between fixed costs and variable costs. The former costs comprise general expenses and cost for derivation and distribution of water in the primary networks, the depreciation of the technical investments and maintenance, which should portioned among all the agricultural parcels served. The latter costs, which comprise the management costs of the secondary network, the control and measurement tools and the energy costs borne for water pumping (the so called specific costs), should be partitioned, on the basis of the volume distributed, among the owners of the parcels who directly use the water.
2. the graduation of the fees according to the water consumptions. The experience gained over the recent years with severe lack of water resources, shows that even for the agriculture, in order to limit water consumption, it is necessary to introduce a progressive fee whose rate should depend upon the amount of water taken up by the farmer, as it was first introduced for the civil users.
3. the ability of the fee method to affect, through adequate differentiations, the orientation on the cultivations to be grown. The choices have changed or will change towards horticulture, orchards, cultivation under the greenhouses. The demand of water has been changing over the time then the fixed distribution schemes (for instance the scheduled distribution pattern) show their inadequacy with respect to the user needs. The most flexible distribution schemes should be able to become even more flexible as the water demand is distributed over a longer period during the year and the climate changes are remarkable.

The binomial fee foresees a fixed quota and a variable quota. The fixed quota comprises:

- scheduled maintenance costs;
- ordinary personnel costs;
- investments;
- studies, research, consultancy;
- energy costs.

The fixed quota identifies the direct benefits and therefore will be related to the agricultural area.

The variable quota takes into consideration the actual water consumption (and indirectly also the distribution system), so that it discourages the water consumption exceeding the optimum while it advantages the farmers who follow the indications arising from the water balance as well as the efficiency principles. This quota is concerned with the variables costs of the irrigation (energy costs related to the distribution of water, expenses borne for the personnel overtimes due to irrigation activities).

The contribution of the *i-th* individual farm is computed by the following:

$C_i = (Sf * B_i / \Sigma B_i) + (Sv * V_i / \Sigma V_i)$

where,

C_i : contribution to be paid by the *i-th* individual farm;

Sf : total fixed costs;
Sv : total variable costs;
B_i : benefit gained by the *i-th* individual farm;
and
B_i = (Index of provision) * (Index of use limitation) * (Index of delivery) * (Area of the *i-th* individual farm)
V_i : volume of irrigation water supplied to the *i-th* individual farm.

In the Bi calculation the indexes used, aimed to scale the merit of the farm, enable the partition of the costs on the basis of the real benefits gained by the agricultural land as a function of:

- availability of irrigation tools with low consumption (specific Index of provision);
- water availability on the basis of the existing infrastructures and channel (Index of delivery);
- attitude of the soils (function of the soil characteristics) to increase their productivity through the water supply (Index of use limitation).

At farm level it is necessary to evaluate the variations of the farm income balance as a consequence of the introduction of the binomial fee, such as:

- costs to be borne for the adaptations of the irrigation system;
- the increase in the revenues arising from agricultural products having a higher added value;
- recover of the fee of different income levels to be achieved with the two different scenarios (new irrigation plant of the district: adaptation of the farm irrigation system vs. adaptation of the farm irrigation system).

9. Possible critical points

For what concerns the fee method to be adopted, when the agricultural sector is considered it is figured out that the rate paid should be related to the volume of water consumed, this should work as an economic leverage that could lead to an efficient use of water resources promoted. However this system is not wide-spread and particularly because of the high costs of implementation due to the installation of water flow meters.

In many of the distribution networks it is difficult to proceed with the installation of the flow meters in the existing structures. The application of the binomial fee does not take into account the pricing of the groundwater which, often, is taken up from private wells. The volumetric fee of the water supplied by the consortia networks could have adverse effects in terms of WFD objectives. In fact the increase in water price, explained by the higher fees put into practice by the irrigation consortia to recover the cost for the irrigation investments effected, could lead the farmers to increase the amount of water taken up from the groundwater, causing their excessive exploitation that on the contrary the WFD intends to prevent.