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OPERATION, MAINTENANCE AND MANAGEMENT OF IRRIGATION SCHEMES IN ITALY: OPERATIONAL COSTS

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SUMMARY – This work gives a general description of one of the most important Italian Consortium “Consorzio per la Bonifica della Capitanata” providing information about irrigation schemes, institutional setup, organization of technical services, operation, maintenance and management organization and activities and costs centers. A particular attention is given to the explanation of operational costs which is based on the data related to the reference year 2003. Total surface area under consideration was of about 127,298 Ha. The analysis is performed for three main irrigation schemes and operational centers and includes the list of main expenditure items, cropping systems and costs and volumes of water supplied, aggregate cost of storage – conveyance – distribution activities, the personnel in charge of management and maintenance, other purchases and supplies.. The total costs for water storage and conveyance were 4.78 million € whereas the costs for water distribution were about 5.84 million €. The unit cost of water supplied ranges between 0.03 to 0.09 €/m³, while the aggregate cost of storage – conveyance – distribution varies between 0.08 and 0.19 €/m³.

Key words: irrigation schemes, organizational structure, operational cost, “Consorzio per la Bonifica della Capitanata”, Italy.

GENERAL DESCRIPTION

The “Consorzio per la Bonifica della Capitanata” is a Public Law Body run by the owners of the land falling within the Reclamation Scheme. It has jurisdiction over a land area of about 441,000 ha entirely falling within the province of Foggia – Apulia Region.

The Consorzio has the authority to draw general comprehensive reclamation plans covering all the technical, engineering, agronomic, forest and irrigation activities for rural land protection including environment as well. The Board was set up in compliance with state and regional regulations and the Regione Puglia government supervises all its actions and deeds.

In 1928 several consortia were set up and in 1933 they were grouped and merged into one single “Consorzio per la Bonifica della Capitanata”. The characteristics of the reclamation consortium and the comprehensive reclamation works implemented to date are summarised into Tables 1 and 2. Decision-making bodies and an organizational structure whose competences are listed in Table 3 govern the Consortium.

Table 1. General characteristics of the Consorzio

Irrigation scheme area	Ha	441,500
Municipalities entirely falling within the irrigation scheme	N°	21
Municipalities partly falling within the irrigation scheme	N°	18
Inter-regional watersheds	N°	5
Regional watersheds	N°	8
Associated farms	N°	90,000
Population		568,000

Table 2. Comprehensive reclamation works

Reclaimed areas	Ha	20,000
Wetlands	Ha	8,500
Coastal works	Km	20
Drainage lifting stations	Ha	4,500
Sluice gates	N°	84
Rivers with embankments	Km	500
Natural rivers	Km	1,200
Holdings	N°	111
Rural small villages	N°	5
Rural electrification	Km	215
TRANSFORMER ROOMS:		
- Medium tension	N°	225
- High tension	N°	253
Roads	Km	1,700
Reafforestation	Ha	1,375
Windbreaks	Km	68

Table 3. Administrative framework and organizational structure of the Consorzio

ADMINISTRATION:		
Presidency		
Administrative Deputation		
Council of Delegates		
Consultative Commissions		
ORGANIZATION:		
Directorate General		
Engineering Directorate		
Administrative Directorate		
Agricultural Directorate		
STRUCTURE:		
Executives	N°	6
Managers	N°	21
Officials	N°	149
Clerical staff	N°	18
Workers	N°	243
Seasonal workers	N°	120

THE IRRIGATION SCHEMES

Soon after the 2nd World War, in 1950, the “CASSA PER IL MEZZOGIORNO” (Southern Italy Development Fund) promoted and implemented large public irrigation surfaces in the scheme of “Consorzio per la Bonifica della Capitanata”. The planned irrigation area is 200.000 hectares. At present, globally, an equipped irrigation area of 150,000 ha is under operation (D’Arcangelo and Consiglio, 2005).

The irrigated areas are dominated by storage reservoirs (dams) supplying only the surface waters conveyed through tunnels, large open channels, reservoirs, drainage lifting stations and water towers.

The conveyance networks, all of them pressurized, consist of large diameter pipes. The network is both branched and looped. The distribution networks are all branched with pipes of different material (reinforced concrete, PVC, glass reinforced plastic (GRP), polyethylene). The major data of the equipped irrigated areas are reported in Tables no. 4 and no. 5.

Table 4. Main characteristics of irrigation schemes and irrigation networks

Irrigation schemes	N°	2
Gross surface area served	Ha	150.000
Irrigation users	N°	37.100
Peripheral Irrigation centres	N°	13
Irrigation districts	N°	35
Sectors	N°	898
Dams	N°	4
Check-dams	N°	1
IRRIGATION NETWORKS:		
Tunnels	Km	23,5
Canals	Km	40,4
Reservoirs	N°	52
Primary conveyance pipe network	Km	1.007
Distribution network	Km	8.000
Hydrants	N°	40.000
Drainage lifting plants	N°	7
Remote control	Ha	80.000

Table 5. The location of equipped irrigated areas and served surface area

LOCALIZATION	Area served [Ha]
Nord Fortore Loc. S.PIETRO	512.83.00
Nord Fortore Loc. RENZULLI	578.53.00
Nord Fortore Loc. BELLANTUONI	1.790.00.00
Nord Fortore Loc. MONACHELLE	3.500.00.00
Nord Fortore Loc. TRE TITOLI	2.400.00.00
<i>Tot.</i>	<i>8.781.36.00</i>
Sinistra Ofanto Loc. CANESTRELLO	900.00.00
Sinistra Ofanto Loc. MONTAGNA SPACCATA	12.520.00.00
<i>Tot.</i>	<i>13.420.00.00</i>

MAINTENANCE, OPERATION AND MANAGEMENT

Maintenance, operation and management of the systems, of the storage reservoirs and hydrants are performed directly by the consortium through its own organization. The operational organization of the Board is performed through two distinct Technical Directorates: the Agricultural Directorate that controls water distribution, and the Engineering Directorate that controls water storage, management and conveyance activities.

Three operational centres covering an area of 50,000 ha perform management and operation of the conveyance and storage works (Table 6), whereas the distribution networks are subdivided into 13 peripheral irrigation centres covering about 12,500 hectares.

From the financial point of view, the operational teams of both Directorates are autonomous cost centres and ensure the requirements of routine operation of the whole system. Therefore, they draw up their own budget based on commitments and expenditure of the year before, updating the various items of the balance sheet based on inflation, economic and regulatory improvement of collective labour agreements, insurances, etc.

Routine maintenance and operation activities are directly run by the Consortium, whereas the activities covering large irrigation works (dams, check-dams, tunnels, canals, primary conveyance pipes, lifting plants, water towers, interception and regulation equipment, electricity sub-stations, remote control networks for routine improvement interventions), are entrusted to specialized firms having appropriate specialised technology and know-how.

The organization of Consortia aims to equilibrate the rights and duties of both governmental institutions and farmers. In fact, on one side, the governmental institutions finance public works and maintain their property and on the other, they assign the management task to the Consortia and allow them to exert a control power through the members by right of the council of delegates and the governing board (Lamaddalena et al., 2004).

Engineering-technical services directorate

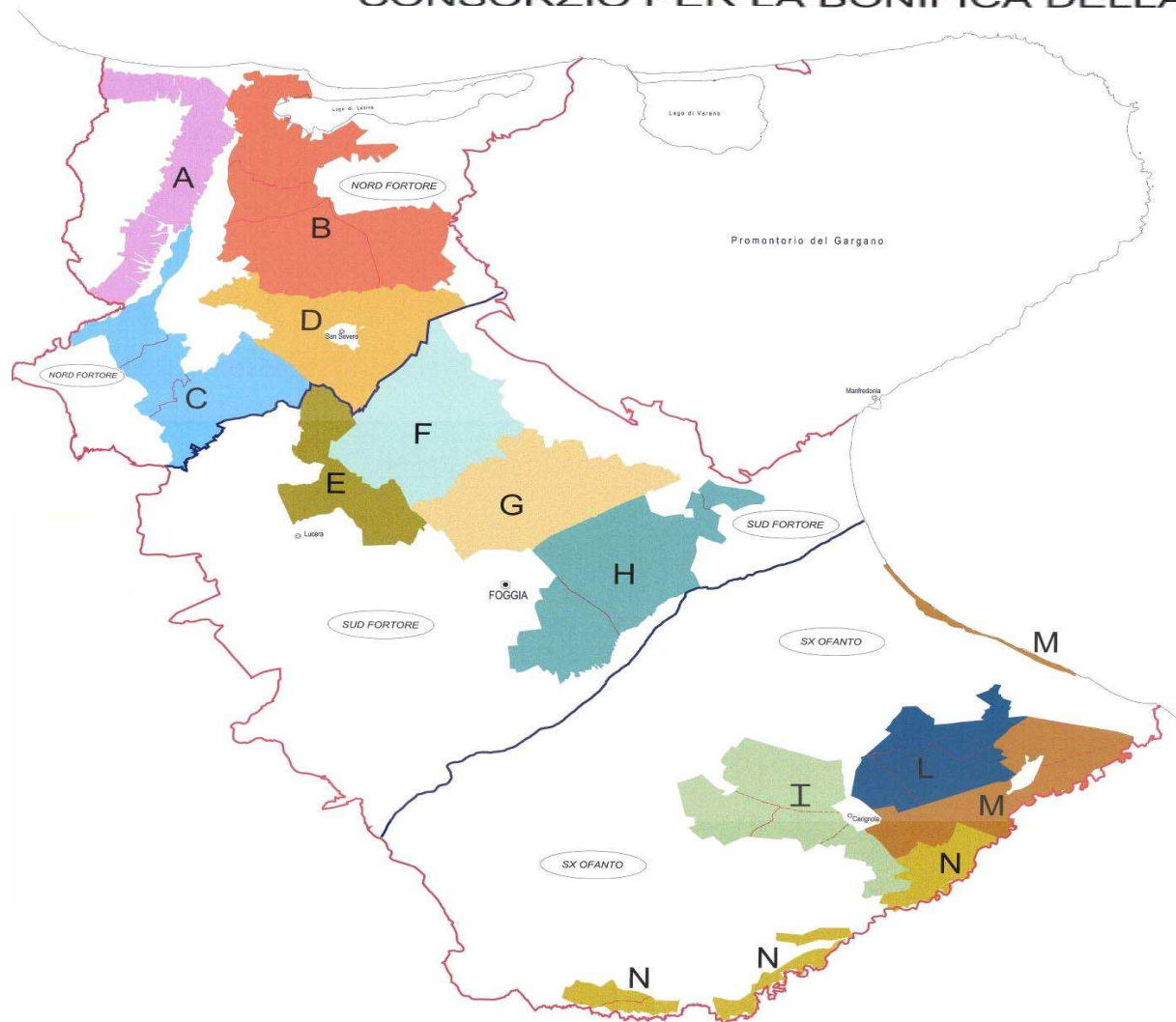
The operational centres covering an area of about 50.000 hectares fall within the competence of the Engineering -Technical Directorate. In particular, they are subdivided (Figure 1) as follows:

1. **NORD-FORTORE** scheme dominated by Occhito dam. The conveyance network is branched, a small portion as open canals, and most of it as pressurized pipes feeding the reservoirs that, in turn, supply water to the districts.
2. **SUD-FORTORE** scheme dominated by Torrebianca dam of Celone stream and the check-dam of Vulgano stream. The network is looped and supplied by 3 big water towers receiving water by gravity from the dam. Water towers are located upstream the supplied districts.
3. **SINISTRA OFANTO** scheme, dominated by Marana Capacciotti dam and the Ofanto river watershed. The conveyance network is branched, with a small portion as open canal and most of it as pressurized pipes feeding the reservoirs that, in turn, supply water to the districts.

Table 6 . Irrigation schemes and cost centres

	IRRIGATION SCHEMES					
	FORTORE				SINISTRA OFANTO	
	NORTH		SOUTH			
Surface area	Net	Gross	Net	Gross	Net	Gross
	Ha 43.571	Ha 48.000	Ha 45.340	Ha 62.000	Ha 38.387	Ha 40.000
Irrigation districts	Districts	Location	Districts	Location	Districts	Location
	1-2a-2b	Castelnuovo della D. Loc.RENZULLI	5a - 2c	S.Severo Loc.SABATELLA Torre P1	1 - 2 - 3 - 4 - 15	Cerignola Loc.SOTTODIGA CAPACCIOTTI
	8	Lesina Loc. VACCARELLA	6a	San Severo Loc. Az. Fortore	6 - 7 - 8	Cerignola Loc. PIGNATELLA
	9 - 10a - 10b - 10c - 10d	Apricena Loc.TRE TITOLI	6b	Lucera Loc. VACCARELLA Torre P2	5 - 9 - 10 - 16	S.Ferdinando di P. Loc.S.SAMUELE
	11	Città di San Severo	5b - 12 - 13	Foggia Loc. Tr. CASTIGLIONE Torre P3	11 - 12 - 13 - 14	Cerignola Loc.POZZO TERRANEO

CONSORZIO PER LA BONIFICA DELLA CAPITANATA



CENTRI DI SPESA

LEGENDA:

NORD FORTORE

Ha 43.571,00,00

A	8
B	9 - 10 (A - B - C - D)
C	1 - 2A - 2B
D	11

SUD FORTORE

Ha 45.340,00,00

E	2C - 5A
F	6A
G	6B
H	5B - 12 - 13

SINISTRA OFANTO

Ha 38.387,00,00

I	11 - 12 - 13 - 14
L	6 - 7 - 8
M	5 - 9 - 10 - 16
N	1 - 2 - 3 - 4 - 15

— LIMITE COMPENSORI IRRIGUI

- - - - - LIMITE COMPENSORI DISTRETTUALI

Directorate of technical-agricultural services

The irrigation schemes are subdivided into districts, with surface areas varying from 2000 to 4000 ha, in turn subdivided into sectors of an area ranging from 100 to 300 hectares. The peripheral irrigation centres constitute the Cost centres of the financial resources made available to achieve the objective of guaranteeing and supplying water to the associated farms.

The macro-areas and the irrigation centres are indicated in the plan. About 16% of the areas served by irrigation are dominated by drainage lifting plants as reported in the list of Table 5.

Water tariff rules

The water fee charged to the farmer - provisionally and subject to settlement – is determined according to binomial rates:

$$C = Q_f + V \times C_u$$

C = Fee paid by the farms served by the public irrigation system

Q_f = € 15,50/ha for maintenance of equipment

C_u = unit cost per cubic meter

€ 0.09 per cubic meter of water used within the limits of the allocation of 2050 m³/ha;

€ 0.18 per cubic meter of water used in excess of the said 2500 m³/ha up to 3000 m³/ha;

€ 0.24 per cubic meter of water used in excess of the said 3000 m³/ha.

V = Volume of water supplied.

As for the withdrawals from the conveyance pipes and the outlets of the dam, provided the authorized amount of water is available, the fee is €/Ha/crop.

Conveyance pipes: € 400,00/ha for tomato on 40% of the farmer's surface area, areas in excess pay € 600/ha
 € 400,00/ha for summer vegetables on 40% of the farmer's surface area, areas in excess pay € 600,00/ha
 € 200,00/ha for autumn vegetables on 50% of the farmer's surface area, areas in excess pay € 300,00/ha

Outlets of the dam: € 510,00/ha for tomato on 40% of the farmer's surface area, areas in excess pay € 600/ha
 € 510,00/ha for summer vegetables on 40% of the farmer's surface area, areas in excess pay € 765,00/ha
 € 260,00/ha for autumn vegetables on 50% of the farmer's surface area, areas in excess pay € 390,00 /ha

Reference costs

The reference year is 2003. During the irrigation season, the volumes indicated in Table 7 in the three operational centres, with the corresponding cropping systems were supplied.

As indicated in Table 7, Sinistra Ofanto, though having an area smaller than the operational centre of Fortore, has a utilization index of the water resource much higher than the two operational centres of Fortore. This is due to the different cropping patterns being practiced. In Fortore area, the water supply is mainly related to annual herbaceous sown crops.

The main items contributing to the expenditure of the activities required for operation and maintenance of the irrigation system are indicated in the lists (Table 8), distinguished by activities: storage and conveyance, distribution.

Table 7. Cropping systems and the volumes of water supply for each operation centre

OPERATIONAL CENTRES	Volume x 10 ⁹	Supplied water m ³ /Ha	Cropping Systems		
			Tree crops %	Vegetables %	Sown land %
<i>Nord Fortore</i>	26	543	15,75	19,25	65,00
<i>Sud Fortore</i>	38	615	5,60	29,40	65,00
<i>Sinistra Ofanto</i>	34	842	65,00	13,00	22,00

Table 8. List of the main expenditure items

STORAGE AND CONVEYANCE	DISTRIBUTION
WORKS DIRECTLY RUN BY THE CONSORTIUM	
PERSONNEL Executive Technical Permanent workers Seasonal workers Prevention of accidents Surveillance	PERSONNEL Executive Technical Permanent workers Seasonal workers Prevention of accidents Surveillance
CONSUMABLES Fuels and lubricants Ironmongery and miscellaneous Equipment	CONSUMABLES Fuels and lubricants Ironmongery and miscellaneous Equipment
OPERATIONAL EXPENSES Maintenance and machineries Telephony and radio Rent for premises Energy consumption Fees	OPERATIONAL EXPENSES Maintenance machineries Telephony and radio Rent for premises Energy consumption Fees
LARGE WORKS OPERATION Watchmen Monitoring Prevention and safety of plants	SPARE PARTS PIPES Gates and devices Miscellaneous spare parts
MISCELLANEOUS Consultancy Insurance and road taxes Unforeseen events Amortization Fiscal costs	MISCELLANEOUS Consultancy Insurance and road taxes Unforeseen events Amortization of machines Fiscal costs
PIECE WORK	

Based on the above items, estimates of expenditure are made every year and they contribute to the operational budget of irrigation, which is a part of the global budget of the Consortium. The criteria for drawing up the estimates of expenditure refer to the previous year balance sheet, to the variations of the incidence of the different items included, updated to the market value and to the current inflation rate, to national collective labour agreement as well as to the tariff of power consumption, telephone, fuels, gas, etc. and to the procedures and compulsory adjustments relative to the prevention and safety of workers, as well as of plants.

Each operational centre is autonomous in its interventions and expenses in compliance with rules of procedures of the Consortium.

Table 9. Costs and distributed volumes of water for each cost centre

Water distribution network						
Costs centres	Surface (Ha)	Total cost (€)	Volume distributed (m ³)	Cost per Ha [€/Ha]	Cost per m ³ (€/m ³)	Lifting plants
NORD FORTORE						
A Loc. Vaccareccia D8	6,569.00	308,637.74	2,697,299.00	46.98	0.11	no
B Loc. Tre Titoli D9-10a-10b-10c-10d	15,332.00	659,349.37	13,894,648.00	43.00	0.05	yes
C Loc. Renzulli D1-D2a-D2b	12,465.00	635,096.56	4,838,142.00	50.95	0.13	yes
D. S. Severo D11	9,205.00	454,268.02	4,681,056.00	49.35	0.10	yes
Total Nord Fortore	43,571.00	2,057,351.69	26,111,145.00	47.57	0.10	
SUD FORTORE						
E Loc. Sabatella Torre P1 D5a-2c	8,951.00	355,192.88	5,904,537.00	39.68	0.06	no
F Loc. az. Fortore D6a	13,041.00	308,637.74	12,301,467.00	23.67	0.03	no
G Loc. Vaccarella Lucera torre P2 D6b	7,000.00	276,299.48	6,297,688.00	39.47	0.04	no
H Loc. T. Castiglione torre P3 D5b-12-13	16,348.00	556,853.80	13,008,909.00	34.06	0.04	no
Total Sud Fortore	45,340.00	1,496,983.90	37,512,601.00	34.22	0.04	
SINISTRA OFANTO						
I Loc. Pozzo Terraneo D11-12-13-14	12,520.00	598,471.48	10,782,945.00	47.80	0.06	yes
L Loc. Pignatella D6-7-8	8,610.00	394,847.48	9,222,797.00	45.86	0.04	no
M Loc. S. Samuele D5-9-10-16	10,962.00	598,470.48	10,782,944.00	54.60	0.06	no
N Loc. Sottodiga D1-2-3-4-15	6,295.00	692,084.50	5,457,294.00	109.94	0.13	yes
Total Sinistra Ofanto	38,387.00	2,283,873.94	36,245,980.00	64.55	0.07	
Grand totals and means	127,298.00	5,838,209.53	99,869,726.00	48.78	0.07	

Table 9 illustrates the costs relative to the activity of each irrigation centre with the details of the cost per hectare and the cost per cubic meter of distributed water. The lowest cost is the one relative to Sud-Fortore scheme that, though bigger, has a smaller total cost due to the presence of larger surface area of districts.

The most significant data seems to be the presence of a distribution network with districts covering an area of 200 hectares and a larger farm holding. There are as many as 5 drainage lifting plants in the Nord-Fortore area and 2 in the Sinistra Ofanto.

Table 10 – Costs and distributed volumes relative to the storage and conveyance works – shows that the lowest costs refer to Sinistra Ofanto and Sud-Fortore, where districts are bigger and few drainage lifting plants are present. The aggregate costs of storage – conveyance and distribution are given in Table 11, and they are much more lower for Sud Fortore and Sinistra Ofanto than for Nord Fortore scheme.

Table 10. Costs and volumes of water supplied

STORAGE AND CONVEYANCE WORKS					
	Surface Ha	Total cost €	Stored and conveyed volume m ³	Unit cost €/Ha	Unit cost of water €/m ³
Nord Fortore	43,571.00	2,257,695.93	26,111,145.00	51.82	0.09
Sud Fortore	45,340.00	1,633,642.81	38,142,601.00	36.03	0.04
Sinistra Ofanto	38,387.00	887,751.00	33,688,675.00	23.13	0.03
Grand Totals and means	127,298.00	4,779,089.74	97,942.421,00	36.99	0.05

Table 11. Aggregate costs of storage – conveyance – distribution

AGGREGATE COSTS OF STORAGE – CONVEYANCE + DISTRIBUTION						
Operational centres	Total cumulated and conveyance cost €	Total distribution cost €	Surface Ha	Conveyed and distributed cumulated volume m ³	Unit cost €/Ha	Unit cost water €/m ³
Nord Fortore	€ 2,257,695.93	€ 2,057,351.69	43,571.00	26,111,145.00	99.03	€ 0.19
Sud Fortore	€ 1,633,642.81	€ 1,496,983.90	45,340.00	38,142,601.00	69.05	€ 0.08
Sinistra Ofanto	€ 887,751.00	€ 2,283,873.94	38,387.00	33,688,675.00	82.62	€ 0.10
Grand totals and means	€ 4,779,089.74	€ 5,838,209.53	127.298,00	97,942,421.00	83.57	€ 0.12

The personnel

The flowchart of the personnel in charge of operation and maintenance of the whole irrigation scheme includes:

- Executives (engineers and agronomists)
- Heads of sectors (engineers and agronomists)

- Site managers (holders of a high-school diploma as surveyors or agriculturists)
- Skilled workers (excavator operators, welders, mechanics, electricians, electronic technicians)
- Skilled workers (meter readers, assemblers of hydraulic devices)
- Attendance personnel (residents, shift workers, wandering workers)

The standard repair team is composed of: an excavator operator, a welder, 2 qualified workers coordinated by a team leader worker.

The working group has the following resources: an excavator, a truck, welding-machine and various devices and communication aids.

The type of labour contract for workers can be permanent and fixed-time or seasonal. The present ratio between the two types of contract is 1 seasonal worker to 1 permanent worker. The personnel holding a university degree or a high school diploma are exclusively on permanent contract.

Table 12 reports the absolute number of personnel units in charge of management and maintenance of the Consortium irrigation systems, divided into Storage-Conveyance and Distribution works. Globally, a total of 317 persons are working in the charge of management and maintenance and they are distributed equally between the storage and conveyance and distribution units.

Table 12. Total personnel in charge of management and maintenance

<i>PERSONNEL</i>	<i>Storage and Conveyance Units</i>	<i>Distribution Units</i>	<i>Tot.</i>
Executives	2	1	3
Managers holding a university degree	6	5	11
Technicians holding a high school diploma	30	13	43
Permanent workers	62	71	133
Seasonal workers	62	65	127
<i>Total</i>	<i>162</i>	<i>155</i>	<i>317</i>

Table 13 reports the total personnel in charge of operation and maintenance of the 3 irrigation schemes falling within the Consorzio per la Bonifica della Capitanata.

Table 13. Units and type of personnel employed

<i>Personnel</i>	<i>Storage and conveyance</i>				<i>Distribution</i>			
	<i>Nord Fortore</i>	<i>Sud Fortore</i>	<i>Sinistra Ofanto</i>	<i>Tot.</i>	<i>Nord Fortore</i>	<i>Sud Fortore</i>	<i>Sinistra Ofanto</i>	<i>Tot.</i>
Executives	0.66	0.66	0.66	2	0.33	0.33	0.33	1
Managers with a university degree	2.95	1.45	2.10	6.5	1.66	1.66	1.66	5
Technicians holding a high school diploma	14.33	10.33	5.33	30	5	4	4	13
Permanent workers	27	20	15	62	22	14	35	71
Seasonal workers	28	19	15	62	30	12	23	65
<i>Total</i>	<i>73</i>	<i>52</i>	<i>38</i>	<i>163</i>	<i>59</i>	<i>32</i>	<i>64</i>	<i>155</i>

Table 14 illustrates the incidence of irrigated surface hectares per each personnel unit subdivided at various levels and for each irrigation scheme. It is evident that surface/man is higher in Sud-Fortore scheme.

Table 14. Numerical incidence of the personnel per irrigated hectare

<i>Personnel</i>	<i>Storage and Conveyance</i>			<i>Distribution</i>		
	Nord Fortore	Sud Fortore	Sinistra Ofanto	Nord Fortore	Sud Fortore	Sinistra Ofanto
	Ha/Man	Ha/man	Ha/man	Ha/man	Ha/man	Ha/man
Executives	43,571	45,340	38,387	43,571	45,340	38,387
Managers holding a university degree	14,796	31,268	18,280	26,248	27,313	23,125
Technicians holding a high school diploma	3,041	4,389	7,202	8,714	11,335	9,597
Permanent workers	1,614	2,267	2,559	1,981	3,239	1,097
Seasonal workers	1,556	2,386	2,559	1,452	3,778	1,669

Purchases and supplies

To supply the material required for the operation and maintenance activities, the following procedures area adopted:

- 1 – standard material: direct purchase upon an order, of a cost of a few hundreds euro;
- 2 – material of a value greater than € 500,00 and up to € 10.000,00: deliberation of the executive board of the Consortium upon preliminary market research;
- 3 – material of a value exceeding € 10.000,00: official or unofficial call for tenders, through administrative procedures in compliance with the regulations;
- 4 – execution of specialised works: only for the storage and conveyance works. Works entrusted though fiduciary contracts to specialised firms.

CONCLUSIONS

The analysis, presented in this work, is performed for three main operational centers (irrigation schemes) of “Consorzio per la Bonifica della Capitanata” on the surface area of about 127,298 Ha. The analysis comprehends the list of main expenditure items, cropping systems and costs and volumes of water supplied, aggregate cost of storage – conveyance – distribution activities, the personnel in charge of management and maintenance, other purchases and supplies.

The total costs estimated for the reference year 2003 were about 10.62 million € . For the same year, the cost referring to storage and conveyance was about 4.78 million € (45% of total) while the cost of water distribution was 5.84 million € (55% of total). The unit cost of water supplied was very variable among different irrigation schemes and it ranges between 0.03 (for Sinistra Ofanto scheme) and 0.09 €/m³ (for Nord Fortore scheme), while the aggregate cost of storage – conveyance – distribution varies between 0.08 and 0.19 €/m³ for Sud Fortore and Nord Fortore respectively. The lowest costs refer to irrigation schemes where irrigation districts are greater and few lifting plants are present.

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