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INSTITUTIONAL SUPPORT FOR THE DEVELOPMENT OF FARMER-MANAGED IRRIGATION IN TRÁS-OS-MONTES: A STRATEGIC PERSPECTIVE

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Abstract:
This paper builds on the previous one, focusing on just one element being central to farming. That is fertilizing. The role of carefully produced manure as opposed to chemical fertilizer is discussed in detail. Echoing Benvenuti's paper, it is concluded that agricultural science is today hardly aware of the value of manure.

Keywords:
PORTUGAL, RURAL AREAS, RURAL DEVELOPMENT, IRRIGATION SYSTEMS, LOCAL GOVERNMENT, STATE INTERVENTION, WATER AVAILABILITIES, DEVELOPMENT POLICIES.

Trás-os-Montes, a region in northeast Portugal, has an important farmer-managed irrigation sector. The farmers manage, maintain and improve the irrigation systems that have been constructed over centuries. The paper presents the results of past and current research of farmer-managed irrigation in two agro-ecological zones of Trás-os-Montes. The final objective of the research is to develop a typology of Farmer-Managed Irrigation Systems (FMIS) which can serve as a tool for improving institutional interventions and designing adequate intervention strategies. The research focused on all aspects of irrigation water management. Both the common features as well as those that differ in the functioning of communal FMIS have been identified. Water allocation principles, water availability and water distribution practices are considered determinant elements in explaining the enormous diversity among communal systems and their environments. This heterogeneity has a direct influence on the rigidity/ flexibility of water use at farm level, which leads to a variety of farmer responses and interventions both within and outside of the communal FMIS. Currently a government programme aimed at the improvement of FMIS is being carried out. The diverse reasons, forms, features and effects of intervention by water users as well as the government have been identified. It is concluded that starting from the heterogeneity and dynamics found in FMIS and their environments, institutional interventions may be improved. For this goal intervention strategies have been formulated.

1. Stating the problem: an introduction

Irrigation in Portugal has followed two sharply distinct *development patterns.* State policy and public investment in irrigation shows a socio-economic bias in favour of the large-scale farmer; an ecological bias in favour of river plains with uniform natural conditions; and a geographical bias mainly since the 1930's towards the southern part of the country. In contrast, for many centuries farmers have developed their irrigation schemes to serve many small scattered areas in mountainous terrain with harsh physical conditions and a marginal aptitude for agriculture. Traditional Farmer-Managed Irrigation Systems (FMIS)[1] serve an area of 550,000 hectares or 83 percent of the total irrigated area in continental Portugal (DGRAH, 1987). The importance of farmer-managed irrigation is underscored by its use on small to very small family farms (<10 ha) mainly in the northern and central parts where the majority of the farming population of the country lives.
In these mountainous zones, FMIS are really an *endogenous resource* in the sense that they were created and developed by local actors without external intervention, in response to local farming needs. Each particular scheme emerged and developed in a specific local context, is characterized by three fundamental dimensions: the physical environment, the structure of social relations of production and the agricultural setting. Irrigation cannot be understood as an isolated phenomenon. It is an integral part of farming practice and local rural society. Irrigation development can be interpreted as both a condition for and an outcome of land use intensification and increasing labour productivity which are components of specific patterns of agricultural development.

Public intervention may potentially contribute to the development of farmer managed irrigation, but it will constitute a rupture with space and time specific practices and dynamics if it is not linked to the specific local needs, context and resource management. Public interventions world-wide have tended to neglect local complexity and diversity and have tried to change the local conditions, traditions and practices in the interests of the (technological) exigencies inherent to a uniform external development model/ blueprint, instead of supporting locally driven development and adapting technology to the specific situation.

Contrary to the policy predominant until recently, the Trás-os-Montes Integrated Rural Development Project (PDRITM), launched by the Government in 1982, has defined the improvement of FMIS as a basic condition for agricultural development in Trás-os-Montes. In this region of north-east Portugal, more than 1000 FMIS were identified, serving an estimated 30,000 hectares. The schemes are small, being concentrated in two agro-ecological zones: the Mountains, and the High Valleys, which form the research area (Figure 1).

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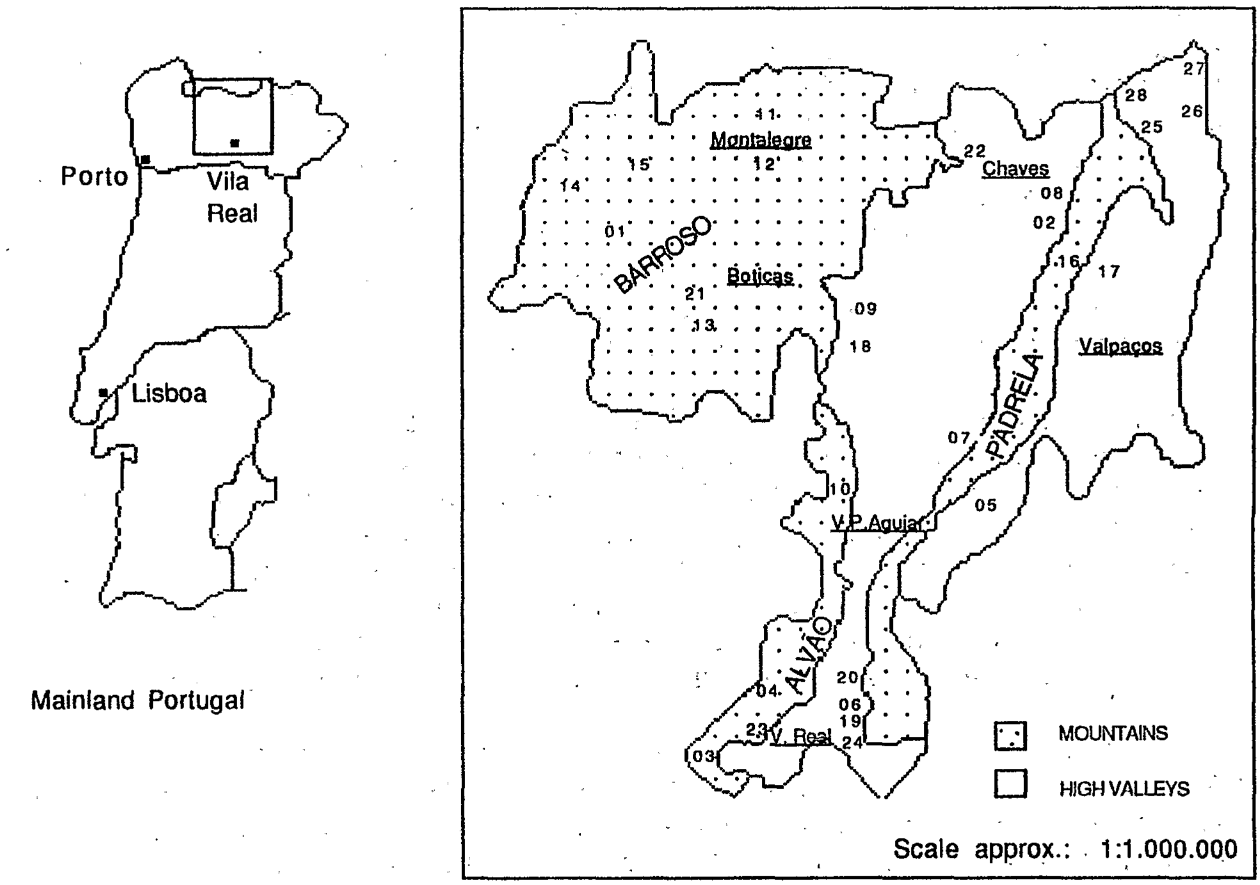
[1] The term "Farmer-Managed Irrigation System (FMIS)" will be used for all those schemes which are constructed, maintained and managed by farmers, both collectively or individually. The qualification `traditional' indicates that these schemes generally have a long history. Until recent times State intervention in `traditional' FMIS was nil or minimal.

Figure 1. Research Area with Selected Villages



SELECTED VILLAGES

01 CORVA
02 SESMIL
03 VILA COVA
04 LAMAS D'OLO
05 COVAS
06 BOUÇA
07 SEIXEDO
08 TRESMUNDES
09 SOBRADELA
10 ST.ª MARTA DO ALVÃO
11 MEIXEDO
12 TORGUEDA
13 ROMAINHO
14 PINCÃES
15 FERVIDELAS
16 ADÃES
17 SANTIAGO
18 VILELA
19 ST.ª MARTA
20 ABOBOLEIRA
21 BOSTOFRIO
22 SOUTELO
23 GALEGOS DA SERRA
24 VILALVA
25 C. DE VILA DE CASTANHEIRA
26 VILAR DE LOMBA
27 BRITO DE LOMBA
28 RORIZ

Small and very small family farms whose areas are divided into numerous plots constitute the prevailing production units. Effectively 116 FMIS had been improved by March 1990 (Portela, 1990). A second phase of this programme is being contemplated over a period of seven years.

In this paper, we focus on these public interventions; their character, their effects, the conditions under which they will contribute to ongoing irrigation development and how they can be improved. To be successful, these interventions must fit into existing local situations, needs and initiatives and link up with existing farming and irrigation practices. Thus, some key issues have to be examined: how to link institutional support to farmers initiatives, knowledge of the local situation, farmer's needs, objectives and resources, and how to integrate irrigation development into local rural development. A crucial point is the role of irrigation in farming and the interactions among these activities. Development is characterized by a local focus which has led to a large heterogeneity among irrigation systems. Another point is the dynamics found in FMIS and the interventions implemented by the farmers themselves. We think that lessons can be drawn: intervention strategies have to be based on the way the farmers themselves intervene in their systems and environments.

The intervention FMIS programme in Trás-os-Montes executed by PDRITM has been set up without detailed knowledge about the complex functioning of traditional irrigation schemes prior to improvement. The CAMAR-research project "Intervention strategies in Traditional Farmer-Managed Irrigation Systems in Northern Portugal"[2] aims at elucidating functioning and dynamics of FMIS, the intervention process as implemented by PDRITM and the effects generated by the interventions. The final objective of the research is to develop a typology of FMIS which can serve as a tool for improving institutional interventions and for designing adequate intervention strategies.

The research activities on irrigation systems include an ongoing inventory study to identify key elements relevant for intervention purposes, and case studies at village level to study certain aspects in depth. This paper is based on the findings of research efforts in 28 villages scattered over the research area (see Fig. 1). The context within which FMIS operates is the subject of the next section.

2. The research area: environment, farming and irrigation

The physical environment of Trás-os-Montes is characterized by an extremely indented topography with considerable differences of altitude over short distances and a harsh

[2] The paper is based on the contributions and experience of many people who are or have been involved in this research project, which is a joint venture with the Department of Economics and Sociology (DES) of the University of Trás-os-Montes e Alto Douro (UTAD) in Vila Real, Portugal and the Department of Irrigation and Soil and Water Conservation of the Wageningen Agricultural University (WAU) in the Netherlands.

climate with large spatial and temporal contrasts[3]. Most soils are acid, thin and stony except in small areas near the villages which have been heavily manured for centuries.

Of the regional socio-economic environment in which farming and irrigation takes place, we want to highlight the following points:

1) Trás-os-Montes is commonly presented as the most depressed area of Portugal. It has an underdeveloped social and economic infrastructure (education and health facilities, roads, markets etc.).
2) Historically, social stratification based on unequal access to land resources was sharp. Until the 1950s some landless groups were hit by periodical food shortages and seasonal hunger.
3) Employment opportunities in Trás-os-Montes outside of agriculture are limited. In 1970, more than 70 percent of the labour force was still engaged in agriculture (Census 1970). According to the census of 1981 this value had decreased to about 60 percent.
4) These factors contributed decisively to the massive emigration from the rural zones which boomed from the late 1950s[4]. According to preliminary data from the 1989 census, in the last ten years the population of Trás-os-Montes has diminished by more than 50,000 people, i.e. by more than 10 percent of the total population. In some rural zones decreases of up to 30 percent took place in this same period. Such massive emigration has transformed the social landscape and profoundly influenced the management of farms and irrigation systems. Emigration drained off many of the agricultural labour resources, but at the same time returning migrants invested in further farm development.

Within this regional context agriculture is still by far the most important economic sector. Household strategies in agriculture have the following common characteristics:

-Making the best use of the fragmented plots and different land qualities and microclimates within the same farm. This explains, in part, the polycultural character of farms and the integration of agriculture and cattle raising. It also explains the very intensive land and labour use on the most accessible and productive land with irrigation facilities.
-Use of the communal common lands (*baldios)* for grazing, collecting firewood and raw material for cattle bedding and organic manure. A marked differentiation in the

[3] People frequently characterize their region by the proverb: "Trás-os-Montes, nove meses de Inverno e três meses de Inferno" (nine months of Winter and three months of Hell).

[4] State interventions by the Salazar and Caetano regimes from the 1940s to 1974 contributed to an accelaration of emigration. The forestry policy of the government took a lot of the communal moorland area (*baldios)* out of the control of local communities, which affected principally the poorest landless people. In many cases their source of subsistence in herding sheep and goats or in the cultivation of small plots in the *baldios* were cut off leaving these people few other alternatives other than to search for a means of living outside the region. Although farming did not offer possibilities for survival to these people, it is ironic that many emigrants are working in agriculture e.g in Switzerland, for example.

importance and use of *baldios* for grazing exists depending on production orientation (milk versus meat production) and the number of small ruminants (goats and sheep)
-Production for household consumption[5] (agriculture) and/or the market (cattle raising). The specific balance between these production components depends on factors such as household size, stage of the demographic cycle of the farming household, off-farm labour and the resources (labour, land, water etc.) that farming households control or have access to.
-Negligible dependence on external inputs (i.e. from outside the farmer's community) for farm operation. Exchange relations for resources (principally labour but also irrigation water) between farming households are crucial in the operation of farms.
-Pluriactivity and (temporary) migration of farming household members to supplement income, to improve living conditions (house) and to invest in the farm (land, cattle, machines, irrigation facilities)[6].

Within the region of Trás-os-Montes a large diversity of ecological conditions, farming systems and irrigation potential exists. Some relevant differences between the Mountainous areas and the High Valleys are shown in Table 1.

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[5] A case study of the production strategies of dairy farmers in the village Cimo de Vila de Castanheira (Baptista and Portela, 1990) it is shown that production for household consumption represents about 50 percent of the total production value of the most common group of small farmers (with 1 to 2 milk cows).

[6] The small-scale farming sector in Portugal has an importance which goes far beyond the level of agricultural production realized. Among other contributions to the Portuguese economy, it is the main supplier of cheap industrial labor. A remarkable case study of two parishes in the neighbouring Minho region (Fragata 1989, p. 169) reveals that about 60 percent of farming households have a member working in nearby industry. It was calculated that the contribution of farm production for household consumption and the locational value of the farmhouse represents 67 percent of the industrial wage that these workers earn. Thus should these households dispose of these use values, industrial wages would need to increase by 67 percent in order to keep the same level of income.

Table 1. Some relevant differences between the Mountains and the High Valleys.

Characteristics	Mountains	High Valleys
a) Altitude	800-1200 m	400-800 m
b) Annual Rainfall	700-1500 mm	500-1000 mm
c) Irrigated/total cultivated area	56% (Barroso) 40% (Alvao/Padrela)	21%
d) Farm size	77% of farms smaller than 5 ha.	81% of farms smaller than 5 ha.
e) Production	Rye/(seed) potatoes rotation. Permanent meadows (*lameiros)* and forage crops. Communal lands(*baldios)* used forgrazing and forest.Cattle raising orientedto produce meat.	Rye/potatoes rotation.Forage crops and some *lameiros* Chestnut trees. Vineyards and olive trees.*Baldios* less important for grazing. Cattle raising oriented to producing milk.

The importance/role of irrigation in farming

Irrigation in Trás-os-Montes can be considered as a key resource[7] in local farming for the following reasons:

- Dependency on irrigation for household consumption of staple foods (potatoes, maize) and horticultural products.
- Decisive factor in forage production for cattle (meat and milk).
- A crucial local resource in agricultural intensification and development.

Relatively speaking, production of food crops for the market has tended to diminish, and forage crops to increase[8]. For some social groups, for example the old and other

[7] Until recently, conflicts about water were one of the most frequently occurring causes of death among Portuguese farmers.

[8] General agricultural development in the research area has been strongly influenced by the massive emigration which has led to a lack of labour. This has increased the relative importance of irrigation in farming. One effect of the lack of labour is the cultivation of less staple food and rye which in the past were commercialized but now only serve for household consumption needs. An extensification in land use was the result, much land which was cultivated in a rye/potatoes rotation was abandoned, became uncultivated land or unimproved natural meadows. Within many farms a shift took place from non-irrigated land to irrigated: the balance between the cultivation of non-irrigated and irrigated lands changed. Extensification of some parts (with the worst soils and more distant from the villages) went

vulnerable groups, production for household consumption is crucial because of a lack of other available means of subsistence/income.

Two climatological factors determine the need for irrigation. In the dry summer big water deficits occur (up to about 200 mm/month). Water availability in the mountainous areas is significantly higher than in the High Valleys, where summer irrigation thus plays a more crucial role. This is further accentuated by production orientation. In the High Valleys where milk production is dominant and more and better cattle feedstuffs are required, irrigation of annual forage crops is very important.

In the winter period (night)frosts occur frequently (60-80 frostdays/year). Irrigation of natural meadows *(Rega de lima)* is thus very important for frost protection, especially in the Mountain areas, and, from the farmer's viewpoint, for the manuring value of the water[9] and for management of the meadows (control of vegetative growth and flora composition)[10].

The next three sections summarize the most important findings of the research into farmer-managed irrigation. The research work is still going on, thus we might expect refinements or even reformulations of data interpretation to occur.

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parallel with a relative intensification of other parts (good quality land with irrigation facilities nearby the villages). In these favorable parts there is a shift from staple food to the cultivation of cattle feed.

[9] Farmers in the mountainous areas say: "Agua limpa é só para limpar a cara" (clean water serves only to wash your face).

[10] However, various contradictory statements and facts about the nature of the "rega de lima" exist e.g.

- It is difficult to understand why in mountains areas this irrigation practice is more important than in the high valleys. In some parts of the high valleys there occur more frost days than in mountain areas. Also as manuring practice there is apparently no reason to be more important in the mountains than in the high valleys.
- Some farmers say that for "rega de lima" you need relatively warm water from springs which give small dicharges compared to rivers. In contradiction to this statement is the opinion that you need large water quantities and if you do not have them it is better not to irrigate at all.

This suggests that the underlying ecological and local factors which explain the nature and importance of the "rega de lima" are not well understood. The research on this irrigation practice is important for defining the nature of interventions and e.g. determining technical design criteria for irrigation canal dimensioning. This research can also explore an interesting hypothesis, namely whether this irrigation practice constitutes a water spreading technique that stores water in the soil profile which in the dry summer period will be gradually released to feed water sources such as springs and wells. The slow melting of snow has the same effect as reflected in the proverb "Ano de nevão, ano de pão" (Year of much snow, year of good harvest). Such applied research undertaken by a team of researchers of different disciplines will in our opinion constitute an outstanding example of institutional support to regional agricultural development.

3. Farmer-managed irrigation

3.1 *Common features of FMIS*

Generally, a multitude of water resources and irrigation facilities exist within a village - small streams, springs, galleries *(mines, Arab influence)* shallow and deep wells. As summer progresses, water availability decreases, especially in the High Valleys (scheme flow generally: <<5 l/s). Related to water availability another relevant difference in hydrological conditions exists between Mountains and High Valleys: surface water sources (streams, brooks or locally named ribeiro (a)s, Corgos) are dominant in the mountains whilst small, scattered sources (springs, wells) originating from subterranean water are principally used in the High Valleys.

In this paper, we will focus on communal systems. A communal system is here defined as the FMIS to which all or at least the majority of the households in a village have access in the summer period. In the sample of villages studied (Fig. 1), the irrigated area (summer and winter included) of the most important communal system of a village ranged from 2 to 35 hectares per system, whereas the number of water users from 8 to 104 per system. Generally the areas irrigated by communal systems are limited to the village domain, thus the geographic and demographic dimensions of the irrigation systems normally coincide. It should be stressed, however, that besides the most important communal system, other communal systems and many smaller group, family and individual irrigation facilities can often be perceived at village level, whose importance may on the whole surpass that of communal systems, especially in villages situated at the High Valleys.

Summer irrigation areas are always located near the villages. In areas with steep slopes they form an authentic man-made terraced landscape with numerous walls. Plots are small (most frequently 0.05-0.1 hectares with extremes of 5m^2 to 0.5 hectares), often irregularly shaped and with varying slopes. The plots consist of man-made soils which have been heavily manured for hundreds of years with a mixture of cattle dung, straw and vegetative material gathered from the *baldios*. These plots are cultivated very intensively in a way that can best be compared to gardening.

Almost all irrigation water is applied by gravity methods: controlled flow irrigation (often locally called *rega por embelga)* on sandy soils and furrow irrigation on more heavy soils. These methods require considerable skill and labour. Low flow rates imply a very intensive labour input in field irrigation (20-80 hours/ha for one irrigation turn depending on available discharges). Application efficiency is near 100 percent (Rego *et al.* 1990), i.e. there are no water losses in water application caused by runoff and deep infiltration. That shows farmer awareness of the scarcity of water but it also points to under-irrigation. Irrigation intervals in many schemes are too long from an agronomic viewpoint (up to 30 days).

In general, winter irrigation does not take place on areas irrigated in the summer[11]. Normally winter irrigation perimeters are located more upstream of the summer areas and along nearly all permanent and temporary surface streams. The use of irrigation infrastructure by (small) groups of farmers *(consortes)* is predominant. The way in which permanent meadows *(lameiros)* are irrigated is diametrally opposite to that for food crops: The irrigation of food crops is labour intensive and field application aims at using small quantities of water in the most efficient manner; irrigation of meadows is labour extensive[12], whereas irrigation canals and field irrigation methods (contour ditch irrigation or wild flooding) are suitable for transporting and spreading large quantities of water.

From the analysis of data on the 28 systems some general features relating to the construction and management of FMIS can be deduced:

-*Simplicity of irrigation* facilities. An irrigation system normally consists of a diversion structure at the water source(s), canal(s) and in most cases reservoir(s), unimproved or (partially) improved. Water distribution structures are absent.
-*Simplicity operation.* Apart from a few exceptions, (summer) waterflows are not divided. Every farmer uses the whole flow in the system when it is his/her turn. In winter, irrigation dividing of (large) water flows is quite common.
-*Few head-tail problems.* Many farmers have small parcels scattered all over the irrigation perimeter(s). Individual water sources often supplement the communal scheme flow.
-*Collective resource mobilization* needed for operation and maintenance is minimal. Normally, water users participate in the collective maintenance efforts during only one day before the summer irrigation starts. At the individual level, however, a lot of labour is needed for operation, routine maintenance, water application and sometimes source and canal patrolling in order to prevent water theft.
-*Absence of formal water users organizations.* The day-to-day functioning of irrigation is informally organized. The importance of local leaders, (interest) groups and

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[11] However, in quite a lot of villages with specific farming systems and scarce labour resources, this is changing because of a recent tendency to transform irrigated arable plots into permanent meadows.

[12] An ingenious labour saving artefact is used generally in Trás-os-Montes, called *pedra de engenha.* This is a self-starting syphon built in a reservoir. When the reservoir is full and the incoming streamflow is relatively large (in the winter period) the syphon will be activated and will empty the whole reservoir in a limited time. It is a type of automatic irrigation fully adapted to the winter irrigation of meadows (large streamflows). In the summer the syphon is not functioning because the incoming streamflow is too low. In this period the reservoir need to be opened by hand and the outgoing streamflow will be carefully regulated to use the small quantities of available water in the best way.

organizational issues comes to the surface at strategic moments (e.g. fixing the beginning of the summer irrigation period) and for strategic decisions concerning the future of the scheme (e.g. improvement of scheme facilities, change of water allocation). The relevance of these specific organizational issues in intervention will be the subject of sections 4.1 and 5.

Besides these shared management/design features, every scheme has emerged and developed in specific historical and local circumstances that have led to an enormous diversity in the functioning of FMIS, an issue that follows.

3.2 *Diversity in FMIS: key elements*

An analysis of the data of the communal systems studied shows that the diversity of functioning of FMIS is most clearly related to water allocation and distribution[13]

In Trás-os-Montes, the traditional irrigation systems were constructed over the centuries by farmers. Most frequently based on the contribution of labour and other resources in the construction of the systems, farmers obtained rights over water. These original water rights changed by inheritance, marriage, buying/selling of land and/or water, negotiations and the external socio-political process, and resulted in the present *rights of access* to water among users. However, in other systems, the relation between the (original) user's resource contribution and the present user's access to water is nonexistent or less explicit, e.g. only separating those who are, from those who are not entitled to use water from a particular source.

In the very heterogenous physical and socio-economic environments of Trás-os-Montes, the historical process of irrigation development has resulted in different water allocation principles and water distribution practices in farmer-managed irrigation.

The following water allocation principles in communal schemes[14] during the summer period[15] have been found (see Table 2[16]).

1. *Time shares.* The water user is entitled to use the whole scheme flow for certain time period(s) in a fixed irrigation interval. Rights are (very) unequally divided among water users. Originally the acquisition of these rights was linked to the contribution of the

[13] Allocation means the assignment of rights of access to the water among users, while distribution refers to the physical distribution of water among the users (Martin *et al.* 1987).

[14] This classification, obviously, cannot catch the whole diversity of water allocation in traditional schemes. Although hybrid variants and combinations of elements exist, this classification in broad categories serves well to show the diversity found.

[15] Water allocation in FMIS has also clear temporal and spatial dimensions, as will be elaborated next in this section.

[16] From the table it seems clear that time-share systems are in the absolute majority. However, posterior empirical evidence shows that in this sample, time-share systems are over represented in relation to systems with other water allocation principles.

user's resources (labour, location of the water source, land necessary for canal construction, right of way etc.) in the construction of the schemes.

2. *Equal shares.* Irrigation water is considered a type of public good. Every *social unit* (a resident household is mostly used as a criterion, but not necessarily so in some villages) in the village is entitled to use the whole scheme flow for a certain period of time which is equal for every water user. To re-establish this right one has to participate in the maintenance of the scheme and/or to contribute to certain tasks of common interest. In some cases, one must also be resident in the village. As a consequence, migrants lose their water right till they return to the village. In other cases, even village inhabitants without land are entitled to the same share which can then be transacted.

Table 2. Summary of water allocation and water availability in the communal systems of selected villages

Village (For location, see Fig. 1)	Water Alloc. (1)	Water Avail. (2)	Agro-Ecolog. Zones (3)	PDRITM Inter-vention ending:	Remarks/Interventions in system by Water users (indicated only the most important)
1. Corva		+++	M	1992	Conflictwith Neighbour Village
2. Sesmil		+	HV	1983	Change in W. Rights (1983-85)
3.VilaCova		+	M	1986	Improvement by Water users
4.Lamas d'Olo		+++	M	1990	Improvement by Community
5. Covas		+	HV		Improvement by Water users
7. Seixedo		+	HV		Upstream of Bouca (06)
8.Tresmundes		+	HV		Improvement by community
9.Sobradela	Group	+	HV		Hybrid water allocation type 1/2
10.Sta.Marta da Alvao		+	M	1989	
15. Fervidelas	1.	+			
16. Adaes		+++	M	1992	
18. Vilela			HV		
19. Sta Marta		+++	HV		
20. Aboboleiro		+	HV		
21. Bosto Frio		+	HV		
27.Brito de Lomba		+	M		
28. Roriz		++	HV	1991	
		+++	HV	1990	
		+			
		++			
		++			
11. Meixedo	2.	+	M		'92 Change in Waterall.type2 to 5
12. Torgueda		+++	M		Past Change in Waterall.type1 to2
26. Vilar de Lomba		++	HV		+ Improvement by Community Past Changes W.All. type 1 to 2
17. Santiago	3.	+	HV	1987	Discussion Waterall. type 3 to 1
24. Vilalva	4.	++	HV	1991	Discussion Waterall. type 3 to 1
6. Bouca	5.	+	HV		Past Change in Waterall.type1 to 5
22. Soutelo		+	HV		Hybrid Water Allocation type 4/5
25. Cimo de Vila Castanheira		+	HV		
13. Romainho	5L	+++	M	1989	Discus. Simplification Waterall.
14. Pincais	6. TP	++	M		Improvement by Commission Baldio
23. Galegos	TP	+++	M		Improvement by community
		++			
		+++			

(1) 1: Time shares
2: Equal shares
3: Parcel based
4: Free-to-take
5: First come, first served
6: Multi-level
5L: 5-Level
TP: Time-Parcel

(2) Scheme source flow:
+ 0-0.5 litre/sec
++ 0.5-1 l/s
+++ 1-5 l/s
++++ 5-15 l/s
+++++ 15-25 l/s
(Based on Discharge Measurements in August 1992)

(3) Agro-ecological Zones

HV: High Valleys
M: Mountainous Areas

3. *Plot based.* The owner of a specific plot is entitled to use the whole scheme flow until his plot is irrigated sufficiently. In this context, `sufficiently' is a socially defined concept. One cannot continue irrigating indefinitely, arguing that the plot still needs more water. The plots are contiguous and are irrigated in a fixed sequence.

4. *"Free-to-take" (a pilha).* The owner of an irrigable plot has the right to use the whole scheme flow whenever he or she wants. No rules exist. In practice, owners of plots at the head-end, or owners of pumps profit most from the water. However, this allocation principle in the purest form does not occur frequently. This principle is frequently found between systems which depend on the same (surface) water source, giving rise to conflicts (e.g. Corva and Paredes) or where water users of neighbouring villages depend on the same canal (e.g. Cimo de Vila de Castanheiro and Sanfins).

5. "*First come, first served"(a vez).* Like "Free-to-take" but with agreements. One basic rule exists: as long as one person is irrigating, he/she will be respected. The other water users wait until that person is finished.

6. *Multi-level types of water allocation.* Different allocation principles also have been found at various levels of some schemes. Irrigation systems have been found with a very complex water allocation (e.g. Romainho). Within this category, most frequently a 2-level distribution is found in which water is distributed to groups of water users on a time basis and within the group from parcel to parcel. These multi-level types probably did not exist when the schemes were constructed; their emergence was certainly a consequence of an ongoing fragmentation of land and water rights[17].

Water allocation in FMIS has also clear temporal and spatial dimensions. In the winter, other plots (with permanent meadows), in most schemes outside the summer area, are irrigated with the same water source by less right holders. Generally, water

[17] A very interesting and relevant question is how these different water allocation principles emerged and developed, what are the underlying reasons for their existence and which relations/ linkages now exist between them. The emergence of the time share type can be clearly traced back historically to the proportional relation between users resource contributions (labour, needed land for canal and reservoir construction, property of water source, rights of passage etc.), to the construction of the scheme and the initial users access to water. For type 3 (parcel based) we will formulate the hypoteses that this type developed out of an irrigation scheme controlled by one farmer. The heirs divided the land but did not fragment irrigation time accordingly. For the 2-level allocation time-parcel a similar hypothesis can be formulated considering an original time-based distribution of water between various farmer households (*casais). Distribution groups often are indicated by the name of a family ("casal"). Type 5 ("a vez") seems to be related to the regularity and reliability of the water source flow.*

allocation principles are different in the winter (October-March) and the summer (June-September). The same applies to the transition period between winter and summer. During these periods, in most schemes the free-to-take or/and the "first come, first served" type of water allocation are gradually applied. These temporal changes are clearly related to water availability and the importance of permanent meadow irrigation. In some communal schemes (e.g. Bosto Frio) `winter' rights and the beginning and end of the `winter' period are rigidly fixed, while in others there is much more flexibility.

Water distribution

In general, one could state that distribution practices have been developed to meet the requirements of the distinct water allocation principles, but water distribution is necessarily complex in the conditions of Trás-os-Montes. In the first place, discharges from the water sources are often too low to irrigate directly. Moreover transport losses in the canals are high. To obtain a manageable flow rate, in many cases farmers need to store the water. Through sale and inheritance, water rights have become fragmented, which is directly associated with the division and scattered nature of plots.

In many cases, the result of these factors is that water for an individual water user becomes almost unmanageable. For example, it is impossible to irrigate a plot for half an hour which is located 800m from a water source with a discharge of 1 l/s, by means of an unimproved earthen canal. Water would never reach the plot.

This problem is enlarged by the fragmentation of plots and water rights that have resulted in an increased relative water scarcity. Formerly, a landowner had more room to manoeuvre in making plans for the summer period: which plots to sow with what crop in relation to water availability (H.Bleumink and M. Kuyk, 1992)

To cope with these problems water users developed a set of complex mechanisms, rules and practices to distribute the water and to manage irrigation.[18] They are products of history and tailored to the specific local situation and conditions of each irrigation system. That makes the management of these systems a truly local art. Although this constitutes a very rich field of study, the scope of the paper does not permit us to go into details.

[18] Irrigation in these schemes also implies a certain synchronization and coordination of farm activities because of the shared use of irrigation channels, the access of draught cattle, tractors and equipment to the plots. In the village "Galegos de Serra" the farmers use expressions like *Caminhos sabidos* (known paths) to indicate that farmers have in summer the right of about eight days to pass over other farmers plots to reach their own plots in order to prepare and plant them. Also water is prohibited to flow in the channels during certain periods in order to drain the plots and to plough and manure them (*aguas sabidas* or *known waters).*

Water distribution practices are essentially the outcome of both water allocation and water availability. In spite of their interearing, we identify these three parameters as key elements which can be changed by intervention and as such constitute building blocks in a typology for intervention purposes.

In the next section, we attempt to interprete the meaning and assess the significance of the diversity found in these three key elements in relation to farming.

3.3 *Rigidity and flexibility in FMIS: effects on farm water use*

Water use at farm/field level is a function of farmers access to irrigation water in a specific system whose productive potential depends on locally available water resources and social arrangements between water users. A specific water distribution pattern has emerged/developed, based on farmers water rights and how these are structured by the locally existing water allocation principle.

The interest of the distinct water allocation principles lies in the different degrees of flexibility/rigidity of water use at farm level, and water application at plot level which have certain practical implications for farming practice.

In Table 3 the different water distribution principles are compared in relation to conditions for water use at farm level (freedom/restrictions on crop choice, plots and transactions) and water application parameters (variability/fixedness of irrigation interval, flow rate and irrigation time for one turn) at plot level. It clearly shows how the different water distribution principles influence the degrees of flexibility/ rigidity of water use at farmer level and water application at plot level.

Table 3. Summary of water-use parameters at farm/plot level in function of water-allocation principles

Water allocation principles	Water use at farm level (restrictions or not)			Water application variables at plot level		
	crop choice(a)	plot bound	exchange/ commerce of water	flow rate (b)	irrig.time	length of interval (c)
1. Time shares (d)	free	no	free	var.	fixed	fixed
2. Equal shares (e)	free	no	free	var.	fixed	fixed
3. Plot-based	restr.	yes	restr.	var.	var.	var.
4. Free access	free	no	restr.	var.	var.	var.
5.First come, first served (f)	restr.	no	restr.	var.	var.	var.
6. 2-level: time-plot	restr.	yes	restr.	var.	var.	fixed

(a) In schemes with water allocation principles 3, 5 and 6 irrigation of pastures is forbidden. The method of irrigating pastures (contour ditch irrigation/ wild flooding) uses too much water compared with the irrigation of food crops. Pasture irrigation is to the detriment of other water users without pastures.

(b) As summer progresses, water becomes scarcer. Consequently, in the case of plot-based distribution, irrigation time and length of interval (up to more than one month) increase. In type 5, competition for water will increase.

(c) In water distribution type 6, a distribution group receives water at a fixed interval. If water is becomimg scarce, not all plots in the group can be served during one turn. There are normally specific rules in a group for sharing water shortages among the members over longer periods. The fixed interval in types 1, 2 and 6 may constitute a rigidity and be experienced as an obstacle by groups of water users if it is a long period (> 1 week).

(d) The holders of water rights in types 1 and 2 are, in principle, free to irrigate every plot. In practice, however, the dispersion of a farmer's plots in the scheme coupled with the obligation to have the water at the entrance to the next user's plot at the beginning of his or her time period can seriously limit this freedom. Because of the fragmentation of land and water rights, in some schemes holders of water rights also have their total time share fragmented into short periods during the length of the irrigation interval; this affects the organisation of labour resources on the farm.

(e) In type 2 systems, rights are temporary and village bound. They may be temporarily transferred but not definitively (by sale or purchase). Another feature is the variation of shares from year to year. This variation can be considerable in some cases (e.g. where every resident (adult or even child) is a potential holder of water rights).

(f) This principle has some characteristics of a demand system but households with more resources than others (e.g. labour to wait for other water users finishing irrigation) probably also profit more.

Water availability (or to be more exact the balance of water availability and water needs) is obviously also a key factor in determining flexibility/ rigidity of water use at the farm level. The availability of larger water quantities enlarges the farmers room for manoeuvre. In the final analysis it is an important determinant of the historic sustainability of irrigation systems. Empirical evidence shows that systems with small to very small water availability tend to be vulnerable to (partial) abandonment and undermining.

In conclusion, allocation principles and water availability determine whether water can be obtained at the right moment, in the right quantity and with a sufficient degree of certainty. They constitute a crucial element in farming households' decision making concerning land use (crops, plots, intensity) and resource management and allocation (labor, inputs) on the farm.
Small available quantities of water and rigidities caused by social agreements about the use and management of this scarce resource are the causes of deviations between actual water use and aspired water use. Farmers are perfectly aware of that. Over a long period of time and by experience they have developed and `discovered' a variety of responses and strategies to cope with and to match water supply with the water demand of their crops. Now, we turn to this focus and elaborate on how water users and government programmes intervene in FMIS.

4. Interventions in FMIS

4.1 Farmers strategies and interventions in irrigation development

FMIS in Trás-os-Montes are relatively successful in achieving the objectives for which they were created. Evidence of this is their long existence and the continuing use made of them, which proves their sustainability.
FMIS are dynamic systems, having to respond to the (changing) needs of the users. Insofar as the functioning of FMIS does not correspond to the changing objectives, resources and interests of farmers, they will try to adapt, change or improve their schemes. Attempts to overcome constraints in the environment and rigidities in the

functioning of the schemes will be made. If the schemes do not or cannot respond satisfactorily to the needs of (groups of) water users, farmers also look individually or in small groups for opportunities outside the communal schemes to develop their own water resources and strategies to obtain water.

Empirical evidence shows that water users themselves actively intervene in irrigation development, both inside and outside the communal systems. In this paper we will distinguish the following types of interventions:

Adaptation. Within the limitations and rigidities of a particular system, water users try to make the most out of the generally small quantities of water available. Many strategies can be distinguished.
Water distribution is made more flexible through exchange of water turns, or, more general, the exchange of different resources (e.g. labour against water etc.)[19]. Water users explore opportunities to make individual or group arrangements among themselves within the limits set by the management and physical constraints of the systems. Water and/or the land of migrants is used by other water users through various arrangements[20]. A range of local agronomic practices are used for adaptation to or escaping from various degrees of water scarcity whose combination is another element of a truly local art. Examples are (combination of) crops, rotations, varieties, plant, sowing and harvest times and plant densities[21]. Irrigation facilities, both

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19 A survey in 1986 among the 125 farmer households of the village of Cimo de Vila de Castanheira revealed the existence of 20 relations between farming households in which water was exchanged for other resources, principally labor. In the farmer strategies of Trás-os-Montes exchange of resources is a crucial social relation of production. Through these relationships farmers mobilize resources which are missing and exchange them for others which they possess in sufficient measure. Even old people who are not able to work any more, by means of this social mechanism, can survive.

20 A case study of the village of Sezelhe (Morgado 1992) in the mountain zone of Barroso reveals that of a total irrigated area (winter and summer areas) of 125 ha, water users irrigate 17 ha of land (or 14 percent of the total irrigated area) that is the property of emigrants.

21 Agronomic practices to make the most adequate use of scarce water resources, include:

- Use of balanced cropping patterns: a proportion between irrigated and non-irrigated (e.g rye) crops at a specific farm which is globally adapted to existing water availability.
- Irrigation of different crops in distinct periods, e.g. potatoes (irrigation in May-June) and maize (July-August).
- Earlier seeding and planting of crops to escape water scarcity. There are differences in planting dates between different zones and also between the farmers of the same area reflecting different increasing risks of frosts and heavy rains wiht earlier seeding and risk behaviour of farmers.
- Use of different plant varieties depending on their water needs, drought resistance, planting dates and crop uses. For example hybrid maize has a higher water need, is less drought resistent and needs to be planted earlier (because of a longer growth period) than the regional, rustic varieties. The longer growth period of hybrid maize is related also to the use of silage when the regional varieties can be used as green fodder or harvested as corn.
- Stimulating of good rooting of crops (e.g. maize) by not irrigating in the first growth period. This has also the advantage that in subsequent irrigation turns, deep losses outside the root zone of the crop are minimalized.
- Timing of irrigation in the critical growth period of the crop, e.g. the flowering/tasseling stage of the maize crop.

traditional (shallow wells and earthen reservoirs) and recent (concrete tanks, sprinkler irrigation) at farm level have a strategic importance for making water use and labour flexible[22].

Changes in Water allocation (principles) and water distribution practices. In some schemes farming communities have changed management principles and in other schemes discussions are taking place to change water allocation (see Table 2). It is understandable that these changes are the outcome of a complex social process because these types of changes imply changes in social relations and resources which farming households control. For some (groups of) water users the actual water allocation/distribution is more beneficial than for others. Usually long time periods are needed but changes nevertheless occur, especially at specific events that offer opportunities for change. For example, in the village of Sesmil, the improvement of the communal system by PDRITM was used as an opportunity by a group of water users headed by a local leader to change the distribution of water rights through linking the new distribution of water rights to the labour contribution of water users on the improvement works[23]. Events such as transactions and division by inheritance of land and/or water are likewise used as opportunities for change[24].

. Relay planting of other crops (e.g. beans in potatoes, annual grasses in maize) which can use the soil humidity that is left after the main crop is harvested.
. Frequent weeding in order to prevent losses of nutrients and water taken up by weeds and hoeing to disturb the upper soil layer preventing water losses by capillarity rise to the soil surface.
. High sowing density of maize. Then dependending on irrigation water availability and rainfall, farmers assess the possibilities of crop yield and survival. Normally they thin out the crop 2 or 3 times. The plants with most hydric stress serve as green cattle feed.
. Irrigation of alternate furrows to give small water gifts to a plot in specific conditions e.g. when it has rained or rain is expected.

[22] Additional irrigation facilities at plot/farm level are for example used to :
. permit a more flexible and improved timing of water application not prescribed by the rigidities of the system (e.g. long lengths of irrigation intervals). By means of temporary water storage in reservoirs (poços, tanques) it is possible to irrigate in between turns which is necessary principally in horticulture.
. irrigate plots which otherwise cannot be irrigated. By means of pumps and flexible tubes water can be transported to plots which are higher and more far away.
. irrigate plots with a convenient discharge that is not too low nor too high, dependent on crop and irrigation method (water storage by tanques/reservoirs and regulation of discharge from reservoirs and by using pumps and *pedras de engenho).*
. irrigate plots more efficiently/with less water and uniformly, mainly pastures, by means of sprinkler irrigation. EEC funds are available for some groups of farmers.
. irrigate with less labor input *(pedra de engenho, sprinkler).*
. permit more flexibility in labor input by use of tanques (important in the combination of farm and off-farm activities). Tanques are frequently found in schemes near cities with off-farm employment opportunities.

[23] The village of Roriz is another interesting exemple. The old system in which water distribution was based on (very) unequal time shares, has been abandoned and not used for years. When rehabilitation recently took place, all households in the village had the opportunity to obtain equal shares by means of equal (money) contributions to the rehabilitation works. The new type of water allocation can be considered as a hybrid type. On the one hand it has type 2 features but water rights are not temporary and village bound. They are attributed to specific persons who can freely dispose and transact these water rights. These are typically type 1 features.

[24] Also change of external conditions may constitute an opportunity. In Vilar de Lombo a type 1 water allocation existed with very unequal access to water among water users but with equal obligations to

In some systems we have observed that the water allocation/ distribution is experienced by an increasing number of water users (principally young people) as too complicated. For example, in Vila Cova young water users consult regularly with some of the older farmers about the periods they have access to water. Besides being complicated, water distribution is very time consuming. Some water users have fragmented water rights over short periods during the length of one irrigation interval (11 days).

Improvement of Irrigation Facilities. The largest physical constraint in many irrigation schemes in TrásosMontes is the scarcity of water at the scheme and field level. Numerous (partial) improvements of irrigation facilities implemented by the farming communities themselves have been found. Two types of improvements can be distinguished: first, to limit losses in the canals and reservoirs by means of lining; second, to get more water by developing actual and eventually new water sources.
These improvements in many cases are supported by local organizations such as the *Junta de Freguesia* (the politicaladministrative unit of the Portugues State at local level) or the *Commissão de Baldios* (Management commission of communal lands). Mostly improvements are implemented in steps, that is to say, one year lining of a reservoir, another year lining some parts of the canal and so on.

Individual Water Resources Development. For many years, farmers have also developed their own water resources, traditionally springs, wells and old mine galleries[25]. Concerning the quantity and density of individual water sources, a remarkable difference exists between the Mountain and High Valley areas. Hydrological conditions in the High Valleys, in which small scattered sources originating from subterranean water dominate in irrigation (see section 3.1), were more conducive to development of water sources on an individual base: discharges from many of these sources are too low (in the order of 0.050.3 l/s) to permit communal use. Recently, two factors have enormously accelerated the search for water and the development of private water sources in some regions. They are the impact of emigration and the availability of modern technology.

One of the effects that returning emigrants have had on local society, principally in the 1970s and the early 1980s, was that they brought back with them capital that was used to invest in developing water sources on an individual basis. At the same time, new technology became available that supported this type of development (Davidse, 1991).

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maintain the system. This was experienced by a lot of farmers as injustice. The Cravo Revolution in 1974 was used by the group of water users who had little access to water, to impose a change. Water rights were equally distributed among all households in the village, in spite of big water users protests and attempts to re-establish the status quo by means of juridical procedures.

25 The rationale is obvious: individual water sources imply more control over individual water use. It will be interesting to test the hypothesis that development of individual water resources is positively related to the different degrees of rigidity of water use found in the communal systems and the emergence/ development of specific farming systems.

Long PVC tube lines made it feasable to transport small quantities of water from distant water sources to the best plots near the villages and so reinforce available water from the traditional systems and/or decrease dependence on traditional communal systems. This stimulated the creation of small enterprises to develop water sources and to dig trenches for the tubes. Another technology generally used in TrásosMontes to reinforce available water quantities is the deepwell and use of the electric motorpump.

The development of sources for drinking water and the construction of home connections by State institutions is also quite recent. The rush to exploit water sources has even led, in certain villages, to existing irrigation schemes being undermined and to a decrease in the available water for these schemes to such a degree that, in some cases communal systems have virtually died[26]. This undermining is further aggravated by two factors. One is the effect of migrants spending August holidays in their villages. At such times the population of a common village will double or sometimes triple.
The combination of this sudden population increase and more demanding water consumption habits, leads to high requirements exactly in one of the driest months.

From an analysis of the functioning and dynamics found in farmermanaged irrigation, as expressed by farmer interventions, we have deduced what, in our opinion, are the relevant elements for defining intervention strategies:

Contents of intervention: The specificity of local FMIS, both in functioning and context. The very large heterogeneity among FMIS includes such interwoven aspects as:
The relative importance of and the particular balance between communal, group and individual irrigation facilities (High Valleys versus Mountains)
The relative importance of winter irrigation (HV's versus Mountains)
The rigidity/flexibility of water use
The balance of water availability/water needs

These factors have a profound influence on how and to what degree farmers intervene in their irrigation schemes or take initiatives in irrigation development. The need and willingness to change things and the contents of change will be highly dependent on particular local conditions at specific moments. This has consequences for public interventions both in the selection of schemes, the contents of intervention and the time horizon.

Methods of intervention: The intervention process. Characteristics of how farmers intervene are:
timing when need exists and opportunities appear;
stepwise, in phases, testing out results, experimental;
based on local knowledge;

[26] Striking examples can be found in villages in the high valleys where during the last 10 years under the influence of the building of collective milking parlours farming became principally oriented to milk production. That required more water for more and better cattle feed. Some farmers have made enormous investments to explore small quantities of water.

decision making is an informal process involving local actors which have most interest in intervention;
use of local resources (labour) with support of local organizations;
use of local construction methods and materials (half circular concrete elements: *meia manilha)*

4.2 *Actual state interventions*
An important development since 1982 is the involvement of the Portuguese Government in irrigation development in TrásosMontes, financed by World Bank loans and structural adjustment funds of the EEC. In the development programme of PDRITM, irrigation is seen as a basic condition for agricultural development.

Globally the government supported programme for irrigation development consists of three components. Two minor components are:
The process of planning, design and construction of the scheme is essentially an external intervention with nearly no involvement/ participation of future water users.

Implementation of new smallscale irrigation parameters. The most relevant differences with traditional irrigation schemes are:
An enormous increase of summer water availability through the construction of small dams and respective storage (in the order of a million m^3 per scheme). In this sense the intervention is an adequate response to one of the most felt needs of farmers: more water. This option is very relevant for High Valley areas.
With these schemes not much experience is yet available but PDRITM will in the future focus on these type of schemes more and more.

State subsidies for creating individual irrigation facilities. Access is limited to large farmers. How far such facilities undermine other existing schemes needs to be questioned.

Until now, the most important component of the PDRITMprogramme for irrigation development has been the improvement of traditional irrigation schemes (*Melhoria de Regadios Tradicionais* or MRT). The PDRITM intervention programme for improvement of communal FMIS aims at developing intensive dairying based on increased forage production. The type of intervention is conceptually not very different from the initiatives already undertaken by the farming communities themselves. Contrary to many other rehabilitation programmes worldwide, this approach respects the existing local situation with its intricate complexities and does not change the functioning of existing irrigation schemes but focuses on the improvement of the physical infrastructure of the schemes, essentially by limiting water loss by lining canals and reservoirs. Another guideline is that improvement will only be implemented if at least twothirds of the water users agree and subscribe to the respective protocol. Direct resource contributions (labour or other) of the water users are also required (5 to 20 percent of the value of the total investment)[27].

The implementation process and the effects of the interventions of the PDRITM programme for improvement of traditional irrigation systems are extensively documented (Portela *et al.* 1985; 1987; 1990). In this paper we will summarize the most important findings/ conclusions:

In general, water users readily agree that the PDRITM interventions produced multiple benefits, appreciated at scheme and village level because of diminished summer water scarcity and labour required for operation and maintenance, and at farm level for its general beneficial effects on landuse intensification, increased labor productivity and less drudgery.

Conceptual errors are pointed out by water users in some villages (principally in the Mountain zone). Canals are designed for summer irrigation only, or are substituted by tubes. The canals which are underdimensioned and positioned too high and therefore hinder surface water to stream and tubes, disrupt winter irrigation (which has to be done with much and `dirty' water), reducing the yields of permanent natural pastures.

Interventions are of a very limited character: the increase of water availability at scheme source level is very small or nil. In the case of a (much) reduced water availability, as in the High Valleys, the productive effects of intervention are small or negligible[28]. One might question whether the employed resources in the investment would not have had greater benefits in alternative use.

The often isolated and unintegrated nature of intervention in relation to local development, needs and priorities[29].

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[27] The difference in contributions appears to be related to the two different kinds of finance sources of the programme (World Bank and EEC).

[28] E.g. comparing two real but simplified cases:

Irrigation scheme:	High Valleys	Mountains
Source flow:	1 l/s	20 l/s
Before improvement		
losses:	70%	50%
Available water:	0.3 l/s	10 l/s
After improvement (canal lining)		
losses:	10 %	10 %
Available water:	0.9 l/s	18 l/s
Incremental available water	**0.6 l/s**	**8 l/s**

The differential productive effects of lining are in these two cases very clear.

[29] A whole series of exemples can be given. Irrigation systems are improved where necessity is less felt than in other hamlets where for instance conditions are created for milk production by the building of a collective milking parlour (SCOM). The same happens with the improvement of rural roads. Synergic effects of development efforts are seldom explored. In a broader scope actions could have contradictory effects e.g. forest developments which dry up water sources on which improved irrigation systems depend (when a forest burned down, as happened in Soutelo and Sta. Marta do Alvão sources flowed

The selection/prioritization of schemes for intervention is not very clear and subject to pressure from (political) power groups. Selection criteria are more centred on the convenience of the implementing agency. Actual water management and the productive potential of a scheme plays a minor role.

Usually (groups of) water users are not, or are minimally (or selectively) involved in the planning and design phases of the intervention. This leads to conceptual errors in the design and to unnecessary problems and delays in the implementation phase.

Improvement of the (supposed) largest village scheme without knowing the relative importance of this scheme for the village farmers[30].

Effects of improvement on water distribution and water use

The overall effect of PDRITM interventions is increased water availability on scheme level which signifies an increased room to manoeuvre at farm and plot level. A crucial question is how and by whom this incremental water may be used, depending on the water allocation in specific schemes.

Table 4 shows which changes occur in access to water after improvement. In type 1, water users with big shares profit much more from the improvement of the scheme than water users with small shares. In types 3 and 6 the irrigated areas of water users do not change but improvement makes a more intensive land use (higher yields) possible. In types 4 and 5 the absolute access to water has increased but it is not clear to what degree users profit from it. Probably households with more resources (e.g. labour force to wait for the water in type 5) also profit more.
Another important question is how far improvements constitute an incentive for changes in water use, especially use linked to the production objectives of PDRITM, namely, increased forage production. The incremental water can be used to intensify land use (more water on the same parcel/area) and/ or to extend the irrigated area. Schemes of type 1 and 2 offer the highest flexibility to farmers to use adequately the incremental water quantities. No restrictions exist in relation to parcels, crops or exchange/ commerce of water, thus it is to be expected that water will be applied in a

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again). Local needs and priorities might be different even related to water supply (Example: Mourilho where people in the first place were interested in a reservoir to combat forest fires and not to improve their irrigation scheme).

30 There is evidence for doubt whether in some cases (e.g. Santiago) the most important communal system was really improved. In many villages, principally of the high valleys there are a great number of individual and small group water sources whose importance could be more important than the communal system. For instance, some measurements in the village of Sesmil show in the case of one user that she receives from the communal system some 2.1 m3/day (July 1992) and her shallow well yields approximately 3.7 m3/day which corresponds to 65 percent of her total water supply (Schultink 1992). In this village, estimation, at a rough level, the contribution of scattered individual water sources is about 80 percent of the total water supply in the summer. On the basis of other empirical research we can expect that similar situations are general in the High Valley zone.

way which corresponds to the most suitable use of water under the given circumstances[31].

Table 4. Effects of improvements in function of water allocation principles

Water Allocation Principles	Changes in access to water as effect of intervention			
	(a)	after improvement	gain	crit.
1. Time shares	a	2Q	Q	Quant.
	b	20Q	10Q	Water
2. Equal shares	a	2Q	Q	Quant.
	b	2Q	Q	Water
3. Plot-bases	a	A	-	Area
	b	10A	-	Irrig.
4. Free access	a	?	?	?
	b	?	?	
5.First come, first served	a	?	?	?
	b	?	?	
6.2-level:	a	A	-	Area
time-plot	b	10A	-	Irrig.

[31] The only rigidity in type 1 and 2 is the fixed irrigation interval, which if a long period, is already or can become an obstacle for improved water use and increased production.

Water allocation principles	Effects of interventions on production parameters (c)		
	Increase irrg. area (d)	Increase pastures	Exchange/ commerce of water
1. Time shares	incentive	incentive	incentive
2. Equal shares	incentive	incentive	incentive
3. Plot-based	restr.	restr. ?	rest.
4. Free access	?	?	restr.
5. First come, first served	?	?	restr.
6. 2-level: time-plot	restr.	rest.	restr.

(a) Comparison of 2 water users a and b with different water (Q, 10Q) or land (A, 10A) resources in schemes with distinct principles of water distribution.
(b) It is assumed that water availability at scheme level doubled as a result of improvement.
(c) The more water becomes available by improvement, the more pressure that can be exerted from groups of water users to change the distribution rules in types 3 and 6. In general, all rules can be made more flexible if water users agree among themselves.
(d) However, in types 3 and 6 the increase in irrigated area is restricted, irrigation of existing plots may be intensified (shorter length of intervals, larger water gifts).

In schemes of type 3 and 6 water use is conditioned by more or less rigid rules, thus no incentives and/or possibilities exist in these types to increase irrigated areas and pastures however irrigation of existing parcels may be intensified. In schemes of type 4 and 5, changes in water use are difficult to predict and very dependent on the local situation.

Thus it can be concluded that a uniform type of intervention, namely the improvement of irrigation facilities, works out differently in irrigation schemes with different water allocation principles. This implies differential production effects of incremental water in the various schemes.

Having identified the diverse reasons, forms, features and effects of intervention by water users as well as the government, the next question is what lessons can be learned. Starting with the heterogeneity and dynamics found in FMIS and their environments we will formulate intervention strategies to improve public interventions

5. Linking institutional support to farmer-managed irrigation: intervention strategies

Trás-os-Montes is a so-called marginal region whose rural areas are seriously threatened by human depopulation. To stop this tendency, rural development in Trás-os-Montes is of the utmost importance. The implementation of exogenous development models from the growth poles is not recommendable because of negative environmental and economic side effects. Moreover these external development models/ modernization blueprints are virtually impossible to implement because of the physical and socio-economic conditions in Trás-os-Montes.

So, an alternative must be searched for in the development of the local potential of human and natural resources and infrastructures.

Starting with the premise that building upon and improving the local potential of human and natural resources is/or forms the basis for sustainable rural development, institutional interventions and support may play an important role in strengthening local development. In the foregoing we have shown that farmer-managed irrigation constitutes a local resource of crucial importance for agricultural development. Although actual state interventions in communal FMIS respect the local situation and limit themselves to a physical improvement of the infrastructure, they are of a uniform character and do not take in account the heterogeneity/diversity in functioning and the local dynamics found in the farmer-managed irrigation sector.

Based on the diversity and the local dynamics found, the following intervention strategies (concerning both the contents and the process of intervention) are, in our opinion, vital for improving existing and designing new institutional interventions:

An integrated approach to local (irrigation) development. Public interventions in FMIS are often isolated actions and not systematically linked to local development, specific needs and priorities. The same is valid for interventions by other (public) institutions, that are often not adjusted to the local situation and coordinated from a local perspective.

Integrated development needs to be defined at local level according to the specificity of the local situation (existing development tendencies, use of local resources) and local needs. Various dimensions can be distinguished:

The importance of irrigation versus other forms of water use in the local situation. Priorities for local development may envisage that other interventions or irrigation development, to be effective, need to be complemented by other interventions.

A crucial point is the role that irrigation plays in farming and the complex interactions involved. Irrigation practices cannot be understood as isolated phenomena. They are integral parts of farming. Irrigation development in order to can be interpreted as both a condition for and an outcome of land use intensification and increasing labour productivity, commonly associated with the modernization model.

Key questions are: what is the role of irrigation in the specific agricultural practices of particular (groups of) actors? and which irrigation interventions are a condition and/or a stimulus for local agricultural development patterns?[32]

Concerning irrigation development a whole range of interventions need to be considered from a local perspective, not only a uniform type, i.e. the improvement of the physical infrastructure of the communal system of a village, supposed as the most important.

As we have already seen interventions by water users are much more diverse, context dependent and space/time specific. Moreover, there are linkages between factors. For example, an increase in water availability will (again) initiate local discussion about water distribution, i.e. whether the distribution pattern will fit the new situation created by the intervention.

- An integrated approach implies that all the aspects and effects of intervention need to be considered, which are not necessarily limited to one village. Where various irrigation systems depend on the same surface water resource, adequate interventions need to consider a whole catchment area or even a whole region if subterranean water development is involved. A constraint on a national scale related to water resources development is the obsolete Portuguese water legislation and its deficient application (Matos Ferreira 1989).
- Local implementation capacity. Social organization. Local potentials and constraints.

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[32] Irrigation is crucial for all farming households to secure production for household consumption needs. Moreover, the development of specific farming systems is conditioned by the availability and increase of water supply. In the 4 farming systems identified by Christóvão et al. (1992) in the mountain area of Barroso the specific uses of water and the importance/dependency of an increasing water supply can be summarized as follows:

- Intensive dairy farmers: The most important forage crops are silo maize (hybrids) and temporary meadows. Intensification of land use on the basis of these crops, modern seeds and fertilizers require an increased supply of irrigation water. On one hand the introduction of these innovations is conditioned by the existence of good quality land with irrigation water, on the other, farmers in this category, develop their own water sources and use modern technological means (sprinklers, constructed irrigation tanks) more than other farmers. The development of this farming system (modernization) is in a high degree conditioned by the technical and (social) means to increase the available water supply.
- SCOM (small dairy) farmers: Forage is based on traditional maize and hay. Because of low cattle density necessity of increased water supply is much lower. Higher cattle densities will inevitably require an intensification of forage production and therefore an increased water supply.
- Intensive meat producers. Most important forage sources are hay and pasture in the "baldios". Hay production is the "bottle neck" for a further increase in cattle density. The development of this farming system (an endogenous development pattern) depends on the increase of hay production which is conditioned by an increase in the water supply.
- Extensive meat producers. At present, this category of farmers are not longer developing their farms: farming is part of a multiple income and survival strategy. An increase of water supply is for this category of farmers at present less necessary.

In the High Valleys there can also be distinguished great variety of farming systems, based on the forage system that farmers use, (Baptista *et al* 1990). Irrigation potential and practice appear crucial variables in the identification of these forage and farming systems.

Use of a typology of FMIS as a resource for mapping the heterogeneity of FMIS and their local environments. A typology constructed on:

- The relative importance of and particular balance between communal, group and individual irrigation facilities/ systems at village/local level.
- The relative importance of winter and summer irrigation.
- The key factors/determinants of heterogeneity in the functioning of FMIS and the related rigidity/ flexibility of water use at the farm level.
- the balance of water availability/water needs.
- local dynamics as expressed by farmers' interventions, ideas and discussions but also in a indirect way, e.g. requests for support from public institutions.

The constructed typology enables one to focus the content and process of intervention on the specific situation at local level, and to abandon uniform blueprint models and intervention methods. Fundamental dimensions concerning the contents of intervention are the different interests of local socio-economic groups, the importance of and actual functioning of the local irrigation schemes and related farming practices.
Irrigation presents different interests for the different social groups (see section 2), which may eventually clash with each other. In the section concerning farmers strategies the existence of a strong tendency to develop individual water resources was revealed, related to particular conditions (hydrological, impact of emigration, production orientation, the balance between water needs/ availability), especially in the High Valleys. In some places this tendency resulted in the undermining and subsequent abandoning of communal systems, prejudicing vulnerable groups with few resources. In the Mountain areas farmers invest also in individual irrigation facilities but communal systems are still the most important at village level. The differing significance of summer and winter irrigation is related to the importance of locally dependent, specific farming practices. Interventions neglect the local importance of winter irrigation of permanent meadows (see second section) and in some locations interventions are directly prejudicial to this farming practice. We have shown in section 3.2 how the heterogeneity found in the management/ functioning of FMIS is related to the diversity in three identified key variables.
This diversity has a direct influence on the rigidity/ flexibility of water use at farm level which leads to a variety of farmer responses and interventions both in and outside the communal FMIS. These key factors are operational elements in the sense that they can be changed. As already mentioned interventions implemented by water users themselves nearly always involve changes in one or a combination of these elements. Finally, it was shown that the uniform character of public intervention (improvement of the physical infrastructure) in FMIS with distinct management features has different effects in terms of access to water and in terms of potential changes in water use. This may help us to assess the different effects that are likely from this type of intervention.

The constructed typology will constitute an instrument for planners, designers and implementers at various levels for mapping heterogeneity, complexity, flexibility/ rigidity, dynamics and potentialities of irrigation at village and scheme level. On a more aggregate level, the typology can also be linked to (certain) contextual/ environmental factors (e.g. agro-ecological, production orientation etc.) that will be useful for global planning purposes.

The constructed typology contains crucial guidelines for intervention purposes and as such constitutes a tool for focusing on the most relevant features of local irrigation development. That leads to the following intervention strategy.

- *Improved invention* will be a first step to and condition for improved interventions. Till now, invention of FMIS was limited to technical constraints, and was based on information from a very limited number of local informants. Improved invention needs to include actual functioning and dynamics of FMIS, specific local needs and local initiatives in order to avoid external proposals being unrelated to the local reality. This requires an exhaustive consultation of different actors at the local level.

In this way, inventarization is fundamental in designing interventions suited/ tailored to the local situation, and to the needs of different (groups) of actors to local dynamics. Selection criteria for intervention can be derived or established. It leads to a next intervention strategy.

- *Improved selection* and prioritization of sites considered for intervention. Up to now, the selection of which FMIS to improve has been based mostly on technical criteria (access paths, length of main canal, size of weirs, water flows, irrigated areas, soils, size of village population)[33] biased towards quick implementation. Selection criteria need to be derived that are based on a typology with a focus on local dynamics. For the selected villages to intervene, the following intervention strategy appears on the horizon.

- *Defining the decision making process as a joint venture of* institution and local water users. Up to this moment, water users have virtually been excluded from the planning and design phases of the intervention. The contents (what to do) and process (who, how, when, where) of intervention need to be defined and discussed at the local level by all actors who have an interest in the intervention. The constructed typology may be used as an instrument to focus the discussion on the essentials. This will avoid conceptual errors related to neglecting the specificity of agricultural practices as e.g the *rega de lima* (see second section). The contents and process of intervention will be explicit issues in the decision making. In this way, intervention may be a suitable moment and opportunity to initiate debate and to establish new rules which enable the highest local benefits to be gained from the envisaged intervention.

- Defining intervention as support to ongoing local dynamics and as strengthening local initiatives, helping with means, resources, technical assistence which are not within the reach of local actors. This implies the creation of a new relationship between

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[33] In spite of the limited character of these criteria, much evidence exists to question the reliability of the data on water flows and irrigated areas which have been used for design purposes. Irrigated areas and water flows are not measured and are frequently overestimated.

local initiatives and central intervention programmes[34] which signifies in practical terms an important rupture with usual interventions. Institutional interventions are not linked to local initiatives.

The fact that, in many cases, farmers (communities) themselves, supported by local organizations,[35] actively intervene in irrigation development is of crucial importance. It is an indicator of the capacity and decision making of water users and their organizations to create and change things. It represents a potential that is actually not used by institutional interventions.
We think that this resource can be combined with institutional efforts to improve interventions through an approach similar to what Coward (1985) called "the indirect investment approach". Through indirect investment, critical resources are provided by state agencies to local irrigation groups to create and improve those locally owned and managed systems[36]. If the groups of water users, who ultimately are the risk-takers of irrigation investments, are given the due status and roles, they can make themselves accountable to the institutions which supply these resources. Strongly related to this is the following intervention strategy.

- It will start with the assumption that farmers' avoid excessive risk taking, and experiment on a limited scale. This links up with the way farmers intervene in their systems i.e. partial step by step improvements. This signifies a rupture with actual implementation of interventions[37]. It implies that the role of external agents e.g. constructors will decline and be of a different nature i.e. the implementing of specific parts which are not within the reach of the local community. Also relations between these external actors and the local community will change. In the first place they will be accountable to the local community instead of the intervening institution.

- It will start with the farmers' local knowledge of the area, physical conditions and farming/ related irrigation practices. PDRITM intervention consultations with farmers are minimal and biased towards local bosses, big farmers etc. Using local knowledge will point to better suited solutions (adequacy, cost-effective) to specific local problems, e.g. the lining of canals (where is it most necessary? etc.). Farmers knowledge of specific

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[34] The balance between local initiatives and institutional intervention need to be specific for every local situation. It is obvious that the relation is different in traditional FMIS intervention than in the creation of new small-scale irrigation parameters.

[35] A salient example is the village of *Cidadelhe de Aguiar.* The local commons-management commission invested 40,000 US$ in irrigation works (9 km channel) (Brouwer 1992).

[36] This approach seems not entirely new in Trás-os-Montes. People in some villages informed us about the former existence of an *Instituto de Reforma Agraria* created after the Cravo Revolution of 1974 which supported local water supply projects with e.g. construction materials complementing the labour of the village habitants. Another example is the village Gallegos de Serra, in which the local habitants in 1974 substituted 500 meters of earth canal by a canal constituted by half-circular concrete elements (*meia manilhas).* These elements were supplied and transported to the village with an order of the then *governador civil* of the Vila Real district.

[37] The practicality of this intervention strategy is dependent of the local situation and specific for the type of intervention. It is obvious that the implementation of new small-scale irrigation perimeters requires other methods than improvement of traditional FMIS.

local farming and related irrigation practices is of crucial importance in avoiding conceptual design errors (e.g neglecting winter irrigation practice) and in creating adequate designs adjusted to these practices.

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