

Traditional Irrigation and its Importance to the Tourist Landscape of Valais, Switzerland

DARREN S. CROOK & ANNE M. JONES

ABSTRACT *The contemporary landscape of the Central and Haut Valais, Switzerland, is partially a product of the ancient but extant bisse irrigation system. The current principal conduit network extends for approximately 760 kilometres, whilst the distribution network stretches for over 25 000 kilometres. Both systems have had a major impact on the Valaisan landscape. Besides this, traditional distribution techniques (ruissellement) have also altered dramatically the landscape of specific locations in the Valais. The contribution of bisses to the local milieu has been recognized by the federal, cantonal and communal governments. All three levels of government have provided incentives to farmers and local irrigation institutions to conserve traditional farming practices where appropriate and protect traditional methods of irrigation. This paper describes the landscape impact of traditional and modern irrigation practices and the instruments available for protecting these practices. It also appraises the success of these interventions and examines what future role bisses might play in protecting the current agricultural landscape, which has become so crucial to the success of summer tourism.*

KEY WORDS: Valais, irrigation, ruissellement, agriculture, tourism

Introduction

Drylands (Beaumont, 1993) often place restrictions on livelihoods because of climate constraints on agriculture, limited water resources, scarce natural resources and economic marginalization. Responses to these constraints are reflected in the landscape. These responses often lead to highly distinctive landscape features, such as terracing or water control structures, which characterize large areas. For example, there has been much research into ancient water harvesting, floodwater farming and irrigation which have had major impacts on landscape throughout the drylands of the developing world (e.g. Barker, 1996; Critchley *et al.*, 1992; Evenari *et al.*, 1982; Gilbertson, 1986; Vincent, 1995; Wilken, 1987)

Comparatively little attention has been paid to drylands in the developed world. The Valais canton of Switzerland is one such area. In summer, parts of

Darren S. Crook & Anne M. Jones, Department of Geographical and Environmental Sciences, University of Huddersfield, Queensgate, Huddersfield HD1 3DH, UK.

the Central and Haut Valais have low precipitation (Figure 1) and high rates of evapotranspiration which result in a seasonal water deficit (Crook, 1997). The Valaisans, in response to this water deficit, constructed numerous irrigation canals known locally as *bisses*, *suonen* or *wasserleitung*. The system is ancient (ca. 1008 AD; Liniger, 1980) and has contributed to creating a distinctive landscape type as is the case with the Levada of Madeira (York, 1992) and the Cape Verde Isles (Haagsma, 1995), Ruz of the Val d'Aoste (Gerbore, 1995), Balinese Subak (Geertz, 1972), Arabian *hemas* (Saleh, 1997) and diversion systems in Tarakot, Nepal (Werner, 1995) and Cusichaca, Peru (Bowen, 1995).

Bisses were constructed principally to irrigate meadows for improved grazing and fodder (Dubuis, 1995). The current principal irrigation conduit network extends for approximately 760 kilometres, whilst the distribution network stretches for over 2000 kilometres and field channels are estimated at around 25 000 km (Aufderregen & Werlen, 1993). The unique agricultural landscape of the Valais largely results from traditional irrigation practices, as described in a later section. Since the Second World War the irrigation network has been modernized and rationalized, often in line with a process of communal reorganization known as *remaniement parcellaire*. The effects of such changes on the traditional landscape, described later, have been substantial.

Besides their agricultural function, *bisses* have become important to the summer tourist industry, because they are a crucial component in the formation of the traditional 'chocolate box' tourist landscape. *Bisses* also have tourist value as historical features, they provide an important network of tourist footpaths and they often make visually striking and spectacular landscape features.

Both national and regional governments have realized that the traditional rural landscape is threatened by recent agricultural changes and tourist development associated principally with winter tourism (Schwery, 1995). A growing disparity between winter and summer incomes was recognized, with many communes dependent on winter revenue (Abegg & Froesch, 1994). Thus, political concern heightened as winter incomes declined because of variable and unreliable winter weather patterns and further threats of rapid *climate change*. This produced a political reaction which aimed to reduce the disparity between summer and winter incomes. As part of this process the summer tourist resource has been enhanced. A number of fiscal incentives are provided by local (commune), regional (canton) and national (federal) governments to protect and conserve the traditional landscape. These are described and appraised in the fourth section.

This is part of a much wider movement to conserve extensive farming systems and traditions throughout Europe, because of their environmental, landscape, habitat, wildlife, cultural and tourist value (Bignal & McCracken, 1992; McCracken *et al.*, 1994). In the UK this is illustrated by the reinforced commitment to upland landscapes and expansion of the Countryside Stewardship option in 1998 (Ministry of Agriculture, Food and Fisheries, 1998). Outside the UK, however, many countries in the European Union (EU) have been slow to implement national agri-environmental initiatives (Kerrell, 1998, pers. comm.). The Valais, like the rest of Switzerland, although outside the EU, provides examples of good practice when conserving traditional tourist landscapes. It lies outside the scope of this paper to discuss whether this desire to conserve largely unproductive tourist landscapes is ethically and morally desirable.

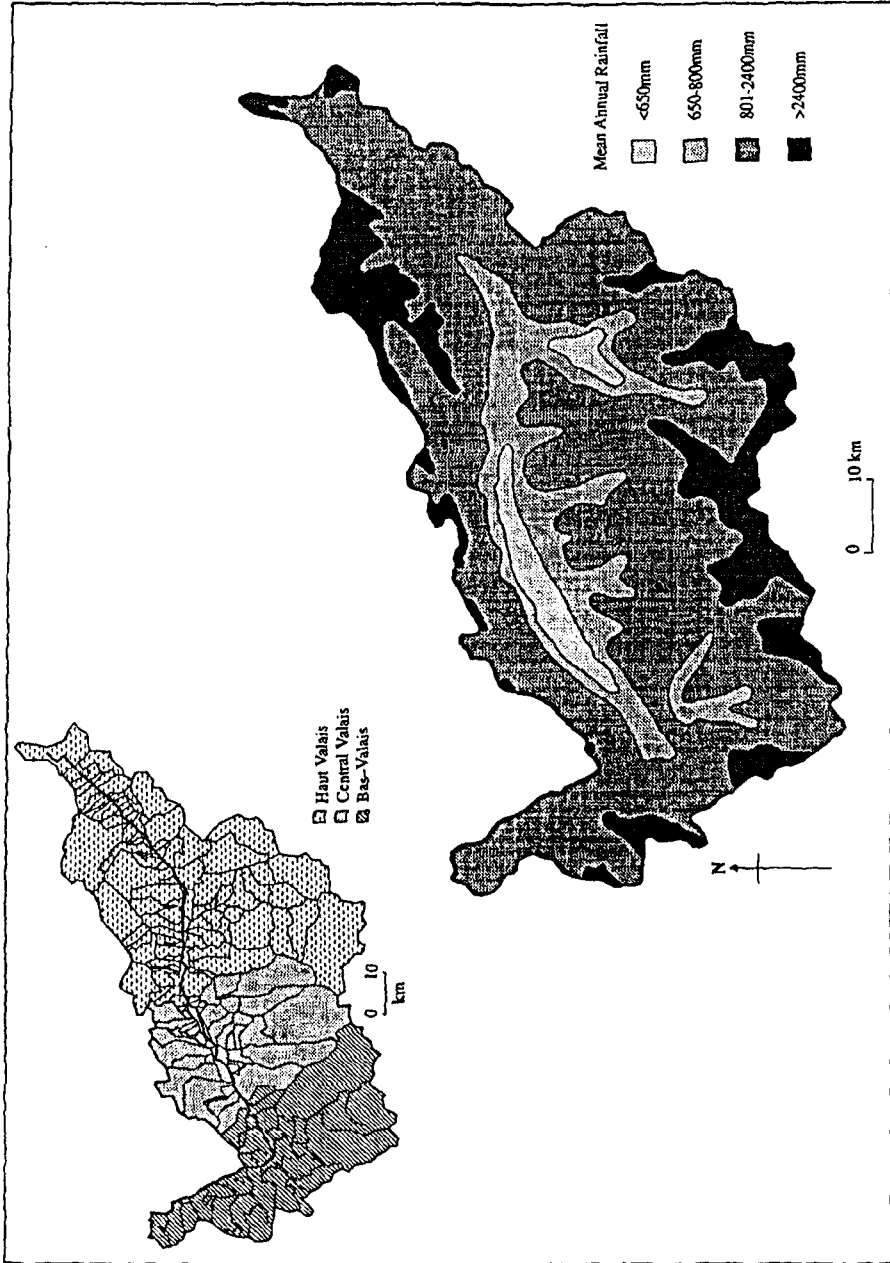


Figure 1. Rainfall isohyets in the Valais.

Thus, this paper first introduces the Valais as a dry mountainous area. It then describes the traditional and modern irrigation techniques associated with *bisses* which have had the greatest impact on the local milieu. The fourth and fifth sections discuss the instruments available to three levels of government which serve to conserve this unique landscape. It separates those measures specific to conserving the landscape for tourism from those which support agriculture. The success of these interventions is assessed in the sixth section and the future role of *bisses* is discussed in the final section. Place names referred to in the text can be found on Figure 2.

Context

The *bisses* are primarily slope offtake systems which divert water from glacial meltwater streams that feed into the upper reaches of the River Rhône. They convey this water to areas in need of irrigation (Crook, 1997). Irrigation, whilst not essential for cultivation, is necessary to produce an agricultural surplus which allows trade (Dubuis, 1995). Traditional agriculture was based around vertically controlled mixed agro-pastoral systems (Vincent, 1995) which took advantage of preferential environmental conditions at different altitudes.¹ The ephemeral nature of these climatic conditions meant that agriculture followed a seasonal cycle, which often involved periods of seasonal transhumance for either individuals or whole villages (Loup, 1965). Likewise, irrigation was operated in line with these cycles of activity. The major areas to be irrigated were meadows which produced grazing and fodder, thus enabling the over-wintering of cattle. During the late nineteenth and early twentieth century many alps (collectively managed pasture at high altitude) had their production intensified using a process known as ferti-irrigation in which manure was collected from cattle sheds in small channels and then distributed onto fields (Viérin, 1995). Around the same time agriculture was rationalized and modernized, which involved the introduction of numerous spray irrigation networks (*réseau d'irrigation*). Marshy sections of the Rhône plain were drained and the river 'corrected', which enabled an extension of intensive high-value crops into these areas (Loup, 1965). This eroded the traditional links between the plain and mountain formed by the now archaic transhumance patterns. Sedentary agriculture became more specialized and mechanized and centred on high-value crops such as vines, strawberries, orchard fruits and vegetables. Each irrigated crop had different water allocation and scheduling requirements. The following two sections introduce the major impacts of traditional and modern irrigation techniques on the landscape.

Impacts on the Environment

Traditional Impacts

The typical risk strategy used by the original constructors of *bisses* was to build a number of *bisses* down a slope, thus avoiding disturbance to the whole agricultural zone by dynamic slope processes. This increased water security and allowed diversion of water into different agricultural zones. The conveyance channels of *bisses* were built with small slope angles to prevent erosion and incorporated locally produced materials such as wood and stone. The preferred

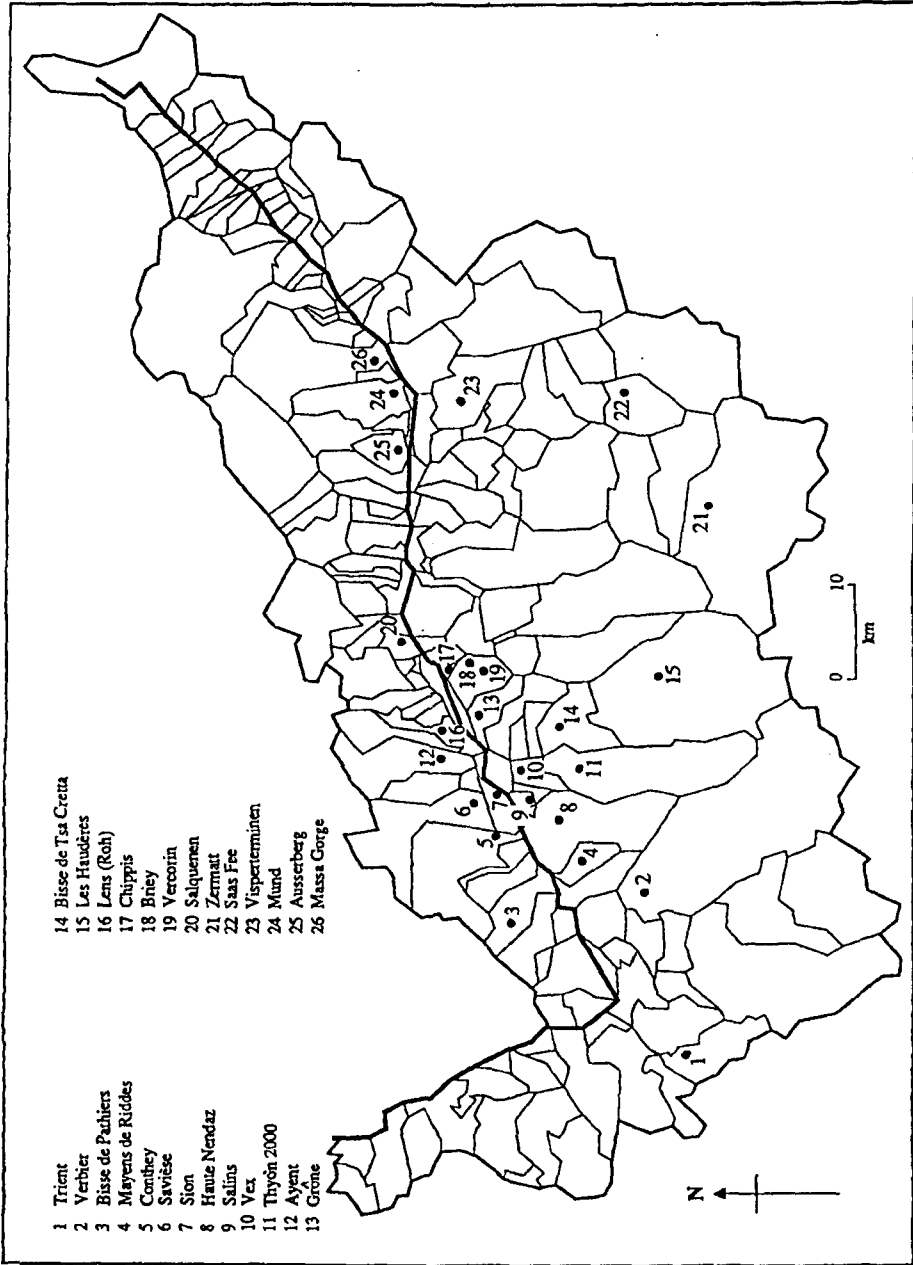


Figure 2. Place names mentioned in the text.



Figure 3. The *bisses* of Salquenen (D.S. Crook).

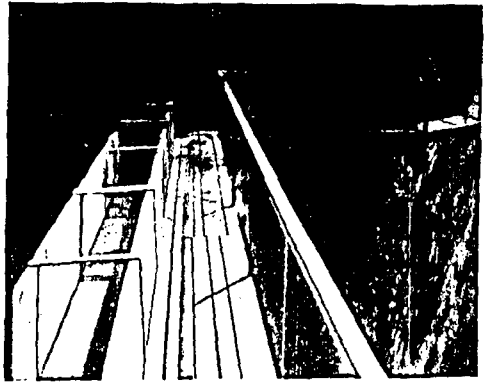


Figure 4. A wooden bridge on the Bisse du Roh (D.S. Crook).

channel cross-sectional design was trapezoidal or semi-circular and cut into the earth. Suspended sediments from glacial meltwaters help to line these channels, although most channels suffer from infiltration losses. This has meant that hydrophilic vegetation has established itself next to *bisses* and tree growth is improved. For example, the *bisses* at Salquenen have had a dramatic impact on the surrounding landscape by producing two green swathes against the pale limestone background (Figure 3).

The dynamic nature of the highly active mountain environment meant that in places adjustable bridges and trellis support systems were used, which are often visually spectacular, particularly when traversing sheer rock faces (Figure 4). The wood for some of these structures came from purposefully managed forests set aside for the replacement of construction materials (Mariétan, 1948). Frequently, small-scale water-powered industry was also reliant on water delivered by *bisses*.

Ruissellement is the traditional distribution technique most often associated with the irrigation of meadows to improve grazing and fodder for cattle or sheep. It is a surface irrigation technique which relies on blocking small open channels and allowing the water to flow under gravity to the end of a field. *Ruissellement* techniques, particularly on the flatter lands of valley floors, led to the accumulation of sediments on fields and particularly along distribution channels, often increasing significantly the height of the sides of the channels. This, coupled with the fragmented nature of land holdings resulting from partible inheritance strategies (Weinberg, 1972), can produce striking landscape features (Figure 5).

Land was managed in a regulated sequence that related to crop production and animal husbandry at different altitudes and climate seasons. Family and community livelihood strategies often involved transhumance from the plain to the alp and utilized specialized farm buildings (Netting, 1972). This allowed a better use of labour and materials during the agricultural season. These practices led to individuals owning a large number of small parcels of land spread between different parts of a commune (Loup, 1965). Farm units became smaller and more dispersed as each inheritor received an equal share, unless impartible partibility² was practised (Jones, 1987), which led, for a period, to the maintenance of land and water rights intact. At the end of the nineteenth century,

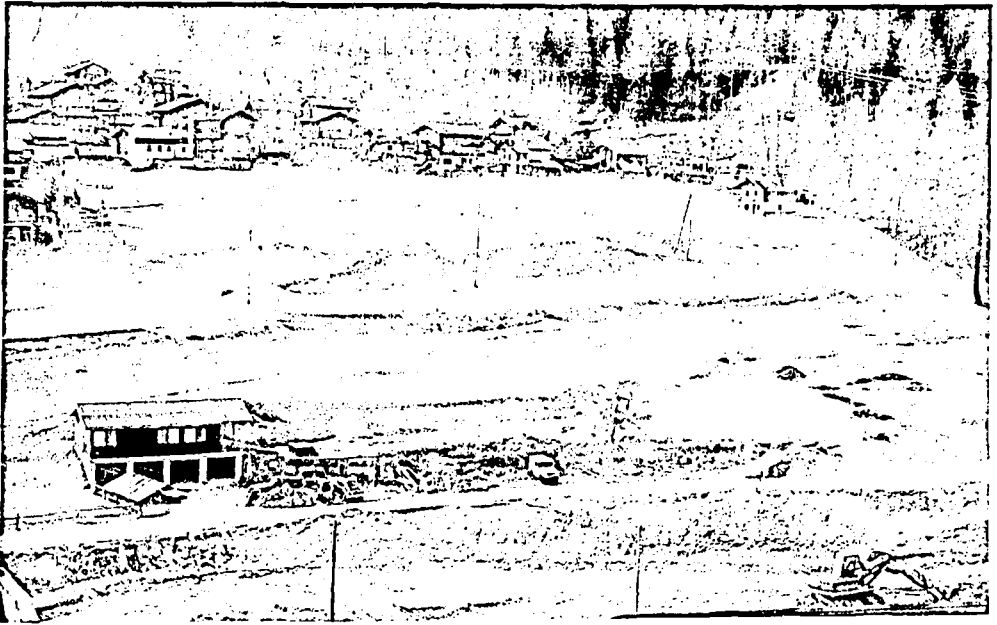


Figure 5. The aggradational landscape at Les Haudères (reproduced by permission of C.O. Hunt).

population increase continued to lead to fragmented landscapes even with consolidation strategies in operation. This resulted in poor economies of scale in terms of labour, resources and crop yield potential.

Traditional irrigation practices often produce poor uniformity in water distribution and large temporal gaps between irrigations because of different management strategies and *ruissellement* techniques (Crook, 1997). These practices, however, have been beneficial to inter- and intra-field biodiversity (Perraudin Kalbermatter & Marin, 1995). The intra-field variation in soil moisture content and nutrient status resulting from traditional methods of distribution and field topography produces a mosaic of different niches for plants (Beauverd, 1962; Crook, 1997; Theurillat, 1986), which affects the inter-field composition of meadows. In particular, dry zones diversify plant assemblages (Perraudin Kalbermatter & Marin, 1995), such that dry meadows are richer and more diverse than the irrigated meadows (Aufderregen & Werlen, 1993). The clearing, dumping and accretion of *bisse* sediments, along with the irregular nature of irrigation, create a diversity of microhabitats that allows plant species to establish [e.g. meadowsweet (*Filipendula ulmaria*), avens (*Geum* spp.), long-leafed mint (*Mentha longifolia*), knot grass (*Polygonum* spp.), marsh valerian (*Valeriana dioica*), goutweed (*Aegopodium podagraria*), stinging nettle (*Urtica dioica*), hemp agrimony (*Eupatorium cannabinum*), purple molinia (*Molinia arundinacea*), yellow saxifrage (*Saxifraga aizoides*) and bittersweet (*Solanum dulcamara*)]. Thus, *ruissellement* has created local variety in the landscape and provided a diversity of forms, colours and odours along *bisses* which are attractive to tourists.

Table 1. The active working population of the Valais according to the economic sector, 1930–1980.

Economic sector	Year					
	1930*	1941*	1950*	1960*	1970†	1980†
Primary	29 443 (52%)	29 147 (48%)	26 408 (41.4%)	18 190 (25%)	13 676 (15.3%)	9936 (10.2%)
Secondary	13 712 (24%)	17 117 (28%)	18 747 (29.4%)	28 835 (39.6%)	35 679 (40%)	35 684 (36.6%)
Tertiary	13 785 (24%)	14 320 (23.5%)	18 526 (29%)	25 738 (35.3%)	39 717 (44.5%)	50 164 (51.4%)
Others	0	276 (0.5%)	169 (0.2%)	78 (0.1%)	222 (0.2%)	1756 (1.8%)
Total	56 940	60 860	63 847	72 841	89 364	97 540

*Not including part-time workers.

†Including part-time workers.

Source: Office de Statistique du Canton Valais (1997).

Modern Impacts

At the beginning of the twentieth century, Valaisan agriculture was rationalized and modernized (Loup, 1965). With this came changes to the *bisse* system. Of particular note was the development of the Rhône plain for intensive market garden crops, the modernization and rationalization of Valaisan vineyards and the pastoral economy, and the introduction of spray irrigation techniques. This trend has continued through to the present with a concomitant reduction in the number of people employed in agriculture (Table 1).

Non-agricultural infra-structural development of the canton centred around industry, hydro-electric power (HEP) installations and tourism (Cosinschi, 1994). The development of HEP, particularly in lateral valleys, improved the infrastructure in these areas, which facilitated the development of winter tourism in some communes and also provided alternative income opportunities (e.g. at Saas Fee, Thyon 2000, Haute Nendaz, Zermatt and Verbier). As a result, these communes have developed their infrastructures to promote these alternative livelihood strategies at the expense of the agricultural resource. In other areas (e.g. Ausserberg and Vex) these changes have allowed dual income strategies to be pursued based around agriculture and employment in industry or the tertiary sector (Cosinschi, 1994). In many mountain areas agriculture is non-intensive and can be described as 'hobby' farming (e.g. in Vercorin and Briey) as it is not necessary to sustain livelihoods. In either case much agricultural land has been lost to building development, particularly the construction of holiday homes on the *mayens* (traditional spring and autumn pasture) once favoured for intensive irrigated meadow production.

The many socio-political, cultural, economic and technical changes which have occurred have had a major impact on the *bisse* system. In particular, many distribution channels have been cut, covered or forced underground. Improved tunnelling techniques have facilitated the improvement of many previously dangerous or high maintenance *bisses* (e.g. *bisses* in the Massa gorge). This has

led to the partial or sectoral abandonment of other *bisses* and particularly the loss of many impressive wooden support structures and small rock-cut platforms (e.g. Bisse de Savièse, Bisse du Roh).

In many communes, spray irrigation has replaced *ruissellement* as the principal form of water distribution. The major focus for this change has been in those areas where commercially competitive crops can be grown. The principal irrigated crops are the vine and various orchard and market garden crops. Spray irrigation, available since the 1920s (Schildtnecht, 1933), is often associated with wider changes to communal infrastructure. Since the Second World War many communes have been forced, with the consent of the owners, to consolidate and redistribute land holdings in a process known as *remaniement parcellaire*. For each commune this was a 4–5-year physical and psychological process of reshaping and development reliant on cantonal and federal subsidies (Grove & Grove, 1990; Loup, 1965; Sauvain, 1980). Most communes on the Rhône plain and valley slopes received cantonal subsidies to assist these changes. Cadastral records provide evidence which suggests that water resources and, more specifically, irrigation have been the primary focus for this intervention in many communes (Office Federal de l'Agriculture, 1975, 1979). Irrigation networks (*réseau d'irrigation*) set up to facilitate the introduction of spray irrigation can be visually obtrusive, particularly where covers are also used to reduce evapotranspiration or prevent frost damage to the crop.

Ad hoc and incremental changes to the *bisses* are also associated with an increased need to store water, partly because the agricultural demand for water amongst individual farm units coincides more under monoculture than under mixed farming systems. This is unlike the situation with traditional water allocation and scheduling techniques (Crook, 1997). This has meant that there are now a far greater number of small storage reservoirs in use with spray irrigation networks. Many *bisses* are retained principally to supply storage reservoirs, which are then attached to spray irrigation networks (e.g. Grand Bisse de Lens, Bisse Tsandra at Conthey). The cost of installing piping and hoses, however, and the technical restrictions resulting from topography have meant that traditional *bisse* irrigation is still maintained in many Valaisan communes (e.g. Ausserberg, Mund, Visperterminen).

Regulation and Protection of the Cultural Landscape through the *Bisses*

Development has been so extreme in some communes (e.g. Zermatt) that commercial agriculture has been abandoned, along with the principal *bisse* channel. There are many implications for the landscape resulting from *bisse* abandonment. First, hydrophilic plant species growing next to the *bisse* tend to die off (e.g. in the Sarmona section of the Grand Bisse de Lens). Second, slope hazards can increase as land is destabilized by unmanaged water supplies (e.g. landslides have occurred since *bisse* abandonment on the Mayens de Riddes). Third, remaining agricultural land is often poorly managed or abandoned (e.g. many meadows on the Lens plateau are poorly maintained), increasing the fire hazard. Finally, these losses reflect a loss in patrimony and heritage which are fundamental to the cultural landscape (Schüle, 1995; Schwery, 1995). The negative impacts of *bisse* abandonment on local cultural landscapes have been recognized by all levels of Swiss government, federal, cantonal and communal,

since this threatens the tourist industry which is now the major source of revenue in the Valais (Office de Statistique du Canton Valais, 1997).

The major incentive for promoting traditional agricultural practices arises from the desire to reduce the evident disparity between winter and summer incomes in many Valaisan communes (Hebling, 1995, pers. comm.). Many communes developed around winter tourism have been hit in recent years by poor snow conditions (Brown, 1996). The increasing uncertainty attached to the possibility of regional climate change have increased this concern (Beniston, 1994). The summer industry is reliant on maintaining the bucolic rural idyll, the 'chocolate box' image of the Alps. This image can only be supported by promoting traditional agricultural practices, many of which have long since been economically unviable. Integral to this is the use of traditional irrigation practices. In the Simplon region (Simplon Dorf) of Valais, it has been shown that it is neither desirable nor practicable to change from traditional meadow surface irrigation to widespread sprinkler irrigation because of ecological, economic and nature conservation reasons (Meurer & Müller, 1987). There is little benefit to primary production resulting from the introduction of spray irrigation and, as explained earlier, biodiversity is improved by the use of traditional methods. The costs of expanding *réseau d'irrigation* to isolated areas of the commune are also inhibiting.

In general, within the mountain environment, there has been a co-ordinated attempt to conserve traditional agriculture. This is principally directed by the Office Federal d'Agriculture and the Département de l'Environnement et l'Aménagement du Territoire (DEAT), both of which acknowledge the important role of *bisses* in this process. The next section discusses the measures, both direct and indirect, taken by these departments to protect and enhance this resource.

Governmental Actions to Preserve the Traditional Rural Landscape and *Bisses*

A decree by the DEAT regarding the political motives behind *l'aménagement du territoire* was made in October 1992. The main objectives that had influence on the *bisses* were: to safeguard sites and cultural objects of value; to reinforce extensive tourism and safeguard and evaluate existing and new sites of value, historic monuments, and natural objects that enhance the cultural and natural landscape; and to respect the diversity of the structural elements of the natural and cultural landscape. These measures were introduced to mark the 700th anniversary of the Swiss Confederation. The objectives of the financial aid were as follows:

- to protect, preserve, maintain or reconstitute the traditional rural landscape;
- to maintain and encourage traditional modes of exploitation that are adapted to the local conditions;
- to protect, preserve, maintain, renovate or reconstruct buildings or historic routes or other elements of the traditional rural landscape; and
- to provide information on the necessity to safeguard and maintain the landscape.

As a result of these initiatives, a basic study of the *bisses*, the *Fiche de Coordination F.7, "Bisses"* was passed into the category of "*mesure arrêtée*" (fixed measures) by a decision of the *Conseil d'Etat* on 9 December 1992 and incorporated into the

cantonal *Plan Directeur* (Schwery, 1995). This study evaluated the actual condition of existing *bisses*, assessed their contemporary role and importance and identified measures to be taken to conserve and restore this resource. The principles established to safeguard the *bisses* are: to classify all *bisses* larger than 1000 m via an inventory; to maintain the *bisses* in an open condition; to promote the maintenance and construction of *bisses* using traditional methods and materials; in cases of abandonment, to replace/maintain *bisses* to a level of local importance (see below); and to encourage the conservation and restoration of *bisses*. These principles are taken into account when adapting the *Plans d’Affection de Zones*. All infrastructure and zoning must be identified within this strategic communal plan.

The first phase of this initiative was to collate a *bisse* inventory based on a previous study made in the Haut Valais by Rauchenstein (1908), existing literature, site visits, interviews with communes and the Cantonal *Service des Améliorations Foncières* (SAF) (Aufderreggen & Werlen, 1993). The results of the inventory are illustrated on local government-controlled 1:25 000 maps. The inventory reports and evaluates the characteristics of each *bisse* and the external value of the *bisse*. The external value refers to things external to the actual channel and the date of construction, for example the distribution method, attachment to a *réseau d’irrigation* and the existence of pathways alongside the *bisse*.

After appraisal of characteristic and external values, a *bisse* is classified by its historical, agricultural, tourist and landscape value. These values are then placed in an evaluation matrix to determine their importance. There are 44 *bisses* of cantonal importance (e.g. Bisse d’Ayent, Nîwarch at Ausserberg) (Figure 6), 51 of regional importance (e.g. Bisse d’Ayent, Bisse Grône), 83 of local importance (e.g. Bisse de Patier, Bisse Tsa-Cretta) and 12 not evaluated (Aufderreggen & Werlen, 1993).

The second phase of the inventory project was to analyse the results and propose measures for the conservation and restoration of *bisses*. The *bisses* fall under a number of different legislative processes, which protect and/or promote the agricultural, patrimonial, cultural, natural, landscape and tourist value:

- *Agricultural legislation*: *bisses* are considered part of the *réseau d’irrigation* and as such fall under cantonal law 2/2/1961 regarding SAF and other measures in favour of the agricultural economy;
- *Law on the Aménagement du Territoire (LAT)*: *bisses* are listed as cultural and landscape monuments of great value that are essential elements of the cultural patrimony under Article 17 of the federal law on l’*Aménagement du Territoire* (22/6/1979). According to this law, *bisses* must be protected in the communal *Plan d’Affection*;
- *Tourism legislation*: *bisses* are considered important to the tourist infrastructure. They must be managed and conserved in the sense of Article 2 of the cantonal law (23/1/1987) concerning the application of LAT;
- *Law on the protection of the environment (LPNPS)*: *bisses* are sites evocative of the past considered worthy of protection. The cantons, according to the federal constitution, are responsible for the protection of the environment and landscape. *Bisses* are also protected under the federal law for the protection of the natural environment and landscape and the conservation of objects worthy of protection (Article 13 1/7/1966). This amounts to subsidies of 35% of the costs;



Figure 6. The *Croix* section of the Bisse d'Ayent (D.S. Crook). The Bisse d'Ayent at the *Croix* tunnel had the old wooden suspended section rebuilt in 1991, incorporating abandoned stanchions dated 1802, 1810 and 1814 from the original suspended section. This was reconstructed for heritage and tourist reasons by the commune of Ayent as the *bisse* is classified as Cantonally Important.

- *Footpath legislation (LCRP)*: under the application law (27/1/1988) of the federal law (4/10/1985) on footpaths for pedestrians and rights of way footpaths are subdivided into principal and secondary networks (Article 3). The criteria for these are comprehensive, with length being one important variable. Many of the *bisses* fit into these criteria;
- *Legislation on water courses (LEP)*: open *bisses* are considered as water courses under Article 17 LAT or as fishing waters in the sense of Article 2 of the federal law on fishing (14/12/1973). The latter law is peculiar, since the *bisses* in general only remain open for three or four months a year and therefore do not constitute a suitable environment for fish.

Thus, financial aid for regenerating *bisses* is given to safeguard the management of the traditional rural landscape. This aid can represent 50-80% of the costs incurred by local irrigation associations (*consortages*) (Michelet, 1995). The major period of federal and cantonal investment in *bisses* (SFr. 11 000 000) occurred between 1894 and 1929 (Departement de l'Intérieur). A *bisse* from each of the three categories (i.e. of cantonal, regional and local importance) competing for funds at the same time would receive subsidies in a rising order of priority (Michelet, 1994, pers. comm.).

Many *bisses* have also been included in the Inventory of Historical Paths (*Inventaire de Vieux Sentiers*, IVS, in preparation) because of their age (e.g. Niwarch 1381, Grand Bisse de Lens 1448-50). The Valais canton, in order to

conserve and maintain the *bisses*, has included them in the general long-term planning documents (*Richtpläne*). Those *bisses* that fall into this category are favourably placed to benefit from any subsidies, thus easing any financial concerns resulting from maintenance costs (Schwery, 1995).

Appraising the Success of Government Strategies

The major non-governmental organization involved in irrigation is the *consortage*. *Consortages* were originally constituted from a cartel of founding members. They remain the key organization in the governance and organization of *bisses*, where there is commercial interest in *bisses*. Their interests, therefore, are linked strongly to encouraging a profit and promoting water resource efficiency throughout the principal *bisses*. This has meant that newer, less aesthetically pleasing materials are preferred over traditional materials to prevent infiltration losses, and enclosed channel designs are often favoured because they prevent water loss from evaporation. Both preferences have a detrimental impact on the cultural and physical landscape (e.g. the entire Bisse Tsandra flows underground). The relatively recent attempts to encourage the use of traditional materials and methods in place of modern technology have, in a few isolated cases, resulted in conflict between the *consortage* and other interested ecological and tourist agencies. For example, on the Sarmona section of the Grand Bisse de Lens, ecologists and tourist managers have contested the *consortage's* desire to use concrete channels, because this will threaten the rare flora which is dependent on infiltration losses from the *bisse*, and is aesthetically less pleasing (Crook, 1997). It is evident that there is a need for the prudent administration of government subsidies and grants so that those *bisse consortages* with commercial agricultural interests are able to maintain a competitive edge in local and regional markets. To do this, farmers must maintain economies of scale and prudently manage resources for households to maintain economically sustainable livelihoods.

Communal tourist boards, however, are increasingly utilizing the potential of *bisses* in promoting the area to summer visitors. In particular, *bisses* inspection paths (*banquettes*) have gentle gradients which provide good routes in often spectacular scenery (Figure 7). Of the 165 agriculturally active *bisses* identified in the cantonal *bisse* inventory, 72 (44%) are utilized for tourism and 25 abandoned *bisses* have potential tourist functions (Figure 8). The cantonal SAF, however, will not regenerate a *bisse* solely for the purpose of tourism (Michelet, 1995). There must be primary (i.e. agriculture) or secondary (e.g. HEP) objectives before the cantonal SAF will make a financial contribution. The offshoots from this intervention, however, may have benefits for the tourist industry and contributions solely for tourism are available from the canton and private industry. The regeneration and recharging (putting water back into a *bisse*) of abandoned or moribund *bisses* thus becomes important.

A number of *bisses* are now features of thematic walks, designed by communes and private investors, which often have accompanying maps or publications, for example the *chemin de l'Adret*, *sentier du Grand Bisse* at Vercorin and the Bisse de Trient *sentier thématique*. The *chemin de l'Adret* is an inter-communal initiative which explores features of the traditional landscape including *bisses* and traditional distribution methods. The *sentier du Grand Bisse* at Vercorin uses the *bisse* as a focus to explore traditional land husbandry and its



Figure 7. The Grand Bisse de Lens (D.S. Crook).

impact on the natural landscape in and around Vercorin. The Bisse de Trient *sentier thématique* was inaugurated in September 1995 as part of the international *Espace Mont Blanc* initiative developed by the regional councils surrounding the Mont Blanc Massif in Switzerland, France and Italy. This was one of three projects to safeguard the natural mountain environment and landscape, whilst promoting sustainable socio-economic development in the region of Montagne de Balme (Schwery, 1995, pers. comm.). This is a marked shift in emphasis from national to regional agri-environmental initiatives which follow both cultural and regional boundaries as opposed to national boundaries.

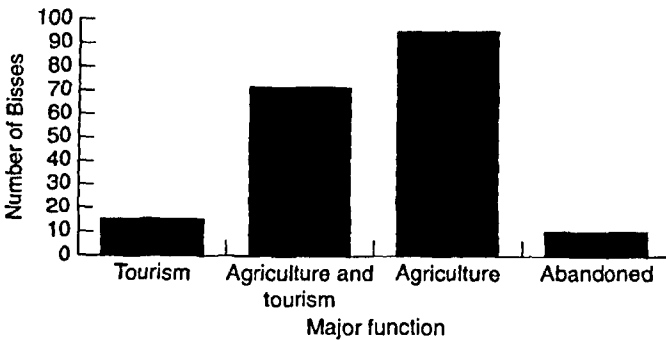


Figure 8. The major function of *bisses* included in the 1993 *bisse* inventory (after Aufderegg & Werlen, 1993).

Two major *bisse* regeneration schemes are the Grand Bisse de Vex and the Riddes section of the Bisse de Saxon. Both projects are principally concerned with promoting tourism, although the underlying importance to agriculture is not ignored. Each project acknowledges the need for water to irrigate gardens or small agricultural units and to provide an anti-incendiary emergency water supply. This latter function was illustrated by the use of water from the Bisse de Ricard to extinguish the Flange forest fire in April 1996 (Nouvelliste, 1996).

The Future Role of Bisses and their Importance to the Landscape

The *bisses* are undeniably crucial to the Valaisan landscape, both in terms of their historical importance and contemporary significance. The *bisses* were co-evolutionary, both shaping and being shaped by the overall trajectory of the rural economy. The current role of the *bisses* must be understood not simply in terms of their agricultural importance. Indeed, irrigation needs to be seen as a multi-functional resource that not only supports the agricultural system but also has other benefits to the cultural and physical environment. The continuity and persistence of the *bisses* is, in many places, reliant on following opportunities offered by alternative livelihood strategies, such as development for tourism or slope management. A *bisse* will survive economically only where it provides real livelihood opportunities either solely for agriculture or integrated into conserving tourist landscapes. Thus, *bisse* irrigators have adapted their irrigation to suit innovation in other parts of the livelihood system. Only by maintaining this dynamic will the system survive. As such it is possible that the landscape will continue to evolve in line with these changes.

Acknowledgements

D.S. Crook acknowledges a University of Huddersfield Research Studentship and a grant from the Dudley Stamp Memorial Fund. The help of numerous Valaisan farmers and officials was invaluable. Thanks also to Dr. C.O. Hunt for his helpful comments on an earlier draft of this paper and to Steve Pratt and Sally Barker for cartographic and IT assistance. The authors would also like to thank two anonymous referees for their comments on an earlier draft of this paper.

Notes

1. Vertically controlled agro-pastoral systems are those which reflect the agricultural land uses and practices found at different altitudes. This is reflected in the local and regional patterns of transhumance. Irrigation requirement and the timing of irrigation will also be determined by these different altitudinal zones.
2. *Impartible partibility* occurs when the property is divided between the heirs (partibility) but in the interests of efficient management or as a requirement of a will, remains undivided in practice.

References

- Abegg, B. & Froesch, R. (1994) Climate change and winter tourism, in: Beniston, M. (Ed.) *Mountain Environments in Changing Climates*, pp. 328-340 (London, Routledge).

- Aufderegg, J. & Werlen, C. (1993) *Rapport bisses/suonens*, Service de l'Environnement et l'Aménagement du Territoire (Sion, Canton du Valais).
- Barker, G. (Ed.) (1996) *Farming the Desert, The UNESCO Libyan Valleys Archaeological Survey, Volume One: Synthesis* (Paris, UNESCO).
- Beaumont, P. (1993) *Drylands: environmental management and development* (London, Routledge).
- Beauverd, G. (1962) Le paysage alpestre et son interprétation botanique, *Bulletin du Murithienne*, 79, pp. 76–92.
- Beniston, M. (1994) Climate scenarios for mountain regions: an overview of possible approaches, in: Beniston, M. (Ed.) *Mountain Environments in Changing Climates*, pp. 136–153 (London, Routledge).
- Bignal, E.M. & McCracken, D.I. (1992) *Prospects for nature conservation in European pastoral farming systems: a discussion document* (Peterborough, Joint Nature Conservation Committee).
- Bowen, S. (1995) Bringing the Inca canals back to life, *People and the Planet*, 5, pp. 18–19.
- Brown, P. (1996) Meltdown, *Guardian Weekend Supplement*, 6 July.
- Cosinschi, M. (1994) *Le Valais: Cartoscopie d'un espace régional* (Lausanne, Éditions Payot).
- Critchley, W.R.S., Reij, C. & Sez nec, A. (1992) *Water Harvesting for Plant Production. Part II: case-studies and conclusions for Sub-Saharan Africa*, World Bank Technical Paper 157 (Washington, D.C., World Bank).
- Crook, D.S. (1997) *Sustainable Mountain Irrigation? The Bisses of the Valais, Switzerland, a Holistic Appraisal*, Unpublished Ph.D. thesis, University of Huddersfield.
- Departement de l'Intérieur (1929) *Message Concernant la Loi sur l'Amélioration des Moyens d'Irrigation dans le Canton du Valais*, CSAF 10/5/1929 (Sion, Departement de l'Intérieur).
- Dubuis, P. (1995) Exposé introductif: bisse et conjoncture économique le cas du Valais aux XIVe et XVe siècles, *Annales Valaisannes*, 70, pp. 39–46.
- Evenari, M., Shanan, L. & Tadmor, N.H. (1982) *The Negev: the challenge of a desert*, 2nd edn (Cambridge, MA, Harvard University Press).
- Geertz, C. (1972) The wet and dry: traditional irrigation in Bali and Morocco, *Human Ecology*, 1, pp. 23–39.
- Gerbore, E.E. (1995) Les Rus de la Vallée d'Aoste au Moyen Age, *Annales Valaisannes*, 70, pp. 241–262.
- Gilbertson, D.D. (1986) Runoff (floodwater) farming and rural water supply in arid lands, *Applied Geography*, 6, pp. 5–12.
- Grove, A.T. & Grove, J.M. (1990) Traditional montane irrigation systems in modern Europe: an example from Valais, Switzerland, *Agriculture, Ecosystems and Environment*, 33, pp. 181–186.
- Haagsma, B. (1995) Traditional water management and state intervention: the case of Santo Antao, Cape Verde, *Mountain Research & Development*, 15(1), pp. 39–56.
- Jones, A.M. (1987) Kin relations in a French alpine community: a preliminary investigation, *Sociologia Ruralis*, XXVII, pp. 304–322.
- Liniger, M. (1980) Bisses et autres raz des Alpes Occidentales, *Les Alpes*, 56, pp. 42–44.
- Loup, J. (1965) *Pasteurs et Agriculteurs Valaisans: contribution à l'étude des problèmes montagnards* (Grenoble, Imprimerie Allier).
- Mariétan, I. (1948) *Les Bisses: La lutte pour l'eau en Valais* (Neuchatel, Editions du Griffon).
- McCracken, D.I., Stillman, R.A., Bignal, E.M., Baldock, D. & Beaufoy, G. (1994) Extensive farmland in Europe: examples of sustainable landscapes of high nature conservation value, in: Dover J.W. (Ed.) *Fragmentation in Agricultural Landscapes*, Proceedings of the Third Annual International Association of Landscape Ecology IALE (UK) Conference, Myerscough College, Preston, pp. 38–45.
- Meurer, M. & Müller, H.N. (1987) Ökologische auswirkungen und schutzwürdigkeit der traditionellen weisenbewässerung im Simplon-Gebiet (Wallis), *Verhandlungen der Gesellschaft für Ökologie*, Band XV, pp. 91–104.
- Michelet, P. (1995) Les techniques d'entretien des bisses, *Annales Valaisannes*, 70, pp. 163–174.
- Ministry of Agriculture, Food and Fisheries (1998) *Action for Jobs and the Environment in the Countryside: Cunningham announces initiatives*, MAFF News Release, 4 March.
- Netting, R.M.C. (1972) Of men and meadows: strategies of alpine land use, *Anthropological Quarterly*, 45, pp. 132–144.
- Nouvelliste* (1996) *Feu de Flange Nouvelliste*, 23 April.
- Office Federal de l'Agriculture (1975) *Commune of Salins, Cadastre de la production agricole* (Sion, Departement Federal de l'Economie Publique).
- Office Federal de l'Agriculture (1979) *Commune of Chippis, Cadastre de la production agricole* (Sion, Departement Federal de l'Economie Publique).
- Office de Statistique de Canton Valais (1997) *Information Statistiques* (Rue des Remparts 12, 1950 Sion, Office de Statistique du Canton Valais)
- Perraudin Kalbermatter, R. & Marin, H. (1995) *Vercorin: Les sentiers du Grand Bisse* (Sierre, Calligraphy).

- Rauchenstein, F. (1908) *Les Bisses du Canton Valais* (Sion, Department de l'Intérieur).
- Saleh, M.A.E. (1997) Toward a sustainable land management of vernacular landscape in the highlands of SW Saudi Arabia: indigenous and statutory experiences, *Landscape Research*, 22(3), pp. 283–302.
- Sauvain, P. (1980) *Évolution socio-économique récente de la commune de Bagnes en Valais et rôle de l'agriculture à temps partiel en région de Montagne*. Thèse ETH No 6504, l'École Polytechnique Fédérale de Zurich (Zurich, Juris Druck).
- Schildtnecht, H. (1933) *Die Bewässerung im Wallis, im Lichte Moderner Bewässerungstechnik* (Bern, Beneteli).
- Schüle, R.-C. (1995) Les bisses dans les récits traditionnels, *Annales Valaisannes*, 70, pp. 341–350.
- Schwery, R. (1995) Inventaire, classement, politique, de mise en œuvre et mesures de protection des bisses en Valais, *Annales Valaisannes*, 70, pp. 175–186.
- Theurillat, J.-P. (1986) Carte de la végétation, Mörel-Hoflue (Valais, Suisse), *Bulletin du Murithienne*, 104, pp. 113–224.
- Viérin, E. (1995) La ferti-irrigation, *L'Echo des Alpes*, No. 2950, p. 10.
- Vincent, L. (1995) *Hill Irrigation: Water and Development in Mountain Agriculture* (London, Intermediate Technology Publications).
- Weinberg, D. (1972) Cutting the pie in the Swiss Alps, *Anthropological Quarterly*, 45, pp. 125–131.
- Werner, P. (1995) Les bisses et leur environnement naturel en Valais: utilité des observations de la végétation actuelle pour les reconstitutions historiques, *Annales Valaisannes*, 70, pp. 75–90.
- Wilken, G.C. (1987) *Good Farmers; traditional agricultural resource management in Mexico and Central America* (Berkeley, CA, University of California Press).
- York, U. (Ed.) (1992) *Madeira, Insight Guides* (London, Apa Publications (HK)).