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Irrigation agriculture in high mountain communities the example of Hopar villages, Pakistan

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IRRIGATION AGRICULTURE IN HIGH MOUNTAIN COMMUNITIES:
THE EXAMPLE OF HOPAR VILLAGES, PAKISTAN

By

David Aaron Otto Butz

B.A., Wilfrid Laurier University, 1984.

THESIS

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Hopar Settlement as viewed from across the Bualtar Glacier, facing NNW.
Photo: Ken Hewitt

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ABSTRACT

The interaction of humans with their geophysical environment has been a popular theme in cultural geography. Mountain regions have been common sites for such studies. Pakistan's Karakoram Ranges, however, have received relatively little attention. Those studies which have been undertaken in the Karakoram are too general to yield credible descriptions or explanations. In addition, many approach human/environment relationships from a superficial environmentalist perspective. Recent efforts by agricultural development agencies to improve conditions in Northern Pakistan have created a sudden interest in the way traditional high-mountain farming communities interact with their geophysical surroundings. Unfortunately, development agencies concentrate on direct causal relationships at the plant or crop biology level, often without considering the whole community as a closely knit system. The result may be harmful development initiatives.

This paper examines one traditional agricultural settlement in the Central Karakoram- Hopar- and attempts to provide a thorough and credible description of its human/environment interactions. Information is presented in terms of the salient characterizing feature of Hopar's social and cultural environment- meltwater irrigation. The resulting description fills a gap in the cultural geographical literature of mountain areas, and offers specific information which may help development agencies to formulate more comprehensive recommendations.

Approximately 4000 inhabitants occupy the five distinct villages which form the community of Hopar. These villages and their lands are scattered throughout a broad depression between the lateral moraines of the Bualtar Glacier and steep valley walls. Sedentary agriculture between 2500 and 3000 metres is complemented by pastoral herding upslope to form a fundamentally subsistence economy. Villagers have overcome the environmental challenges of rough and unstable terrain, low precipitation, short growing season and relatively distant and low quality water supply. Much of this accomplishment is due to the painstaking development of an irrigation network of over 200 kilometres of channels which direct water from cirque shaped snow and ice catchments located in a moist environment above 3600 metres to the naturally arid, but warmer valley floor. This intricate meltwater irrigation system relates closely to many aspects of Hopar's agricultural and social existence, including crop type and distribution, land tenure, inheritance, sociopolitical structure and affiliation, division of labour, distribution of wealth, and economic relations with the outside. Successful development must recognize the importance of the traditional irrigation system both to stable exploitation of the community's geophysical habitat, and to its social identity and cohesion.

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CHAPTER ONE

IRRIGATED AGRICULTURE IN HOPAR: INTRODUCTION AND RELEVANT LITERATURE

1.1 EXECUTIVE SUMMARY

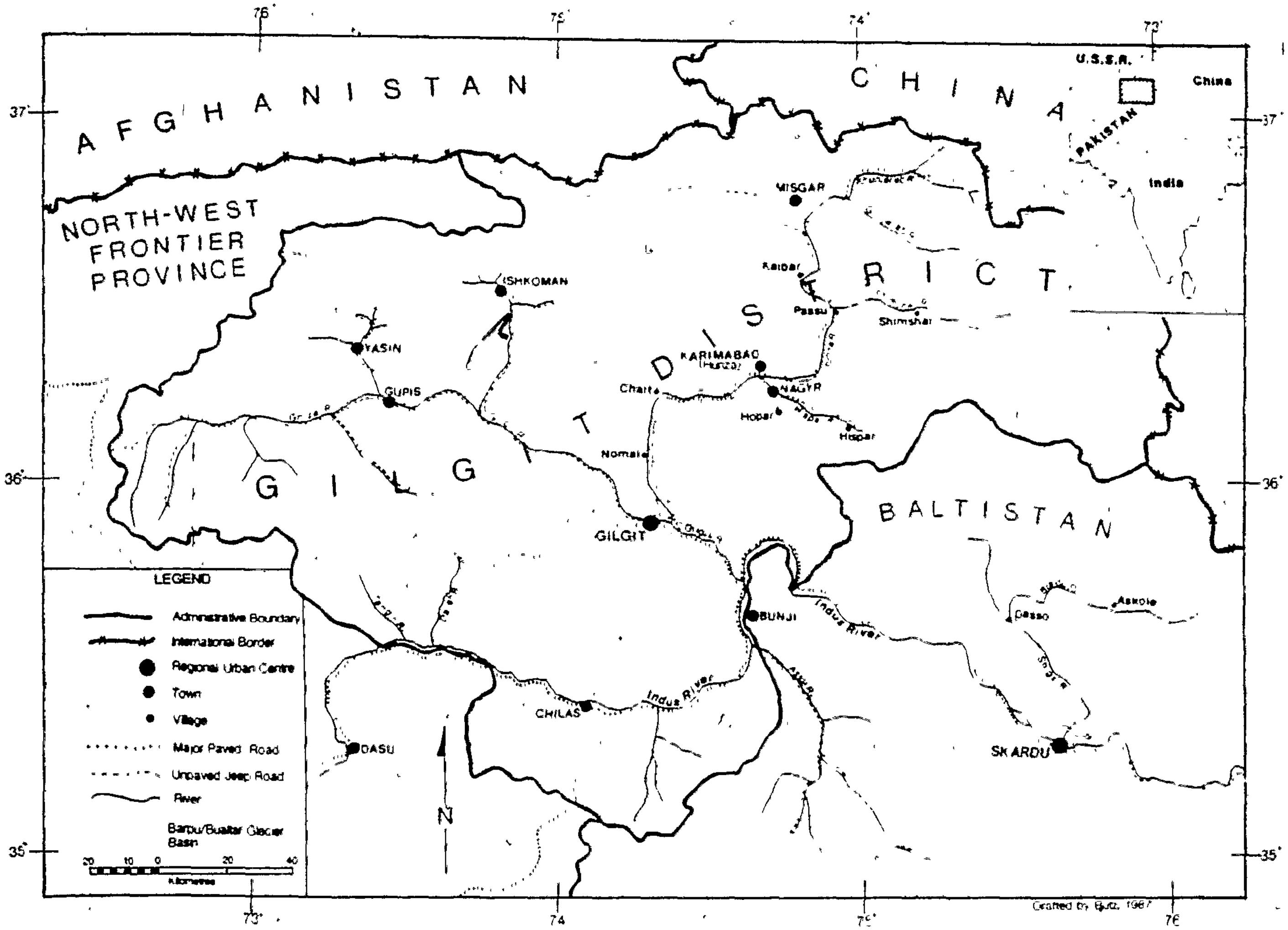
Agricultural production is constrained by a large variety of geophysical and human factors. Often one or two of these are so significant that the effort to ameliorate them characterizes the agricultural system. Such constraints decisively influence the use and usefulness of all other components of the natural and human agricultural environment. Growing season, for example, constrains and influences the agriculture of Alberta's Peace River District. Similarly, farming in Japan is decisively shaped by the shortage of arable land. Farming communities in much of Europe and North America face overwhelming economic limitations, such as limited demand.

Describing and understanding key constraining factors provides a means to characterize and explain a total agricultural system. It enables the arrangement of diverse agricultural components in a meaningful way, as they relate to the key constraint, or constraints. The resulting relationship is likely to reflect the way farmers themselves perceive their system. This contrasts with many agronomic and economic models, which deal in terms far removed from the perceptions of the agricultural community. This is particularly true as models relate, or fail to relate, to traditional societies.

The controlling constraint in many high mountain valleys of the Central Karakoram, and throughout much of the Himalaya, is moisture. Hopar, the study area for the present report, is an excellent example. The areal extent of temperate crop cultivation is limited to an upper threshold of 3000 m by altitudinal temperature gradients, and by increasingly rugged terrain. However, below this threshold rain-fed agriculture is inhibited by low precipitation and high evaporation. They combine to produce a negative moisture balance for the period of peak water need. Only by utilizing meltwater from snow accumulation in the more humid environment above 3600 m is agriculture possible. The characteristics of a snowmelt water supply, and the process of transporting it to the cultivated areas, and distributing it among fields relates to all physical and cultural components of agricultural production. Indeed, the irrigation system which has evolved is the most prevalent feature of the physical agricultural landscape. It is also closely related to Hopar's social structure. In short, irrigation and water distribution in Hopar touches upon all aspects of agricultural production, and unites many diverse components of the agricultural community.

Hopar is a community of five agricultural villages located at about 36° N 75°E in the Central Karakoram region of Pakistan's Northern Areas (see Figures 1.1a through 1.1d). It is the highest permanent settlement in the former feudal kingdom of Nagyr. Today the 73 villages of Nagyr are a small and remote portion of Gilgit Administrative District.

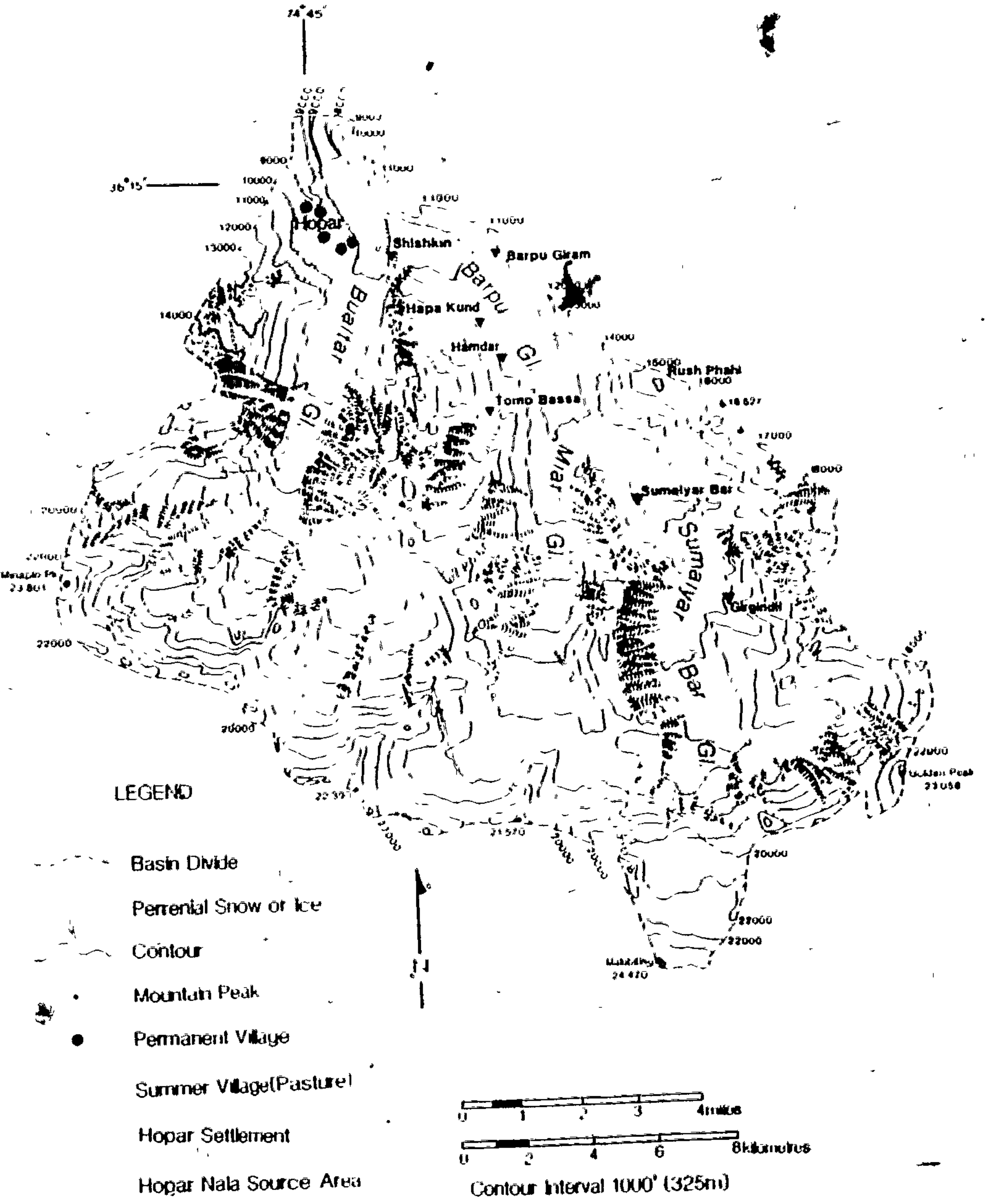
Figure 1.1a GILGIT DISTRICT, NORTHERN PAKISTAN



BARPU-BUALTAR GLACIER BASIN

Karakoram Himalaya

Figure 1.1b



SOURCE-Mott, 1950-Redrafted by P.Carnochan & D.Butz, 1987

Figure 1.1c HOPAR SETTLEMENT: CHANNELS & VILLAGES

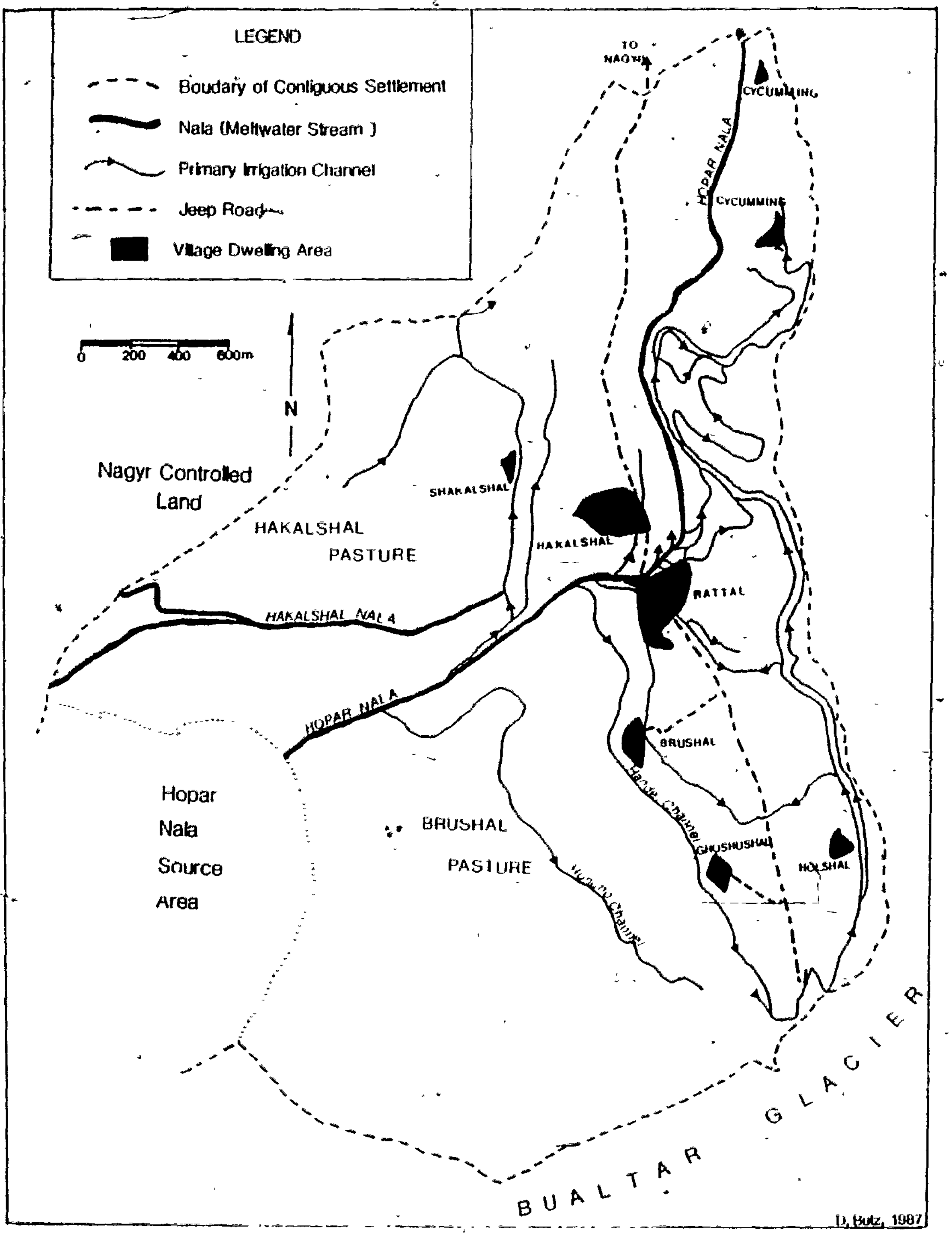
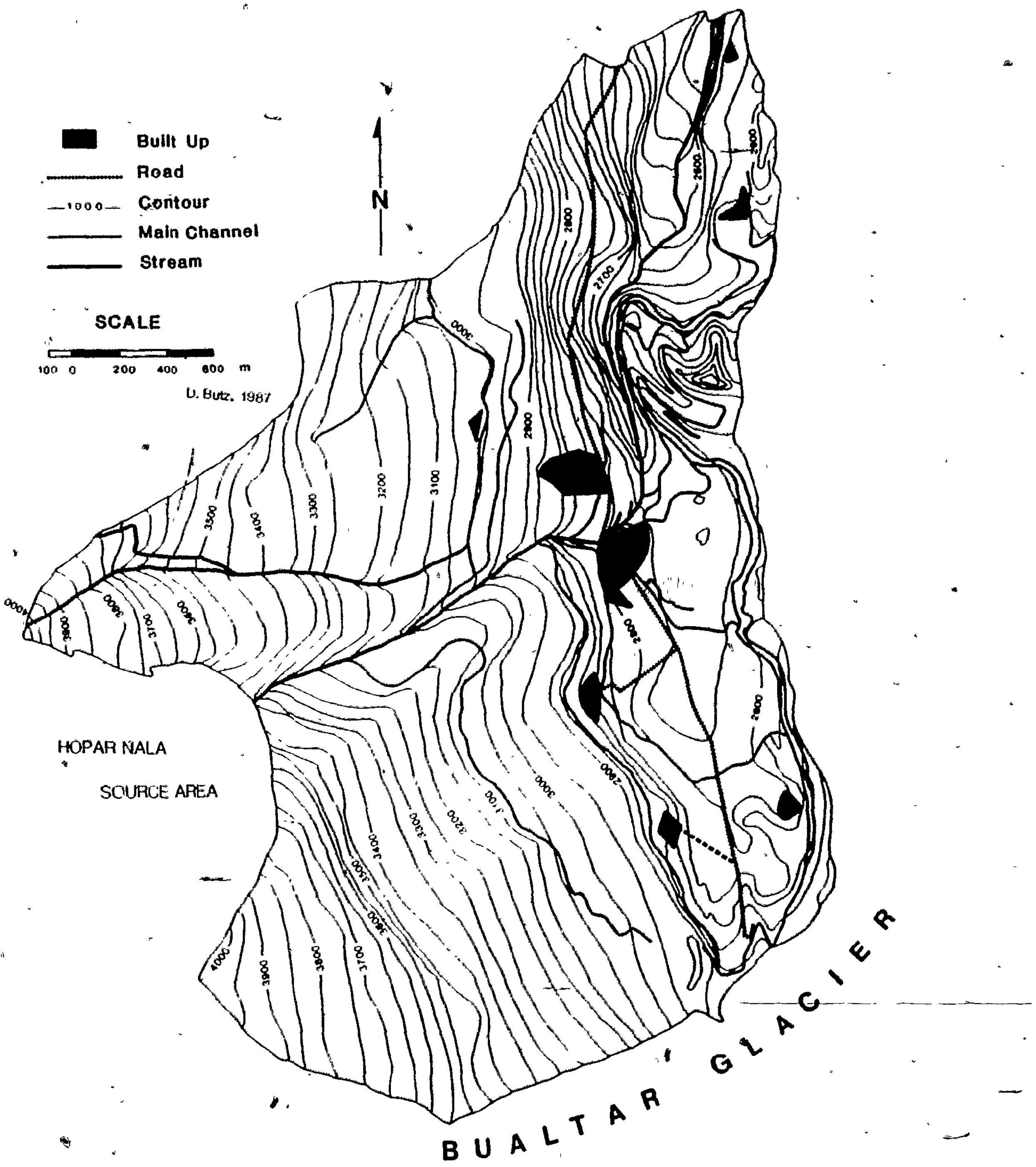


Table 1.1d **HOPAR SETTLEMENT**



Approximately 4000 villagers inhabit the Hopar settlement. It occupies a broad depression – possibly an ancient kame terrace – between lateral moraines of the Bualtar Glacier, and steep mountain slopes. The landscape of the valley is naturally arid and parched, however centuries of effort have transformed it into a verdant agricultural oasis. Over 300 km of irrigation channels link meltwater from snowfall above 3600 m to 280 hectares of cultivated terrace and 160 hectares of sloping alfalfa fields between 2500 and 3600 m. High summer pasture on mountain slopes rising from the Bualtar and Barpu Glaciers, and above cultivated terraces support some 1200 domestic animals. This combination of sedentary agriculture and pastoral herding constitutes the traditional subsistence economy of Hopar.

Subsistence is supplemented in most households by government subsidized wheat flour. In addition, many men earn cash as porters, or from seasonal employment downcountry. Thus, the people of Hopar survive by combining traditional agricultural endeavour with participation in the regional cash economy.

Meltwater irrigation characterizes Hopar's cultural ecology. Hoparis sustain intensive agriculture by transforming irregular meltwater runoff into a constant irrigation supply, and through crop complexes which interact with that supply to suit the topographic, climatic and social characteristics of the valley. Recently modernization and access to outside influence have confounded the effectiveness of Hopar's agricultural system. Thoughtful development, such as that undertaken by the Aga Khan Rural Support Program can help to reverse this trend.

The underscored words in the above thesis are keywords which provide structure to the body of the report. Each represents a component of Hopar's agricultural water use that deserves detailed attention. Due to the interactive nature of farming systems these components are not dealt with in isolation. Rather they appear and reappear in various combinations. An effort is made, however, to make particular combinations predominant in each section, and to shift the focus in a logical sequence. The sequence begins by exploring the physical and cultural parameters of the community. Next water supply, water distribution, and crop/water interaction are investigated. In the final chapter information is synthesized into an overview of Hopar's cultural ecology. Recommendations to development agencies stem from this synthesis.

Chapter Two describes the important elements of Hopar's climate and physical geography. The third chapter deals with diverse components of the community's society and culture. They provide an overview of the conditions within which irrigated agriculture occurs as well as an introduction to the array of circumstances that relate to water supply and use in high mountains. Climate Section 2.2 especially reinforces the perception that high Karakoram agriculture depends on snowmelt irrigation. Unlike subsequent chapters, key factors are examined in relative isolation. Nevertheless, the background developed here is essential to subsequent interpretation and analysis.

The fourth chapter deals specifically with the flow of meltwater from its origins above 3600 m to individual terraces within Hopar. The chapter begins with a detailed description of snow accumulation and melt conditions. Sections 4.3 to 4.5 follow the efforts of irrigators to distribute water effectively among all fields. Special attention is given to discussing how farmers manipulate water at three distinct levels, to increase consistency and control as it descends to Hopar villages.

Interaction among water, crops, and growing conditions are examined in Chapter Five. It begins with an overview of crops that are grown in Hopar, and investigates how their presence reflects the climatic, geologic, and social condition of the settlement. Specific crops are arranged spatially to enhance the utility, or diminish the harm, of valley wind systems, radiation, temperature, slope, aspect, elevation, etc. Furthermore, particular cultivation and crop-watering techniques interact with spatial distribution and crop growth condition to enhance productivity. Sections 5.3 to 5.5 explore these relationships among irrigation, crop pattern, and growing conditions.

The final chapter attempts to synthesize diverse components of irrigated agriculture in Hopar. Key concepts are discussed in Chapters Two through Five, and numerous relationships among them are identified. Chapter Six unites them into a portrayal of Hopar as a community which is at once sustained and constrained by traditional meltwater irrigation.

Primary information was collected in Hopar for a short period in June 1985, and from May to July 1986. Logistical expenses during the field seasons were covered in part by the Snow and Ice Hydrology Project, a joint Canada/Pakistan snowmelt hydrology research project for Pakistan's portion of the Upper Indus Basin. Much of the data collected for this study also help further the goals of the Snow and Ice Hydrology Project. These goals, and the rationale for the project are outlined in Appendix Ia. The activities undertaken by project members during the summer of 1986 are summarized in Appendix Ib. Appendix II describes the methodology of field investigation.

1.2 RELEVANT LITERATURE

1.2.1 Introduction - Mountain regions are the subject of a multitude of scholarly and popular literature. Much of this is geographical. In particular geographers contribute varied and detailed studies of physical forms and processes, including geomorphology, hydrology, glaciology, meteorology, and climatology. All mountain regions are represented in this work. Peoples who occupy mountain areas have received less attention from geographers. Still, geographical publications, including mountain ecosystem fragility studies, development research, and traditional geographical area studies do provide some understanding of the interaction between mountain communities and their natural environment. This literature ranges between two poles of perception. At one end is environment as the sole determinant of culture. Geographical area studies tend to present a very environmentalist outlook. The other pole perceives human practices as the major determinant of negative environmental change. Ecosystem fragility studies commonly take this perspective. Most studies lie close to one of these poles. This is an indication that geography continues to be limited by an enduring force in mountain research – environmental determinism, or overreacts in the other direction. Only agricultural development research studies present a balanced representation of interaction between human activity and environment. Unfortunately, they focus narrowly on relationships between crops and individual agricultural inputs, rather than overall understanding of the farming system.

Geographical literature, particularly development reports, are important sources of observations, measurements, and field investigation methodology for this paper. However, they offer no conceptual basis for examining the relationship between agricultural communities and the geophysical environment. That basis comes from literature in cultural ecology. The remainder of this chapter deals specifically with cultural ecological research.

Appendix III summarizes important features of high mountain geographical literature under the headings Traditional Geographical Area Studies, Mountain Ecosystem Fragility Studies and Agricultural Development. The strengths and weaknesses of these categories are outlined, and characteristic examples are provided.

1.2.2 Cultural Ecology– Balanced and thorough investigation of human/mountain

environment interaction appear throughout publications in cultural ecology. Cultural ecology is described by Orlove (1979) as "the subfield of anthropology that examines the interaction between human populations and other features of their ecosystems". Wagner and Mikesell (1962,p.20) expand by saying that it "discovers, describes, and analyses actual processes" which link culture to the natural environment". Steward (1976,p.42) speaks of cultural ecology as a method of investigation; "it is a methodological tool for ascertaining how the adaption of culture to its environment may entail certain changes".

Cultural ecology's main objective is to identify characterizing features of human/environment interaction given a certain set of conditions. Steward (1976,p.37) states "cultural ecology pays primary attention to those features which empirical analysis shows to be most closely involved in the utilization of environment in culturally prescribed ways". Characterization may be limited to specific features of an individual community, or generalized to include all communities sharing similar adaptions to similar geophysical habitats. Several cultural ecologists have attempted to uncover common themes of generalization and characterization for all mountain communities.

At the time cultural ecology was evolving as a sub-discipline of anthropology, geo-ecology was developing in geography. Like cultural ecology it was developed as an approach to deal with human/environment interaction. Geo-ecologists have traditionally been attracted to mountain regions. This stems from Troll's (1939,1968,1972) work in the Himalaya and South America. True to mountain geographical studies, Troll and his early successors presented an environmentalist viewpoint which stressed reaction to natural conditions, rather than interaction. According to Allan (1984,p.196), a current geo-ecologist, "Troll and his English speaking followers reduce man to a position where the unique attribute of humans, culture, is rarely employed in any articulate discussion of the mountain environment".

While both cultural ecology and geo-ecology are aware of interaction among peoples and environment, they have developed from different perspectives. Geo-ecology was originally based on a belief that physical habitat has a direct and active determining role in the function of society. Cultural ecology evolved from social and human ecological thinking which stressed the "purely secondary and passive role" of environment (Steward,1976,p.35). Since their origins both disciplines have migrated from their respective extremes to a perception that environment has some sort of limiting, but not determining, role in cultural evolution. Still, most studies in cultural ecology deal more competently with culture than physical environment. In mountain areas at least, the influence of environment upon humans is thoroughly explored, but geoghysical processes themselves are dealt with inadequately. Geo-ecological studies, on the other hand, are comfortable and competent in their discussion of geophysical variables, sometimes at the expense of thorough research into society.

Despite minor differences in emphasis it is becoming increasingly difficult to distingush between the work of geo-ecologists and cultural ecologists. This has prompted Wagner and Mikesell (1962,p.22) to suggest that modern cultural ecology combines aspects of cultural geography and anthropology into a single approach to "problems of the habitat of cultural communities at every stage and condition". Together they present a balanced and perceptive view of human/environment interaction. The discussion below includes geo-ecology as part of cultural ecology.

Cultural ecologists discuss human/environment interaction through one dominant feature which characterizes all important relationships. It may be economic, political, historical, technological, religious and so on. Characterization in mountain areas tends to identify agricultural or pastoral features as crucial links between society and natural environment.

European alpine studies concentrate on this link in terms of economic conditions, supplementary income, tenure, inheritance, and political history (see Berthoud, 1972; Burns, 1961, 1963; Cole, 1969, 1972; Cole and Wolf, 1974; Foster, 1965; Friedl, 1972, 1974; Naroll and Naroll, 1962; Netting, 1972, 1976; Ott, 1981; Puigdefabregas and Fillat, 1986; Weinberg, 1972; Wolf, 1962, 1970). The South Tyrol has inspired excellent studies of culture's influence on ecological adaption (Cole, 1969, 1972; Cole and Wolf, 1974; Naroll and Naroll, 1962; Wolf, 1962, 1970). This literature, particularly Cole and Wolf's (1974) *The Hidden Frontier: Ecology and Ethnicity in an Alpine Valley* examines divergent ways Italian and German speaking villages have interacted with a single physical habitat throughout economic and social change. The study is an example of thorough and detailed cultural ecological research. It also soundly refutes prevailing environmentalist attitudes to mountain folk. The study is discussed in some detail below.

Both Cole and Wolf are teaching anthropologists at American universities. Between them they spent four years in the Val di Non of the Italian Tyrol studying differing ecological adaptions to change between adjacent villages. The villages, St Felix and Tret, are similar in size and share a single geophysical environment. They are five kilometres apart in the same valley. Both are currently peripheral satellites to the political economy of lowland Italy. The main difference between Tret and St Felix is ethnic identity. Residents of St Felix are all German speaking. This reflects a primarily German political history and cultural identity. All Trettners are romance language speakers. Tret has historically been governed by an Italian state, and villagers affiliate themselves with Italian culture.

Cole and Wolf compare and contrast the political, economic, cultural and agricultural history of both villages. They detail the response of each village to past stresses, and pay special attention to the period of rapid modernization since WWII. As a result of ethnic differences each village has responded differently to change. These divergent responses have resulted in remarkably different adaptions to the mountain environment. St Felix continues to be a viable homestead-oriented farming community which is supplemented by labour in the mainstream economy. Residents of Tret earn most income from labour outside of the valley. Farmland is being abandoned and fragmented rapidly. The Hidden Frontier successfully portrays ethnicity as the characterizing features in human/environment interaction in the Val di Non. The book is readable, yet remains scholarly and convincing.

Cole and Wolf do not attempt to generalize beyond their study area. Other European mountain communities have inspired attempts at modelling agro-ecological activity in the alpine zone. Most models incorporate "Alpwirtschaft" as their central theme (Burns, 1963; Cole, 1972; Netting, 1972; Wolf, 1972). Alpwirtschaft, or "mixed mountain agriculture" is based on agro-pastoral transhumance, and cooperative and communal relations among members of a village economic unit.

Numerous Andean investigations, such as those by Brush (1976, 1982), Guillet (1981, 1983), Lynch (1983), Murra (1972-Spanish), Orlove (1977) and Stadel (1986) relate ecological interaction with the use of "verticality" in high altitude regions. Verticality has some points in common with Alpwirtschaft. Orlove (1977, p.87) summarizes the verticality model as follows:

> According to Murra's model of verticality, Andean populations attempt to control the largest possible number of ecological zones at different elevations in an effort to achieve their ideal of self-sufficiency. The internal organization of these economies is based on reciprocity and redistribution: intergroup trading is peripheral or wholly lacking.

Verticality and Alpwirtschaft models were developed in Europe and South America at a time when Himalayan research was isolated and neglected. They have been applied to populations ranging in size, sophistication and location from remote peasant villages to the Inca empire. The few human-ecological studies that were undertaken in mountain regions of Asia were small-scale and specific to individual communities (Barth, 1956, 1962; Ferdinand, 1962; Troll, 1939, 1963, 1972). These did not attempt to generalize. Fischer (1985, p.109) writes of Himalayan anthropology:

> In comparison with the Andes, there is very little evidence of any clear-cut onward-and-upward trend in the historical trajectory of Himalayan anthropology. The Himalaya are too vast, culturally complicated, and until very recently, too inconsistenly and poorly researched to have developed the kinds of overarching themes and perspectives that have evolved in the Andes over several centuries...overall, accumulated anthropological knowledge in the Himalayas has been, until extremely recently, vague, uneven, and miscellaneous.

In lieu of specifically Himalayan research, scholars attempted to relate European and South American models to Asian mountain communities. They found expected similarities, but also important differences. Recognition among scholars that location specific schools of thought were being developed fostered worries of 'ecological particularism' (Rhoades and Thompson, 1974). Since the mid-seventies several comparative articles have addressed the problem of how to generalize among mountain regions (Allan, 1986; Guillet, 1983; Rhoades and Thompson, 1974). The earliest example is Rhoades and Thompson (1974). They identify two major adaptive strategies common to the

Alps, Andes, and Himalayas. The first strategy is based on a single population which exploits a series of econiches at several altitudes. Subsistence is based on production from these econiches. In the second strategy a population itself utilizes only one zone, but develops trade relations with specialized producers in other zones (Rhoades and Thompson, 1974, p. 547).

Guillet (1983) expands on Rhoades and Thompsons' thesis. He proposes that mountain adaptations have three basic elements:

1) an array of vertical production zones, each characterized by a complex interaction of variables including agricultural regime, social organization, stratification, land tenure, labour organization and level of productivity;

2) choice by the population of an overall production strategy for the exploitation of the vertical production zone available to it, a strategy that may involve specialization in one zone or, in response to a variety of constraints, the combined exploitation of several zones; and

3) a potential for change in strategy, within the constraints of the mountain environment, under the influence of endogenous and exogenous factors.

The comparative models proposed by Rhoades and Thompson, and Guillet contribute to understanding human/ecological interaction by synthesizing themes of high mountain cultural ecology. In addition they offer a starting point from which to examine and analyse human communities in any mountain setting. However, their conclusions are not completely sound, at least in the Karakoram. Villages in Hunza and Nagyr do not control a complete range of ecological zones. Hopar villagers, for example, do not normally own land below 2500 m. Nor do they trade extensively with nearby communities at lower elevations. Interaction with lowland Pakistan through bazaars in Gilgit and government subsidy, is stronger than trade with lower mountain villages. According to Allan (1986) this long distance interaction can be attributed to recently constructed jeep roads, the Karakoram Highway, and efforts by central government to access and control mountain areas. He has recently formulated a model to incorporate economic and political accessibility into our understanding of mountain human ecological relations. Allan states that "the altitudinal zonation model is no longer suitable for characterizing mountain ecosystems. Human activity is directed to new motorized transportation linked to a wider political economy and no longer dependant on altitude" (1986, p.185). This accessibility model has the advantage of being dynamic and predictive. It maintains that what happened last century in the Alps is currently occurring in the Hindukush - Himalaya. The Andean region is beginning the same process. In contrast, zonation models relate to the "anthropological present" which may range from two centuries ago in Europe to present day South America.

Comparative models establish excellent theoretical foundations for examining mountain communities. More specific insight into the myriad details of human/ecological interaction come from studies at the community level. Many researchers have devoted careers to particular locales. (Allan, 1984a, 1984b, 1985, 1986; Barth, 1956, 1962; Cole, 1972; Guillet, 1981, 1983). As a result cultural ecologists often convey a sensitivity to human subjects seldom found in geographical literature. Some scholars present information with such perception and feeling that villagers cease to be subjects, and become individuals and families. Cole and Wolf (1974) and Heliaz (1978) are examples of work which explains far more about human interaction with environment than just physical patterns and activities. Where patterns are important, they tend to be represented efficiently and effectively in diagrams (see Edelberg and Jones, 1979). The main failure of cultural ecology is its neglect of purely physical conditions and processes. Dunlap and Martin (1983, p.201) note an "entrenched habit of ignoring the physical environment". These sentiments are echoed by Rambo (1982) and Preston (1983) with regard to other disciplinary approaches to cultural ecology. Geophysical and climatic variables should be understood both as strictly natural phenomena, and as they relate to human activity, especially since most high altitude human/ecological models are based on geophysical, climatic and spatial zonation. Finally, it is worth noting that cultural ecology has neglected the Karakoram until very recently. In the past half decade Allan (1984,1985,1986), and Kreutzman (1985) have addressed that neglect, but much that has been collected is still unpublished. More research must be undertaken by more scholars if we are to obtain an ecological perspective on Karakoram mountain communities. The present study can claim to help fulfil the requirement for more Karakoram-based research in cultural ecology.

CHAPTER TWO: PHYSICAL GEOGRAPHY OF HOPAR

2.1 GEOMORPHOLOGY AND LANDSCAPE

2.1.1 Topography- Karakoram mountain ranges are characterized by deep main river valleys, with steep and unstable gully slopes. Relative relief in these valleys often exceeds 4000 m. Tributary valleys erode more than 2000 m from sharp ridges to stream beds. Plateau features are uncommon. Perennial snow and ice covers much of the area above about 3500m. Large valley glaciers and innumerable small snow and ice patches extend downslope as far as 2700m.

Current glaciation is the remnant of the last of three main periods of glacial advance which scoured the region in the past, leaving thick glacial and glacio-fluvial sediments in main valleys. Smaller deposits of sediment have accumulated in tributary valleys. Nalas (meltwater streams) continue to deposit material slowly and continuously, or in occasional major mudflows. Agriculturally, these deposits are the most important geomorphic feature of the Karakoram. They combine relatively flat terrain with arable and terraceable soil, and accessible water supply. Often sedimentary deposits are protected from major slope failure from above or below. These characteristics combine to make sedimentary landforms suitable for agricultural colonization.

Agricultural communities are most commonly situated on alluvial fans, where snowmelt tributaries meet larger streams. These form countless relatively flat wedges in an otherwise rugged landscape. Farming villages also settle in flat basins formed of ancient lake sediments. In addition, moraines and kame terraces are occasionally exploited for cultivation.

The Hopar settlements are situated on just such a kame terrace, formed when the Bualtar and Barpu glaciers, which currently lie below the Hopar settlement, were much thicker. These two large valley glaciers are fed by high altitude snow accumulations south of Hopar. They must not be confused with the small cirque-shaped accumulations of snow and ice which supply Hopar's meltwater; these lie directly southwest and upslope from the cultivated area (see Figure 1.1b). The terrace is overlain in places by moraine remnants. Village legend corresponds with the general landscape to suggest that a lake may have covered part of it in the past. Currently Hopar Nala, which supplies water to the cultivated area from a snow and ice accumulation area above 3600 m, also contributes sediment to the cultivated area.

Steep mountain slopes rise from the west side of cultivation to 4030 m. Up to 3000 m these are terraced for cropping. Above that the slopes steepen; and are used only for irrigated alfalfa pasture, grazing, and firewood collection. On the east side of the valley floor Bualtar Glacier moraines rise gradually before plunging 150–200 m to the glacier surface. These moraines are highly prone to slumping. Several main irrigation channels, and tens of hectares of cropland have been lost in the past several decades (see Figure

2.1.1).

Hopar's terraced area lies between 2500 and 3000 m in a north-south oriented depression, just south of the central Karakoram crestline. Hopar's location in the regional landscape is important in three ways. First, the trough running southeast from the Hunza River, through Nagyr, Hopar, and up the Barpu Glacier lies midway between the Greater and Lesser Karakoram. The presence of high crests on all sides situates Hopar in a major rain shadow area. Secondly, Bualtar and Barpu Glaciers provide corridors along and across which to drive domestic animals. Extensive tracts of high pasture on slopes above these glaciers allow villagers to complement agriculture with pastoral herding. Finally, since the community is the highest and most southerly in Nagyr, it is the least accessible from the Karakoram Highway, which follows the Hunza River, and links Gilgit and the plains to agricultural settlements, and finally the Chinese border, upstream.

Figure 2.1.1

HOPAR SETTLEMENT

Land Use

Surveyed by Butz, 1986

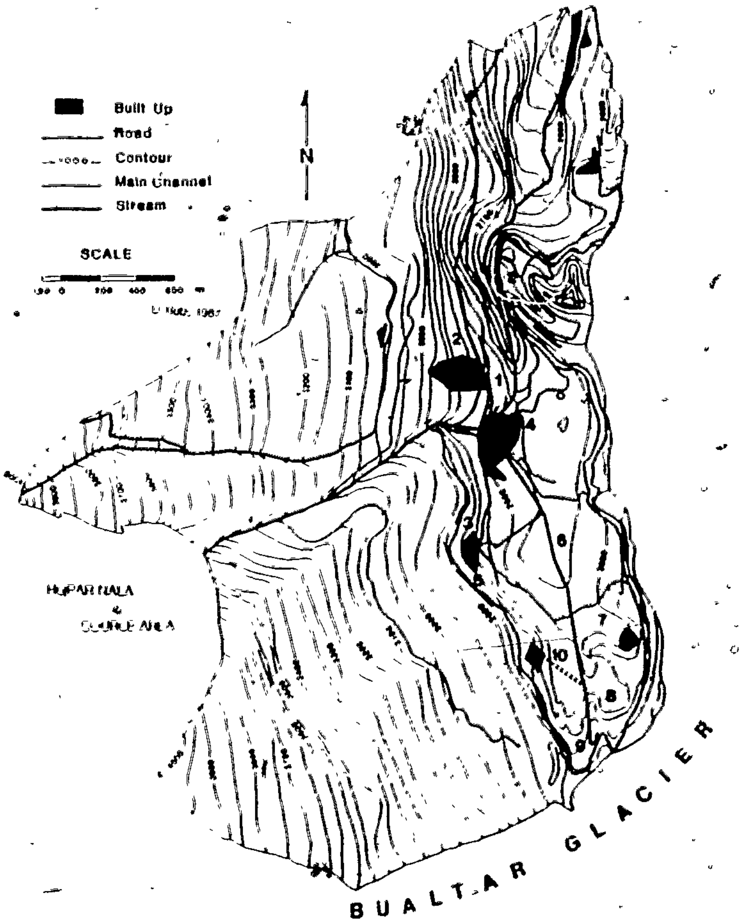
2.1.2 Soils – Most of the Karakoram has no soil cover. Surfaces without soil include rock outcrops; recently deposited alluvium, scree and moraine; water bodies and frequently flooded areas; and regions of permanent snow and ice cover (Mian in Conway, 1983, p.5). The soil cover of remaining surfaces varies greatly in quantity and quality. Nevertheless, most soils have adequate supplies of all essential agricultural nutrients except nitrogen. Whiteman (1985, p.78) attributes generally well-balanced soil composition to deposition from diverse parent material, rather than in-site breakdown of any single type of bedrock. River terraces, alluvial fans, moraines, and scree all involve breakdown of aggregate deposits.

In Hopar soil texture is primarily silty loam, loam and sandy loam. Except in isolated cases, clay percentages are low. Silty, sandy and loamy soils commonly extend to a depth of 30 to 90 cm. Below that stones and boulders prevail (Whiteman, 1985, p.26). Loam and silty loam prevail in those areas of Hopar where glacial fluvial and lake sediments form the valley floor. Sandy loam and sand soils are found toward the north end of cultivation, reflecting deposition by Hopar Nala. Like other areas of the Karakoram, Hopar soils are moderate to high in components necessary for crop growth, except for nitrogen and organic matter (See Figure 2.1.2). Nitrogen is boosted to some extent by chemical fertilizer and manure. Intensive fodder collection and grazing of terraces in winter prevents the accumulation of organic matter. Continual applications of sediment in irrigation water help to keep other nutrient levels high. Unfortunately, sediment also renders topsoil vulnerable to consolidation and compaction, which inhibits root development and increases runoff. The relationship among soil, irrigation water, and crop is explored further in Chapter Four.

Figure 2.1.2 SOIL CONSTITUENTS: HOPAR VALLEY

SAMPLE	%CLAY	%SILT	%SAND	TEXTURAL CLASS	TOTAL SOLUBLE SALTS(%)	pH	CONDUCTIVITY Mz x 10³	PHOSPHOROUS 2O5(ppm)	K_2O POTASH (ppm)	N(%)	ORGANIC MATTER (%)	$CaCO_3$ (%)
1	6.8	42.0	51.2	sand loam	1344	7.5	0.42	252	570	.08	1.66	9.0
2	8.8	46.0	45.2	loam	1728	7.[illegible]	54	117	1020	.04	1.1[illegible]	[illegible].25
3	8.8	42.0	49.[illegible]	loam	0960	[illegible]	30	218	720	.04	.86	[illegible].0
4	2.2	18.6	79.2	loamy sand	1120	7.7	35	75	450	.07	1.48	[illegible].0
5	8.2	46.6	45.2	loam	.0704	7.6	22	71	240	.08	1.66	4.25
6	12.2	56.6	31.[illegible]	silt loam	1280	[illegible]	40	110	1260	.07	1.38	5.25
7	14.[illegible]	56.0	[illegible]	silt loam	1084	7.6	6[illegible]	78	570	[illegible]	2.07	3.25
8	6.2	52.0	41.8	silt loam	0800	7.5	25	54	180	.07	1.3[illegible]	11.0
9	10.2	62.0	27.8	silty loam	1023	7.9	32	55	420	.07	1.48	[illegible]
10	10.2	58.0	31.8	silt loam	0704	[illegible]	22	94	450	.07	1.55	6.75

from A.K.R.S.P. Soil Samples (1985).



2.2 CLIMATE

2.2.1 Introduction– Climatologists have classified our area of study, the trans-Himalayan portion of the Upper Indus Basin as "dry continental Mediterranean" (Hamid et al.1969;Papidakis,1966;Troll,1972). This is useful for global-scale generalization, but it does not do justice to the strong spatial variation in climate throughout the region. Variation results from combined effects of altitudinal gradient, slope, aspect, the influence of relief on orographic precipitation, and topographic shading (Barry,1981,p.17). A discussion of broad climatic patterns introduces the topic. Then particular agro-climatic variables are discussed, with reference to the local conditions of Hopar.

2.2.2 Broad Patterns of Climatic Controls– The discussion of broad climatic controls follows Hewitt (1968, p.43–45). His description is verified and updated by observations from Barry (1981), and Flohn (1969,1974).

Mountain climatic systems are usually discussed in terms of the "orographic effect", which is the ability of mountains to obstruct and then lift air masses. However, the mountainous Upper Indus Basin is subject to a variety of thermal effects, is exceptionally high over large areas, and ends abruptly. These conditions combine to magnify the impact of orography, so that the region is effectively isolated from surface weather patterns of adjacent areas. Rather, upper air conditions influence climate directly (Hewitt, 1968, p.43).

In contrast with climate in the Central and Eastern Himalaya which is controlled in summer by the Indian Monsoon, westerly high level air movement prevails throughout the year in the Upper Indus Basin. Weather is dominated by air masses migrating eastward from the Mediterranean and the Azores High (see Mooley, 1957). Other atmospheric systems occasionally disrupt this westerly pattern of air flow, specifically penetration of the Indian Monsoon, release of latent heat over the Tibetan Plateau, and changes in the distribution of pressure and circulation over mid-latitude Asia.

In winter the westerly jet stream directs Mediterranean-originated depressions toward the Hindu Kush, and into the Upper Indus Basin. These winter westerly disturbances provide most of the region's precipitation. Indeed, winter weather directly depends upon the nature of these depressions. Since westerly movement of depressions is erratic, winter weather is variable. In early June the effect of westerly lows diminishes as the jet migrates north and the Indian monsoon moves northward (Hewitt, 1968, p.44). Most summers, subsidence from a thermal high over the Tibetan Plateau prevents the monsoon from entering trans-Himalayan regions. Still, the primarily western airflow continues to bring heavy cloud and snowfall to high altitudes. Lower slopes and valleys are insulated by lower altitude, fohn effects, and valley wind systems (Hewitt, 1968, p.45; Barry 1981, p.244). Occasionally the Tibetan anticyclone is weakened by systems to the north, and monsoonal weather does reach the mountain. In the interior trans-Himalayan region heavy monsoon precipitation is usually limited to high elevations, although valleys below 4000m may receive above average rainfall.

In summary, climate in the Upper Indus Basin is influenced primarily by depressions carried by westerly upper air movement. The magnitude and number of these low pressure systems is extremely variable, resulting in strong seasonal, periodic and aperiodic fluctuations in temperature and precipitation. Variability is enhanced by monsoon disruption of westerly patterns combined with fluctuations in thermal highs over the Tibetan Plateau. The effects of these broad climatic regimes are strongly modified by altitude and local topography.

2.2.3 Radiation- Radiation is an important factor in agricultural climate because it influences photosynthetic potential. It also relates directly to temperature, evaporation and water balance. The entire Upper Indus Basin receives extremely high incident radiation due to infrequent cloud cover and thin atmosphere. The mountain rain shadow reduces cloud cover, except in the highest mountain ridges, especially in summer. In fact, many of the valley stations receive up to 70% of potential sunshine hours (Whiteman, 1985, p.20a). In 1986 Hopar had greater cloud cover than other stations. This is due in part to its high elevation, but also results from orographic cloud formation in response to the relative confinement of the valley. Main meteorological stations are almost all in broad open spaces. Skardu , whose station is often a reference for Upper Indus Basin climate, is in a basin over ten kilometres wide. In such a location rain shadowing and arid valley wind systems dramatically reduce cloud cover and precipitation.

Atmospheric density is low at high elevations, causing high transmissivity of radiation. In addition, ultraviolet radiation increases as high elevation reduces water vapour and dust particles in the atmosphere. According to Hewitt (1968, p.47) over half of global atmospheric dust and moisture occurs below 2600 m. Although the Karakoram is a relatively dusty environment, due to aridity and windiness, these factors combine to produce high incident radiation, particularly at high elevations.

Incident radiation is modified by the shading effect of topography. Shade is not an agricultural constraint where temperatures are high, but it can be important at the upper limits of single and double cropping zones. For example, Nagyr is able to grow only one crop per season, while Hunza villages at the same elevation harvest two. The difference is that Hunza enjoys a sunnier aspect. Hopar has less shading than Nagyr, but more than Hunza. Direct radiation reaches Hopar's valley floor at approximately 6:45 a.m. in June, and is lost at about 6:15 p.m., due to steep and close western slopes. Thus, in June, topographical shading deprives Hopar of four of a possible 14.5 hours of sunlight. This value must not be confused with sunlight lost to cloud cover. Naturally micro-level topography and terracing within the cultivated area introduce variation into general sunlight durations. Micro-topography is discussed in Chapter 4 with relation to crop distribution.

High intensity and duration of incoming radiation affect agricultural growth in several ways (see Biswas,1979;Cusak,1983;Jackson ,1977;Monteith,1976;Whiteman,1985). First, because of its overall abundance, radiation is not a limiting factor to crop growth; only where topographic shading is important does it become a significant constraint. In fact, incident radiation during the growing season in Hopar is consistently higher than other lowland agricultural regions at similar latitudes. Plants produce and store high quantities of carbohydrates, so potato yields are high; as much as 85 tons per hectare in Yasin at 2450 m (Whiteman, 1985, p.20). This is twice that of many European and North American potato producing regions. Moreover, orchard crops, especially apricots, are remarkably sweet. In addition, villagers can severely cut back trees and bushes for fuel and fodder without damage. It is common to see verdant poplars and willows in July, only two months after losing three quarters of their branches.

The high sunlight conditions of the Upper Indus Basin can result in temperate crop yields approaching their potential maximum (Whiteman, 1985, p.20). This is especially true, since local crop varieties exploit intense sunlight by assimilating radiation more rapidly than down country varieties. High radiation absorption compensates for the inhibiting effect of temperature limited growing season.

Table 2.2.4

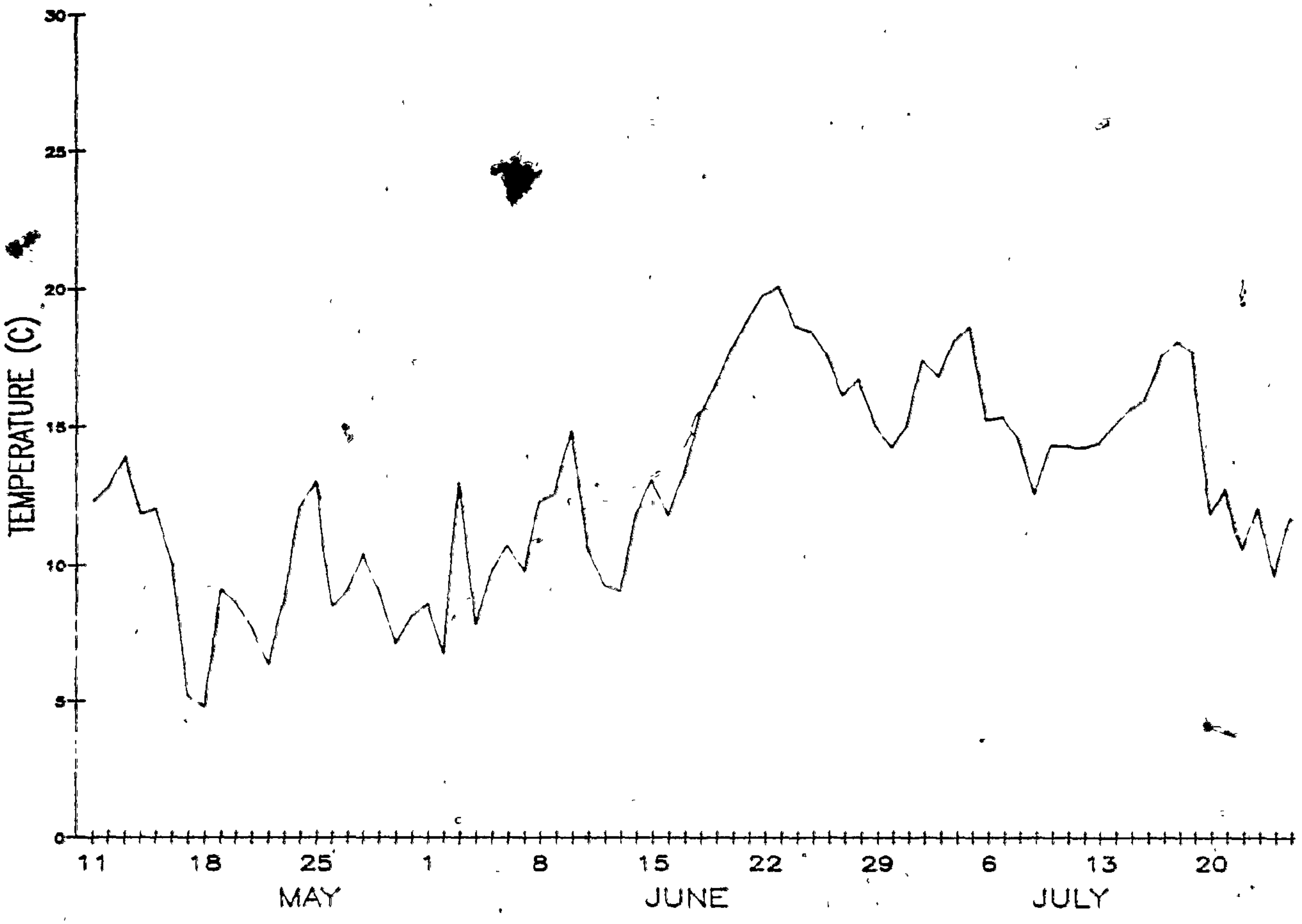
Mean Monthly Temperatures (°C): Selected Upper Indus Basin Stations

Site	No. of Years Record	J	F	M	A	M	J	J	A	S	O	N	D	Extreme Daily Value
Chilas	27 Min	0.5	3.2	8.5	12.6	18.1	24.2	27.5	26.9	22.8	14.6	6.7	1.8	-6.7
(1260 m)	Max	12.1	14.7	19.2	25.2	31.0	37.5	39.8	38.9	35.1	28.6	20.8	13.9	47.0
Gilgit	30 Min	-2.4	-0.6	5.8	10.0	12.0	15.2	19.0	18.4	13.3	7.2	1.2	-1.4	-9.5
(1490 m)	Max	9.1	12.1	17.8	23.6	28.0	34.0	35.9	35.6	31.7	26.2	17.9	11.0	45.4
Chitral	20 Min	-0.7	0.4	4.2	8.6	12.6	15.3	20.2	19.5	13.5	7.7	3.1	-0.8	-12.3
(1500 m)	Max	8.7	9.8	14.9	21.8	27.1	34.5	36.2	35.0	31.1	25.0	18.4	11.4	44.8
Gupis	26 Min	-4.9	-2.8	2.2	7.6	11.3	16.1	19.2	17.5	13.5	7.2	1.7	-2.0	-11.2
(2144 m)	Max	4.0	6.6	12.2	18.3	22.9	29.1	32.0	31.1	26.3	20.0	12.5	6.0	40.3
Astore	25 Min	-7.2	-5.6	-1.2	4.0	7.3	11.6	15.0	15.1	10.6	4.5	-0.6	-4.7	-15.7
(2148 m)	Max	2.6	4.1	8.4	14.8	19.6	25.2	27.3	26.9	23.8	17.1	11.0	4.8	35.3
Skardu	29 Min	-8.0	-5.2	1.3	6.6	9.6	13.8	16.9	16.6	12.2	5.2	-1.6	-5.7	-18.5
(2197 m)	Max	2.6	5.1	11.4	17.9	21.6	26.3	31.2	31.1	26.6	20.3	11.7	5.5	40.0
Karimabad	7 Min	-4.0	-2.6	2.4	7.2	10.6	13.9	16.4	17.2	11.5	7.7	2.6	-1.8	-6.7
(2405 m)	Max	2.1	4.3	9.0	16.1	20.2	25.8	28.5	29.4	23.8	18.1	10.7	4.3	37.8
Yasin	3 Min	-9.7	-7.4	-1.6	4.2	7.9	9.5	11.4	12.1	7.1	2.6	-1.9	-6.6	-15.0
(2450 m)	Max	-0.2	2.4	8.3	13.6	20.3	24.7	26.4	30.1	22.1	16.4	9.8	2.7	36.0
Naltar	2 Min	-9.7	-9.4	-4.7	0.7	4.1	8.7	9.6	12.1	9.6	2.6	-0.4	-6.1	-15.6
(2880 m)	Max	-2.8	-1.4	4.0	9.5	14.0	21.0	27.3	23.9	19.8	14.0	7.0	1.7	32.2
Babusar	2 Min	-14.7	-10.6	-3.0	3.6	(6.5)	10.7	14.5	13.4	9.4	0.4	-5.4	-12.6	---
(3003 m)	Max	-1.6	-1.8	6.0	12.6	(15.1)	20.1	25.4	23.9	19.1	10.1	3.4	-4.3	---
Misghar	17 Min	-13.2	-9.7	-5.4	-0.2	3.4	8.0	11.1	11.6	6.6	-0.1	-5.8	-10.6	-18.9
(3088 m)	Max	-1.1	1.7	7.2	12.3	16.3	21.2	24.6	25.2	20.8	14.0	6.9	0.5	32.8

Source: Whiteman, 1985.

Figure 2.2.4a

HOPAR BASE CAMP
Mean Daily Temperature
(2849m)



Source: Hygrothermograph readings recorded by Butz, 1986

2.2.4 Temperature – The most important factor when discussing temperature in temperate mountain regions is variability. Temperatures in the Upper Indus Basin vary widely with season, altitude, time of day, and topography. The effects of these components are discussed with reference to Table 2.2.4. It provides temperature data for several sites in the region. Figure 2.2.4a shows mean daily temperatures for Hopar in summer 1986.

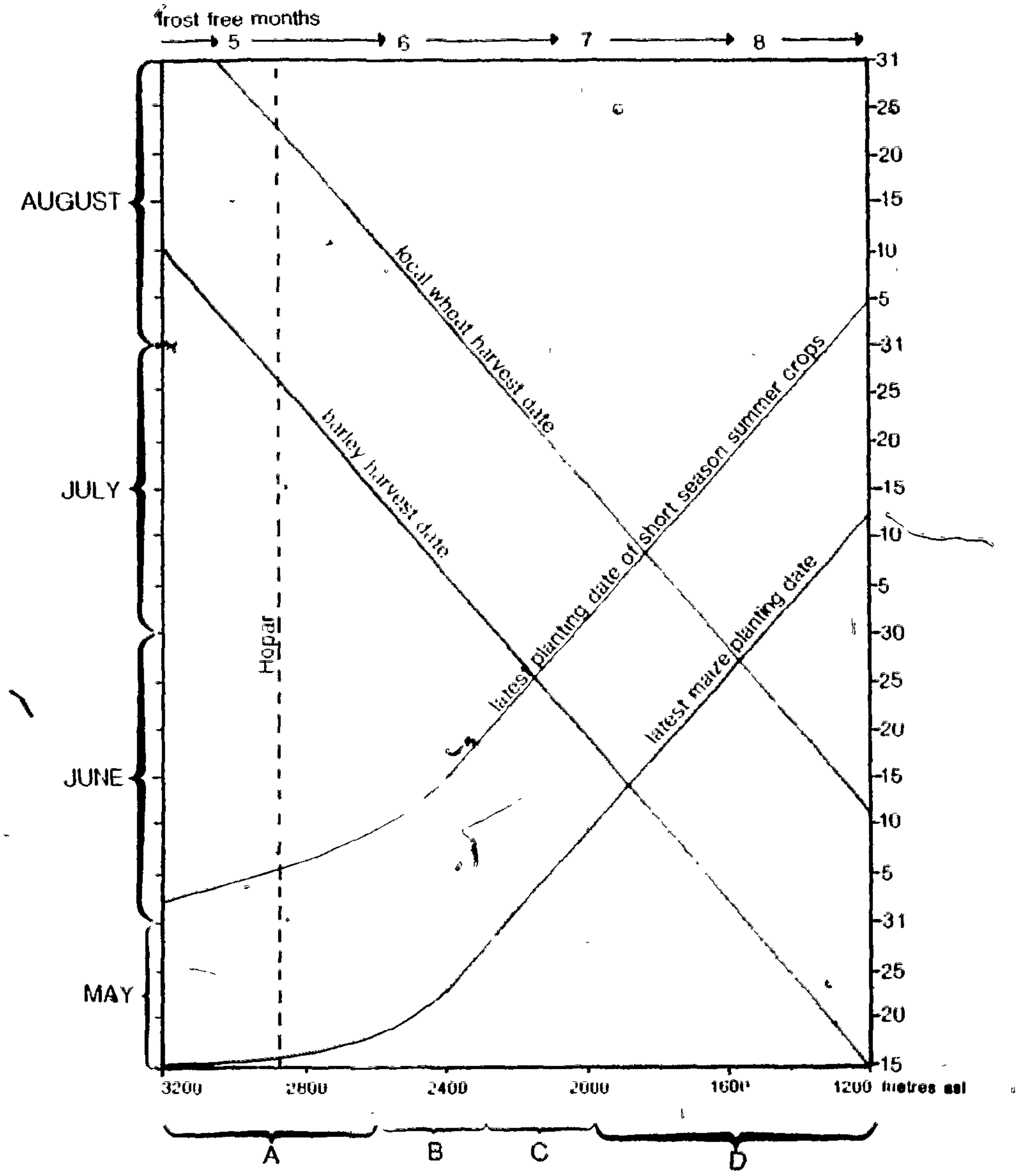
a) Seasonal temperature variations are extreme at all stations; between 32 and 40°C from minimum January mean to maximum July mean. Elevation seems to have no significant effect upon the range of seasonal change. Temperature curves are steep throughout the year, but especially in spring and fall. This means that crops are biologically suited to climatic conditions experienced in only brief periods of the growing season (Whiteman, 1985, p.21). Farmers must choose optimum sowing dates to avoid high or low temperature stress during critical periods of crop growth and maturity. Timing becomes even more important when water supply and moisture requirements are considered. Villagers are helped by the fact that rapid changes in temperature in spring and fall facilitate prediction of first and last frost dates (Whiteman, 1985, p.24). Sowing and harvesting can be adjusted with little risk of frost change.

b) Changes in temperature with altitude are the most significant climatic determinants of crop selection and cropping system at the regional scale. All measures of temperature, except temperature range, decrease with increasing altitude. Whiteman calculated lapse rates between 6.5 and 7.8° Celsius per

1000 m (1985, p.22). He notes however, that local aspect and topography causes sharp departures from these values. Figure 2.2.4b illustrates changes in cropping pattern with elevation, for the Gilgit District; growing season of temperate grain crops steadily shortens with increasing altitude. Confined as it is to grain cropping patterns, the figure does not show that the pastoral component of farming tends to increase as altitude rises. Hopar, at the upper limit of single crop cultivation, greatly supplements its agricultural economy with pastoral herding at high altitudes. Altitudinal gradients are also the basic condition for all meltwater irrigation in the Karakoram. Warm temperatures conducive to crop growth exist below 3000 m. At higher elevations temperature is sufficiently low to permit winter accumulations of snow and ice, some of which melt during summer months. Meltwater is used downslope to supply moisture to crops. Without this coincidence of temperature and moisture supply during the growing season irrigated agriculture could not occur. Locally, aspect and topography vie with altitude as climatic determinants of crop selection. Nevertheless, elevation zones of crop production are distinguishable in many villages, especially those which control considerable elevation ranges. Hopar controls crop land between about 2500 and 3500 meters.

Figure 2.2.4b

CROPPING PATTERN: GILGIT DISTRICT



A upper single crop zone

B lower single crop zone

C marginal double crop zone

D reliable double crop zone

Note: Harvest delayed 5 days per 100m rise.

Source: after Whiteman 1985

c) Diurnal temperature ranges are in the neighbourhood of 15 to 20° C. Both altitude and aridity contribute to diurnal variation, since evening temperatures depend upon absorption of radiation by the atmosphere; dry, thin high altitude air is a poor barrier to loss of heat released at night by ground cover. This is particularly true in the Upper Indus Basin where summer nights are long enough to permit substantial cooling (Whiteman, 1985, p.23). Diurnal range increases with increasing altitude. Large diurnal temperature variations encourage crop growth, but may inhibit development by protracting plant maturity (Whiteman, 1985). It should be noted that soil temperature is probably more important to crop development than air temperature. They are closely related, but dense crop cover, high foliage albedo, and application of cold irrigation water can dramatically decrease field soil temperature. The relationship between crop vegetation and micro-climate is discussed more thoroughly in Chapter Five.

d) Topography and aspect significantly modify altitudinal, seasonal and diurnal temperature patterns. Karimabad Hunza, located on a steep south facing slope, is a good example. The southerly aspect causes high daytime temperatures, while cool air drainage raises night-time minimums. Minimum and maximum temperatures at Karimabad are approximately three degrees higher than Yasin at a similar altitude. Large portions of Hopar's cultivated area occupy north and west facing slopes, although the predominant exposure is easterly. Smaller areas face south. The cropping pattern reflects this variability (See Chapter 4). On the whole, a primarily easterly exposure shifts Hopar's temperature curve toward morning. The moderating effects of several glaciers and snowfields lower all temperatures. In particular, cold air drainage from Hopar Nala cools the lower northern end of the cultivated area.

2.2.5 Precipitation and Water Balance– The distribution and magnitude of precipitation is dominated by orographic conditions both regionally in terms especially of altitudinal gradients, and locally as a function of aspect, direction of moisture bearing winds, and orientation of individual ranges.

Maximum precipitation occurs above 3500 m. Below 3500 m amounts are insignificant hydrologically, and except briefly in the spring, for agriculture. Most precipitation in the cropping zone falls as snow in winter, and is lost in early spring as evaporation or runoff. Only in exceptionally cold cloudy springs are farmers able to utilize moisture from snow which falls within the elevation of cultivation. In some villages they plough snow into the soil to prevent evaporation and runoff.

Throughout the zone of cultivation, growing season rainfall is consistently lower than evapotranspiration, or even potential evaporation. Consequently, crops suffer from a negative water balance. This is reflected by generally low values of relative humidity. In Hopar these averaged about 25% in summer 1986. Humidity values over irrigated fields were significantly higher, indicating that considerable irrigation water is lost through evaporation and transpiration. Moreover, even though the summer of 1986 was unusually cold and wet, measurements in Hopar show potential evaporation greatly exceeding precipitation throughout the growing season (see Figure 2.2.5). Since evaporation increases and precipitation decreases with decreasing elevation, lower villages experience even greater moisture deficits. Southerly and easterly stations of the Upper Indus Basin, such as Besham Qila normally receive monsoon rainfall. This lessens, but does not negate, the growing season moisture deficit (see Table 2.2.5).

Records are poor for high altitude conditions, but it is clear that precipitation exceeds potential evaportranspiration roughly from 3500m upwards in this part of the Karakoram. Above 3500m precipitation is in the order of 110 to 160 cm per year (Hewitt,1968,p49). Certain locations at extreme heights receive much more (Gardner,1987,personal communication; Wake,1987). Most precipitation is in the form of snow (Batura Glacier Investigation Group,1979; SIHP,1986). It is high altitude snowfall that sustains agriculture through meltwater irrigation. Thus, crop moisture depends critically upon high altitude accumulation and melt conditions below the zone of perennial frost, rather than upon precipitation in the crop zone. The main considerations are volume, surface area and aspect of snow and ice accumulations feeding meltwater streams, and the redistribution of snow downslope by avalanches and/or glacier flow. In addition, total moisture release from small basins, such as Hopar, may be critically affected by wind movement and trapping of wind-blown snow. Meanwhile, cloudy spring weather, with fresh snow at high altitudes, actually inhibits crop growth by decreasing melting. This occurs even when rain falls in the cultivated area.

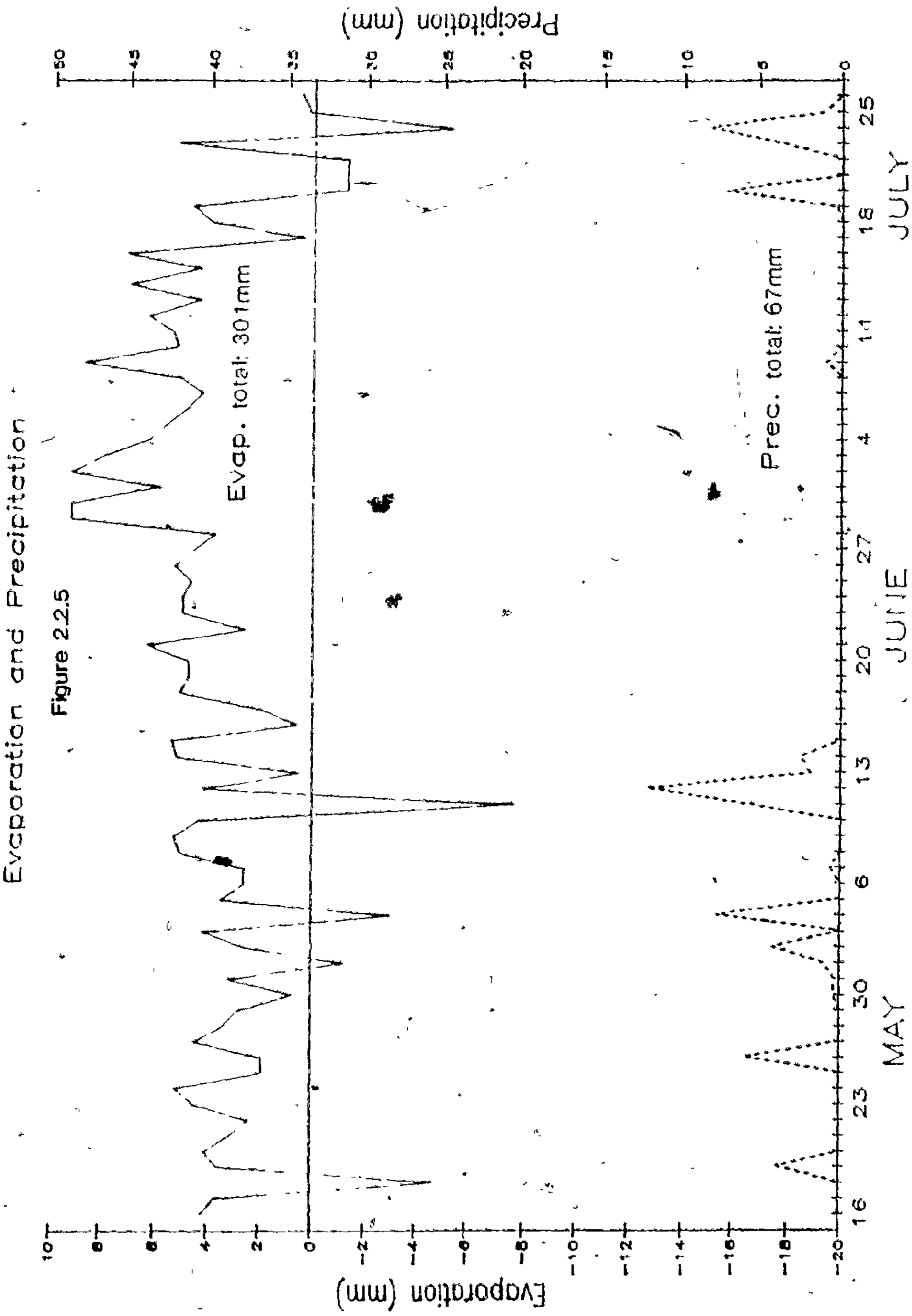
High level precipitation is highly variable. Villagers told Whiteman (1985, p.23) that meltwater shortages occur every four or five years.They attributed these shortages to below average snowfall. In addition timing of meltwater supply depends upon temporal distribution of snowfall events as well as temperature and sunshine. The relationship between snow accumulation and meltwater is discussed in Chapter Four.

Precipitation records in Hopar are too brief and too recent to provide useful comparison with other stations. 1986 brought above average rainfall in spring and late summer. The latter is probably due to a rare northerly migration of monsoon conditions. Unfortunately our records caught only the beginning of some major late summer storms. However, Hopar's elevation at the upper limit of cultivation probably results in slightly higher precipitation than other villages in the same area.

HOPAR BASE CAMP

Evaporation and Precipitation

Figure 2.2.5



Source: Manual readings taken by Butz in 1

TABLE 2.2.5

Precipitation and Water Balance for Selected Upper Indus Basin Stations

Location		Elevation	Total Precipitation	Yearly Water Balance	Frost Free Water Balance
Besham Qila	34°56' 72°53'	900 m	194.8 cm	-23 cm	-23 cm
Kalam	35°32' 72°35'	2408 m	96.2 cm	+32 cm	+23 cm
Dras[Δ]	34°30' 75°55'	3066 m	64.9 cm	+19 cm	-31 cm
Kachura	35°27' 75°25'	2700 m	19.8 cm	-51 cm	-55 cm
Skardu	35°18' 75°41'	2320 m	17.3 cm	-53 cm	-58 cm
Gilgit	35°55' 74°20'	1450 m	12.5 cm	-84 cm	-84 cm
Leh	34°09' 77°34'	3514 m	8.4 cm	-43 cm	-46 cm

Source: Butz and Hewitt, S.I.H.P., 1986.

2.2.6 Wind - Recording stations across the Gilgit District measure wind speeds on the order of 0.9m/s during summer months (Table 2.2.6). Winter winds are much slower, about one-half to one-third of summer speeds. Due to marked local variability, these values are at best rough estimates of regional trends.

Table 2.2.6

Wind at 2m Height: (m/s).

Selected Stations in Upper Indus Basin

Site	J	F	M	A	M	J	J	A	S	O	N	D
Chilas (1260 m)	0.2	0.5	0.7	0.8	0.7	0.8	1.2	1.1	0.9	0.5	0.2	0.2
Gilgit (1490 m)	0.3	0.5	0.6	0.6	0.6	0.5	0.6	0.4	0.4	0.3	0.2	0.2
Gupis (2144 m)	0.3	0.5	0.8	1.0	1.0	1.1	1.0	0.9	0.9	0.6	0.3	0.2
Astore (2148 m)	0.4	0.5	0.7	0.7	0.7	0.7	0.9	0.9	0.9	0.8	0.7	0.2
Skardu (2197 m)	0.3	0.5	0.8	1.0	1.0	1.1	1.0	0.9	0.9	0.6	0.3	0.2
Yasin (2450 m)	0.6	1.1	1.3	1.3	1.2	1.1	0.9	0.8	0.7	0.7	0.8	0.9

Source: Met. Dept. Lahore, except Yasin (FAO) (in Whiteman, 1985)

Powerful, persistent valley wind systems with both up-valley and down-valley winds are a feature of much of the Karakoram Range (Whiteman, 1985, p.18). Intermittent wind records during summer 1986 indicate that up-valley winds occurred between 2500 and 2700 m in Hopar, although very gently. Breezes travelling up-valley from Nagyr are strongest from 11:00 a.m. to 4:00 p.m. Later in the afternoon down-valley cold air drainage reverses the flow of air. The eastern and southern areas of Hopar occasionally experienced cool southerly breezes moving down the Bualtar and Barpu glaciers. Unlike reports from other areas of the Karakoram these were neither continuous or strong. In fact strong winds or even gusts were never recorded in the cultivated area of Hopar by the author. Others reported occasional severe storms with winds sufficiently strong to lodge large areas of wheat and barley (Hewitt,1987,personal communication). The absence of frequent strong winds could be due to Hopar's relatively broad shape, and its situation away from major river valleys. Strong valley winds usually travel along steep and narrow river valleys (Whiteman, 1985, p.18). Strong but shallow down valley winds are often reported above the surface of Bualtar Glacier (MacDonald,1987,personal communication).

Wind does not seem to be a continually important agroclimatic variable in the way that radiation, temperature and water balance are. However, in Hopar it does cause occasional crop lodging and premature fruit drop. In addition, it increases evaporation from fields somewhat. On glaciers adjacent to Hopar, and in snow accumulation areas above the crop zone winds are much stronger. Evaporation from these surfaces is probably affected to a significant extent by wind.

2.2.7 Conclusion– Climatic information is scanty for the Upper Indus Basin, particularly at high elevations in the Karakoram. Nevertheless, we can summarize those features of Hopar's geophysical environment that are most important to agriculture. Hopar is located in a broad and relatively flat depression containing well developed sedimentary soils which contain all essential agricultural nutrients, except nitrogen, in adequate quantities. The cultivated area receives abundant and intense solar radiation during the growing season. In the absense of wide spread and continuous cold air drainage or winds at Hopar, this means that summer temperatures are close to optimum for temperate crops. However, the duration of growing season is limited by the high elevation of fields. Temperatures vary greatly diurnally and seasonally. This is beneficial to crop growth during the hottest summer months, but contributes to the inhibiting length of growing season by decreasing the frost free period. High summer radiation causes high evapotranspiration, which combines with low precipitation to create a highly negative water balance. Hopar's most serious environmental constraint is net water deficit. However, it is a constraint which has been largely overcome by effective meltwater irrigation. The relationships among precipitation, snowmelt, evaporation and irrigation are discussed in some detail in Chapter Four. Chapter Five addresses the effect of local topo–climatic variation upon crop distribution. The following chapter presents the other half of Hopar's agricultural setting-- the community's social characteristics.

CHAPTER THREE: THE COMMUNITY OF HOPAR

3.1 HISTORY

The early history of settlement in the Central Karakóram is unresolved. What little is known is a mixture of local mythology and conjecture by historians and anthropologists. Scholars believe that a collection of peoples speaking the Dardic tongues of Burushaski, Khowal, Shina and Wakhi migrated to the highlands and foothills of the Upper Indus Basin's northern and northwestern fringes around 500BC (Jankovsky, 1971, p.61). They are not certain where Dardic tribes originated. It seems likely that their migration was from the north, since Mongolian and Persian features predominate, sometimes including blue eyes, fair skin, and blondish to reddish hair. Their languages have no Indo-Aryan roots, and are mutually unintelligable. Nevertheless, they do share some characteristics which have prompted linguists to classify them all as Dardic.

Dardic languages prompted Leitner to call the area Dardistan (Leitner, 1866). This term has been used widely since then, if only abstractly, since the region has no concrete political or geophysical boundaries. What is currently accepted by Staley (1982) and others (see Keay, 1979) as Dardistan coincides roughly with the Western and Central Karakoram and the Hindu-Kush, including areas between Chitral-Kafiristan in the west and Gilgit District in the east (See Figure 3.1).

Figure 3.1
DARDISTAN

Redrafted from Staley, 1983

It is tempting to assume that rugged terrain and high altitude caused this society to develop in isolation. Such a view has relevence to particularly inaccessible valleys, but the region as a whole has been influenced since at least the First Century A.D. by Chinese, Tibetan and Iranian religion and culture (Jettmar, 1980). Numerous inscriptions and carved Buddhas near Gilgit and up the Hunza Valley testify to Tibetan-Buddhist religious presence. In addition, several routes and passes, collectively called the Wakhan Corridor, provided tradeways between the Indian Subcontinent and China and the Middle East. Thus, goods and ideas infiltrated Karakoram Valleys from both the northwest and southeast.

Dards comprised only part of the population of the region. Jettmar (1980, p.24) cites evidence from the 11th and 12th Centuries of another ethnic group; the Burushos. He believes that these Burushaski speakers may have migrated to the area before the Dards, and were later forced into less accessible valleys by Dardic immigrants. Presently Hunza and Nagyr form the hub of Burusho habitation. Hopar, situated at the upper extent of Nagyr, is a Burusho community.

The history of Hopar lives primarily in mythology and legends told by Brushal Village elder Zawar Shafiro (personal communication, Zawar Shafiro, 1986). He claims to be the oldest resident in Hopar, at 103 years of age. Legend has it that the Hopar depression was settled by King Burusho, a native of Persia, some 900 years ago. Burusho founded Brushal Village after leaving service as Wazir or Minister of State to the Rani of Gilgit. When he arrived at Hopar, the floor of the present cultivated area was covered by a great lake which drained several generations later. Brushal Village was built on the shores of the lake. Inhabitants of Brushal, and Gilgitis invited to Hopar by King Burusho, gradually settled four other villages. These became Hakalshal, Rattal, Ghoshushal and Holshal. Each village is home to a particular clan or "shal". Over the centuries clans have become interrelated, but they still maintain their village/tribal identity.

Little survives of Hopar's history between the settlement's beginning and the 16th Century. At that time Islam was introduced to Dardistan by saints and missionaries from several Moslem sects. It is told that a particularly blessed Shia saint named Shah Buria visited Hopar on his way from Baltistan to Nagyr. When he arrived the villagers treated him poorly. The saint retaliated by granting the community good fruit and grain harvests, but denying villagers the thrift and industry to exploit these gifts. Hunza villagers, who received Shah Buria warmly, were blessed with industrious and intelligent personalities to compensate for less amenable physical conditions (Staley, 1982, pp.123–125). The inhabitants of Hopar have been Shias since that day. Ironically, the people of Hunza are Ismaili Moslems.

A conflicting story of Moslem conversion is provided by the present Mir (king) of Nagyr. He claims that his ancestors brought Islam from Kashmir 600 years ago. It seems plausible that the Mirs of Nagyr had some role in the forcible conversion of Hopar and Nagyr villagers. Until 1974 Hopar was part of the 73 village Mirdom of Nagyr. In 1974 all rajas were abolished by central government. However, the absolute power of the mirdom in Nagyr began to diminish in the late 1800's with Pax Britanica, and the penetration of British explorers into remote valleys. More imported goods began to reach villages, and direct commerce between villagers and the outside economy increased. The effect of this was small until after partition. At that time Gilgit became central government's administrative centre for the district, and the Mir lost all but nominal authority.

The construction of transport routes, particularly the Karakoram Highway in 1979, completely destroyed what isolation remained. Currently Hopar is in a state of transition. Many values of the former mainly, but not purely, subsistence economy and despotic paternalistic political system still remain. Increasingly, they are compromised by the political economy of central government, increasing opportunities for cash earnings, and international aid. Most agricultural and water supply practices are still traditional and subsistence oriented. Increasingly, however, the effective utilization of these practices conflicts with imported economic and social expectations.

3.2 POLITICAL AND SOCIAL ORGANIZATION OF HOPAR

The current Hopar community comprises approximately 4000 people. Most still dwell in the five original villages. In addition, three small clusters of dwellings have evolved as annexes. Two of these house families whose homes in Rattal were destroyed by a flood in 1978. The other is inhabited by surplus population from Hakalshal. All three are recognized as sociopolitical extensions of their respective villages. A fourth annex, Shishkin, across the Bualtar Glacier contained some forty Holshal households until recent catastrophic slumping cut off its water supply. Some wealthy land-owners are building newstyle homes on land outside of main village clusters. These too are considered part of the parent village. Appendix IV provides demographic characteristics for Hopar and Nagyr.

Three levels of social and political identity are evident in Hopar: the community, the village, and the household. A logical fourth and fifth, the region and the state seem unimportant to most villagers. They look to regional and federal institutions for financial assistance, as they look to foreigners and international organizations for aid. Any affiliation with these outside institutions is economic rather than socio-political. This disinterest is natural considering the wide gap in traditions and perceptions between Hoparis and officials representing lowland Pakistan. The politics and society of outside areas is likely to become more important as villagers continue to leave the community temporarily to work and study downcountry. Already, some youths seem more attuned to mainstream culture than to the expectations and perceptions of their elders.

Community level sociopolitical identity is relatively weak. No internal political authority unites the five villages. Since the abolition of feudalism, traditional imposed unity has diminished as well. Hoparis see themselves as members of particular villages first, and then members of the five village Hopar community. Indeed, a good deal of mild tension, condescension, and jealousy exists among villages. Brushal residents, for instance, consider Holshalis to be idle, inhospitable, and opium addicts. Holshal villagers in turn resent Rattal's "monopoly" on portering, and the fact that men of other villages walk among Holshal fields. Such complaints are recognized by many though not all residents as trivial. Despite belonging to five tribes, Hoparis share too much history and ancestry to become vicious in their remarks.

Apart from tribal affiliation, the community is united by topography, and more importantly, a shared water supply. Villagers are extremely cognisant of the need to distribute water effectively and equitably. In former times the Mir arbitrated water disputes; currently a Tehsildar or AKRSP ~~field~~ representative can be called in for the same purpose. Yet, according to the local AKRSP representative, problems rarely arise, and when they do villagers usually settle them without outside aid. This informal internal system can break down when new schemes are introduced. Semple (1986) describes a situation where a proposed Brushal high channel is being challenged by Hakalshal village council. The community has been unsuccessful in resolving the problem internally, so outside arbitration is occurring.

Most formalized social and political activity occurs at the village level.

Each village has its own mosque, pond, mills, threshing floor, and council. The council has traditionally been a group of seven to ten elders, led by a headman or Numbardar. Council members were chosen by villagers on the basis of social standing, including wealth, age, agricultural expertise and religious merit. The Numbardar himself was appointed by the Mir of Nagyr. Meetings were frequent and informal, and often included non-council members in the discussion. More formal gatherings occurred when serious problems arose. All village concerns were addressed by village elders; however, their fundamental purpose was the regulation of agricultural affairs. Water distribution and allocation, channel maintenance, transhumant cycle, seeding dates and harvesting dates were all decided by this sociopolitical authority group.

Several changes of the past two decades have coincided to alter the structure of village leadership in Hopar. These are the abolition of the raja, increasing accessibility to regional society and economy, increasing influence of Shia religious leaders who have only recently begun to inhabit permanently all villages, and the entry into Hopar of the Aga Khan Rural Support Program. Numbardars and village elders lost the power behind their authority when the raja was dismantled. At the same time they were forced to compete with ambitious villagers whose involvement with the outside world increased their relative prestige. Factions developed around the influence of particular groups, each with their own goals and perceptions. Educated Islamic maulvis (Shia religious leaders), wealthy local shopkeepers and jeep drivers, and retired soldiers all vied with traditional leadership for authority. In 1983 the AKRSP recognized the resulting disintegration of village cohesion. They encouraged villages to form Village Organizations (V.Os) which would elect leadership representative of the population as a whole. The current situation varies among villages. Brushal has maintained its cohesion by enthusiastically participating in AKRSP as a village. Semple (1986) attributes Brushal's high level of integration to very close tribal affiliation and strong leadership which combines traditional authority roles. Thus, the V.O. leaders are a mixture of traditional elders, businessmen, and army retirees. These men are also among the most successful farmers. The maulvi does not participate; yet neither does he oppose the village organization.

Hakalshal exemplifies the opposite extreme (Semple, 1986). Its population is relatively well educated and well travelled. Many Hakalshal occupants participate in the outside economy. As a result the village enjoys the highest standard of living. However, because inhabitants do not perceive traditional clan prosperity as most important, competing factions are strong. The village lacks the integration needed for communal projects. AKRSP village organization has been unsuccessful.

Hopar's village councils, in whatever form, play an important role in agricultural and social decision making. However, most social regulation is non-formalized. While fines exist for allowing livestock to roam cropland, for poor channel maintenance, and for irrigating out of turn, these fines are seldom levied. Rather, as in village systems in Africa, "each villager forces the other into the customary pattern of behaviour by fulfilling and requiring the fulfilment of mutually customary obligations" (de Schlippe, 1956, p.102). This applies especially to agricultural and irrigation activities. For example, channels must be cleaned in spring to allow any irrigation to begin. No individual may irrigate until all village channels are dredged. Despite the lack of stated rules each irrigator is forced into activity by the activity of other irrigators. Most agricultural activity has continued successfully through the period of village sociopolitical disintegration because non-formalized social regulation such as this maintains traditional and proven practices.

The household is the final level of sociopolitical affiliation in Hopar. It is important in several ways. To Hopar villagers, as in other peasant societies (Cole & Wolf, 1974, Ladurie, 1979), household or "house" includes extended family, goods, livestock, land, and the dwelling itself. Three of these, dwelling, land, and livestock, are traditional manifestations of wealth. Goods were not important in the past, however, as emphasis is placed on imported consumer items, wealth is increasingly sunk in goods. The household is significant because it is the level of accumulation of wealth, and the level of economic subsistence. The larger the combined household, the more wealth and greater subsistence a family enjoys. The household is also the level of women's activity. They are not allowed in high pastures, public places, or community decision making. All of these are public and communal spaces. Women are predominant in the fields, in the stables, and in the dwelling; all private household spaces. It is in the household that women raise children, practice the vernacular language, teach customs and folk-lore, carry out traditional rather than imported activities and contribute to decision-making. Thus, household is important because it provides the sole physical and social space occupied by women. Moreover, society is structured so that women, despite their absence from other sociopolitical levels, are able, through their dominant role in the household, to actively participate in decisions relating to the accumulation of wealth, and the continuation of indigenous culture.

In summary, three sociopolitical levels are important in Hopar. Most communal social and political activity occurs at the village level. This activity is tempered by historical, geographical, and hydrological characteristics of the community. Households are private rather than communal space. Decisions relating to the welfare of the family and its property are made at the household level. Agricultural water use is regulated at all three levels: supply is shared by the community; distribution is arranged at the village level; households control its application. It is important to Hopar's agricultural system that community and village level organization do not disintegrate. With the exception of AKRSP initiatives this has been the trend in Hopar, as in other Karakoram communities. The following sections of this chapter relate to and expand upon sociopolitical organization in Hopar.

3.3 TENURE AND INHERITANCE

In former times all land belonged to the Mir of Nagyr, who allocated portions first to villages and then to households, as the need arose. Farmers paid tribute in kind to the feudal government in return for the right to farm land and herd livestock on communal pastures. After the dissolution of the raja all holdings reverted to the occupants. This land reform began in the early 20th Century in Hopar, when the Mir of Nagyr voluntarily reduced tribute to nominal or ceremonial amounts. Since all occupants of Hopar were land holding peasants, all present households own at least some land. High pastures were not occupied by particular households, so today most are still owned by the Mir, but granted to specific villages.

All land is held first by the community of Hopar, and then by the village. Within villages cropland is broken into household or individual ownership. This means that farmers may sell land only to other members of the village. If no other villager is willing to buy the plot, it can be sold to members of other villages. Property cannot be sold outside of the community unless no Hopari will purchase it. Local testimony maintains that land has never been sold outside of Hopar. According to Semple (1986), land within Hopar is in high demand, and some wealthy farmers, particularly in crowded Brushal, are themselves buying plots in the double cropping zones of Hunza.

Cropland in Hopar is individually controlled only during the growing season. After crops are harvested it becomes communal grazing until ploughing begins the following spring. Likewise, only the trees in orchards are privately owned. The land itself can be used for grazing by all village animals. Households claim usufruct to pasture land by owning cropland and belonging to a village. All households have equal access to pasture lands, despite the relative size of land holdings. Thus, all Hopar households can claim a share in communal pasture.

Inheritance of property in peasant societies is commonly described with reference to two extremes: impartible inheritance, where one child, usually the eldest son inherits all property; and partible inheritance, where all children, or at least all sons, receive relatively equal portions (Cole & Wolf, 1974). In the former the holding is maintained at the expense of younger offspring. Partible inheritance results in fragmentation of the household, but assures equitability among siblings. Most societies profess adherence to one or the other, but practice a combination of the two (Cole & Wolf, 1974). Hopar exemplifies this situation.

Until the present century land in Hopar was plentiful, and in possession of the Mir. At that time colonization, rather than partible or impartible inheritance, was the norm. Rather than dividing holdings among sons, uncultivated land was granted and settled. Each household was able to control a viable subsistence unit. In the past several generations all potential arable land has been colonized, yet population growth rate continues to increase (it is presently estimated at 3% per annum). Consequently, the ideal of partible inheritances has been adopted. When a man dies his property is divided into three parts. The eldest son receives most terraced land; the second claims the house and its contents; and the third gets all trees, livestock and pasture rights. If there are more than three sons each of these parcels are divided again. Daughters receive at most, a half portion of property, and at least an apricot tree. If a daughter marries outside of the village she must give or sell property to a brother. However, she may reclaim it if the marriage is unsuccessful. If a daughter is wed to a member of her own village, her property is attached to her husband's household.

Inheritance in Hopar is clearly partible. However, since no household can survive with only arable land, or pasture and trees, or a dwelling, fragmentation does not usually result. Rather, siblings combine their property to maintain the original household unit. With each generation subsistence becomes increasingly meager as a relatively fixed amount of land is expected to feed more household members. This trend is ameliorated somewhat by the recent tendency of younger brothers to seek employment out of the community. Most retain their claim to the land and eventually return to the household. When they do return they bring money to purchase more land, or to buy goods which subsistence agriculture can not provide. Some emmigrants never return. Instead they sell or give their property to other siblings. Still, over 4000 people share 280 hectares of cultivated land, about one third of what Saunder estimates is needed for subsistence in single cropping areas (Saunders, 1983, p.16). Increasingly villagers are looking to the outside economy to supplement subsistence agriculture.

3.4 SUBSISTENCE AGRICULTURE AND AGRICULTURAL LABOUR

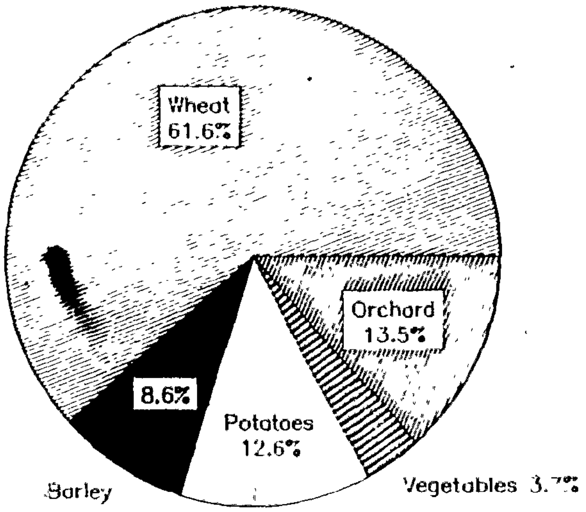
All households in Hópar are directly involved in farming. Most try to be self-sufficient as far as land holdings and production resources permit. Unfortunately, with only 280 hectares of cultivated land, the population of 4000 cannot survive on agro-pastoral production alone. Still, subsistence agriculture is the traditional ideal of villagers, and both village and household units strive to approach that ideal.

Farming in Hopar is a complementary combination of agricultural and pastoral activities. Figure 3.4a summarizes agricultural land use. Cereal cultivation is the basis for irrigated agriculture. Wheat and barley are the primary cereal crops. They are supplemented by small quantities of panicum millet and foxtail millet. Maize, which is a common crop in lower Karakoram valleys, is not grown in Hopar due to elevation constrained growing season. At one time barley was the predominant cereal crop, because it matures faster and yields more than wheat. Today wheat is preferred for its superior flour. AKRSP is trying to convince farmers to reduce cereal production, especially wheat, and concentrate on potato and orchard crops. They maintain that villagers would profit from exporting surplus potato and fruit production, since both of these crops produce extremely well in Hopar (see Whiteman, 1985,p.20). Receipts from produce exports could buy wheat which is imported from Punjab at stable government subsidized rates. AKRSP advice has had some effect. Farmers are growing increasing quantities and varieties of potatoes both for sale, and to eat themselves. Seed potatoes are grown in high pasture fields for sale downcountry. While potatoes are not indigenous to the region, they are particularly hardy, and resistent to rust and other diseases. Villagers are also devoting more land and labour to fruit and nut production, especially apricots. Apricots have always been a staple food in Hopar. The fruit is eaten fresh in summer and dried in winter. Apricot pits are cracked to retrieve kernels, which are high in protein and relatively non-perishable. Kernels can be ground into paste, pressed into oil, or eaten whole. They provide nutrients which often offer the main sustenance to households throughout winter months. Recently apricots, as well as small quantities of almonds, walnuts and apples, have been exported for sale in Gilgit and downcountry.

Figure 3.4a

AGRICULTURAL LAND USE IN HOPAR —

Percentage of Terraced Land



Note Alfalfa and pasture lie outside of the terraced area.

HECTARES OF AGRICULTURAL LAND

	Wheat	Barley	Potatoes	Vegetables	Alfalfa	Pasture	Orchards
Rattal	35		10	2.5	150	50	10
Hakalshal	30	--	6	1.5	90	30	6
Holshal	[illegible]	-	4	2	60	20	4
Broshal	30	12.5	10.5	2.5	78.8	78.8	10
Ghoshushal	57.5	10	2.7	1.3	262.5	11	5.4
Total	162	22.5	33.2	9.8	641.3	189.8	35.4

**Alfalfa and pasture are not within the terraced area. They are upslope and across the Bualtar Glacier. Estimates of cropland by farmers corresponds closely with survey results. Farmers are unsure of alfalfa and pasture estimates

SOURCE: AKRSP (1986)

Cereal production has not suffered from the recent trend toward potatoes and fruit growth. Saunder (1983, p.20) notes that while population has increased about three percent per annum, subsidized wheat imports have remained unchanged. This indicates that inputs of chemical fertilizer have more than made up for the shift in emphasis toward other crops. Wheat and barley production is important not only for the grain it yields, but also for fodder. In fact the value of straw is estimated by villagers to equal that of grain itself. For that reason cereal crops and beans are seeded much thicker than optimum for grain production. As the crop grows, women thin it by over half. These thinnings, and any weeds, are used for stall fodder. Similarly grain and beans are often sown together. Later, one of the two crops is thinned for fodder. The other is left to mature. Sometimes barley is seeded at high pasture strictly for straw (the initiative to replace cereals with potato and fruit production does not consider Hopar's high fodder requirement). The 130 acres of irrigated Lucerne is livestock feed as well.

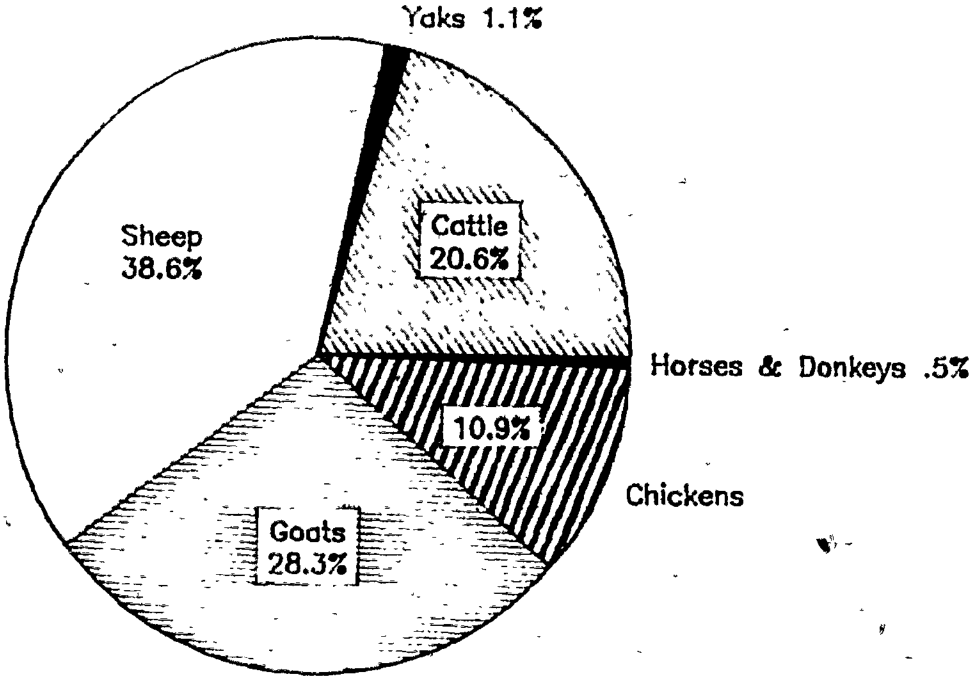
Small quantities of vegetables are grown, usually near household dwellings. Some households take pride in their gardens, and devote much effort to producing good vegetables, but on the whole the quality and variety is low. Vegetables are not perceived as important, because they cannot be preserved for winter consumption, so they receive only leftover water, manure and fertilizer. One exception is a type of kale which is grown in abundance among potatoes. It is dried to supplement the winter diet.

Broad beans are a popular crop in Hopar. They are harvested both for human consumption and as fodder. One of their functions is to replenish nitrogen in the soil. This together with intensive manuring is crucial, since farmers do not practice fallowing or regular crop rotation. Beans often serve the purpose of a rotation without sacrificing an important cereal crop. They are seeded together with wheat, and later thinned for fodder; but not before releasing valuable nitrogen into the soil. The entire cropping system must balance intensive exploitation of biomass potential with the need to maintain nitrogen and organic matter in the soil. Manure from livestock provides crucial nourishment to soil. At the same time, animals require a great deal of fodder which could otherwise be returned to the earth.

Pastoralism is more important to Hopar's subsistence economy than to most other Karakoram communities. Saunders (1983, p.37) cites the need to compensate for single crop production, and proximity to alpine pastures, as the primary causes of this. In the case of Hopar, population pressure on irrigated land may also be significant. Hopar villagers herd over 10[illegible] domestic animals (See Figure 3.4b).

Figure 3.4b

LIVESTOCK TOTALS FOR HOPAR
Percentage of Total Livestock



	Cattle	Yaks	Sheep	Goats	Chickens	Horses	Donkeys
Rattal	800	--	1300	1200	400	5	10
Hakalshal	290	5	600	600	180	1	5
Holshal	200	--	360	280	160	--	5
Brushal	610	120	1550	700	300	1	10
Ghoshushal	350	--	400	300	150	1	10
Total	2250	125	4210	3080	1190	8	40

SOURCE: AKRSP (1986)

Pastoral production is focussed on the high altitude pastures. In Hopar these range up the western slope of the valley from 3000 to 4000 m (see Figure 1.1b). Each village controls its own area of pasture land, and every household has access to it. All village animals except a few milk cows, chickens, and prized rams, kids and lambs spend from early May until October at high altitudes. Certain men are selected to accompany herds and flocks across glaciers and up-slope to the grazing area. They dwell in all male 'summer villages, and spend their time tending and milking the animals, making cheese and ghee (clarified butter) and cultivating small plots of barley and potatoes. Men make frequent trips to and from Hopar villages to exchange dairy products for other supplies. Members of a household often take turns at living in high pastures. Some households are short of available males to tend animals. They arrange for another herder to look after their livestock. He agrees to deliver a certain quantity of ghee to the owner; the rest is his fee. This procedure allows shepherds to profit from carefully tending others' animals.

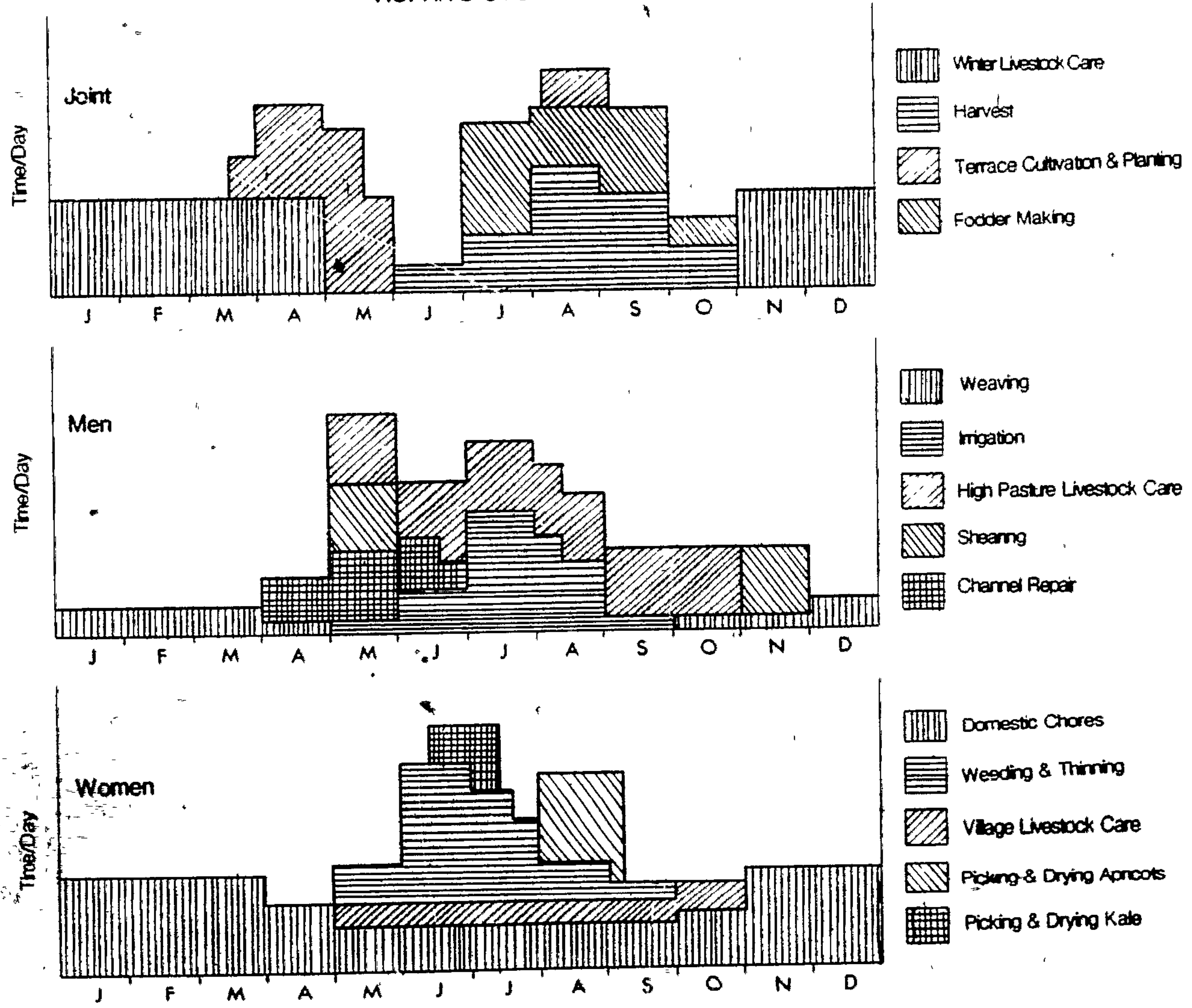
Hopar controls far more high altitude pasture than it currently exploits. The reason for this rare example of undergrazing is the need to winter livestock in the cultivated area. Villagers generally allow animals free range of the village from October to March to scavenge what they can. In addition, they receive some stored fodder, as well as water from village ponds. Unfortunately, the heavily pressured arable land and limited village forages make it difficult to maintain large numbers of animals throughout winter (Saunders,1983, p.36). Some goats or sheep are slaughtered and frozen in

November for subsequent feasting, but most livestock is kept through the winter. Consequently, animals are in poor condition by spring. Yaks and oxen are barely able to pull ploughs, and even sheep and goats are dangerously weak for bearing offspring (Saunders 1983, p.36). If high pastures were grazed to capacity widespread disease and starvation of herds would occur each winter.

Hoparis eat little meat, except in winter, because they have no way to preserve it. However, dairy products comprise a significant supplement to their primarily vegetarian diet. In addition livestock is an important means of accumulating wealth and prestige. A third crucial role of animals is as producers of organic fertilizer. Villagers are aware of the stress imposed by wintering animals on terraced land, but they believe that the production of manure more than compensates for that stress. In essence, neither pastoralism nor agriculture can survive without the other in the traditional economy. This is gradually changing as chemical fertilizer becomes more widely used. Still, pastoralism plays a social role beyond mere agricultural production. It, like irrigation is a communal activity which is dominated by males. Disintegration of pastoralism would result in an imbalance in social relations and in the division of labour between men and women. Figures 3.4c and 3.4d outline the labour division for Hopar, and relate it to growing season.

Figure 3.4c

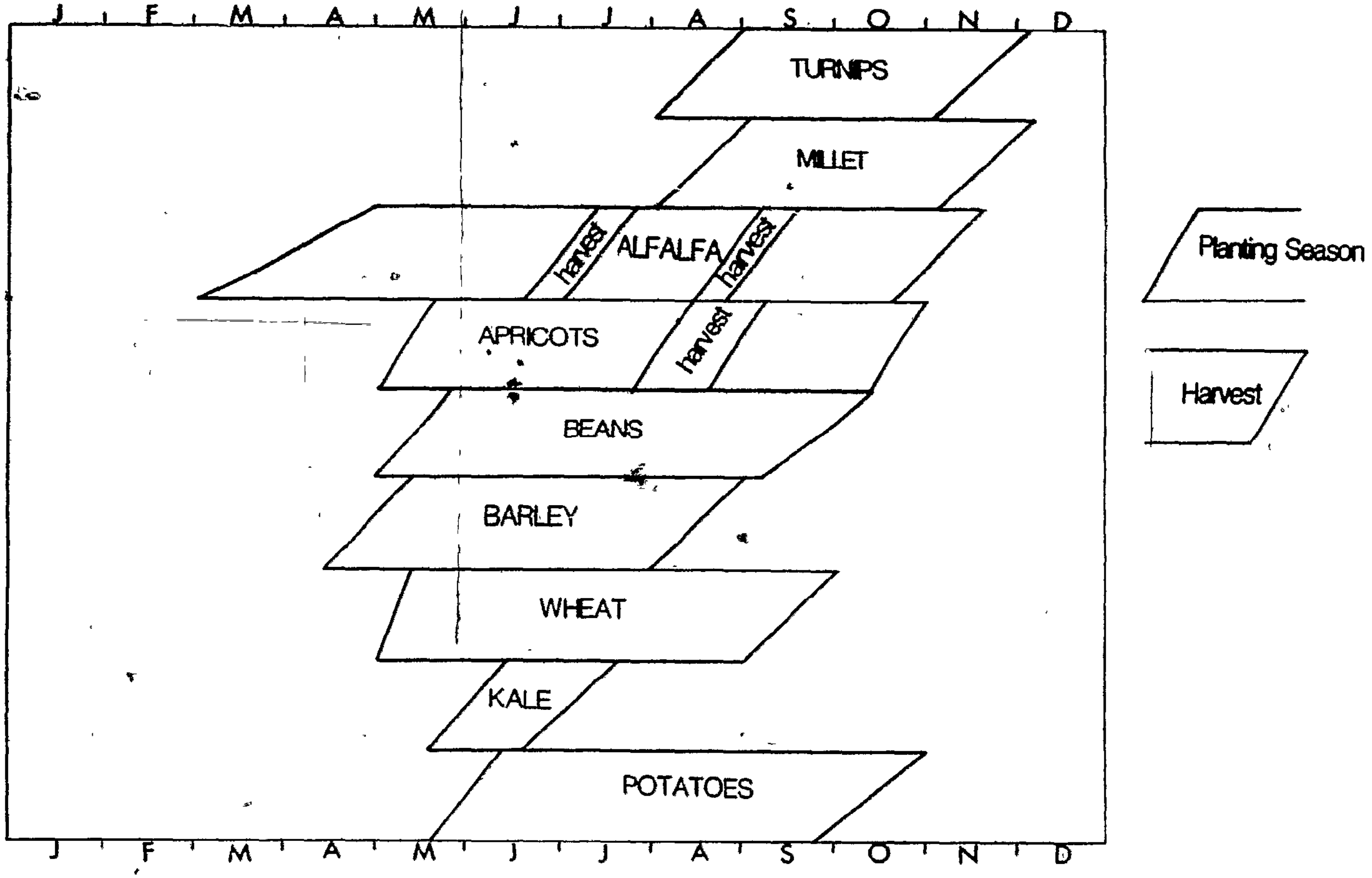
HOPAR'S CYCLE OF AGRICULTURAL LABOUR



SOURCE: Personal Communication with Villagers (1986)

Figure 3.4d

CROPPING SEASONS AT HOPAR



SOURCE: Personal Communication With Villagers (1986)

3.5 ECONOMIC RELATIONS WITH THE REGIONAL ECONOMY

Subsistence agricultural and pastoral production cannot sustain the community of Hopar; nor do most residents desire complete subsistence. Hoparis are eager to partake of the currency, technology, and manufactured goods offered by Pakistan's economy. Unfortunately, they are at a stage where desire for imports exceeds the ability to successfuly produce to trade for them. Consequently, the community relies heavily on government subsidized staples, development aid, and cash from migrant labour.

Hopar's current situation resembles a transitionary stage between peasantry and capitalism. Most interaction with the capitalist economy of Pakistan is through imports. Agricultural and labour exports help to pay for these. Both imports and exports are outlined below.

(1) Export of labour – Labour is Hopar's most important export. It provides cash to households, and allows the community to participate in the regional economy centred in Gilgit. AKRSP (1985, p.2) estimates that 20% of households obtain significant cash income from non-agricultural employment. This seems low for Hopar, where at least one-fifth of all men are employed seasonally outside of the valley. The steadiest and most common employer is Pakistan's army. Three year enlistments provide not only cash, but also a certain amount of literacy and sophistication concerning the outside world. Retired soldiers are respected, and often hold important positions in the village. Another group of Hopar males work intermittantly or seasonally in Gilgit or downcountry. Manual

labour such as construction, factory work, or road building are common occupations. Only rarely do migrant workers sever ties with the community, so most currency returns to Hopar. Usually the purpose of leaving for several months each year is to increase future status in the settlement, not to start a new life elsewhere. Portering is another important source of revenue, especially for men who wish to remain close to home. Young men often porter between agricultural or pastoral duties.

(2) Export of Agricultural Produce– Both crops and animals are exported from Hopar. All villages sell a few cattle, sheep, and goats outside of the village, but Brushal alone has obtained contracts to provide meat to army and construction crews working in Hunza. Hakalshal sells much alfalfa hay to herders in Hunza. All villages export fruit and nuts. Unfortunately, the Gilgit market is often flooded with produce, and fruit spoils in shipment to the lowlands. Dried apricots and almonds are relatively non-perishable, so they are shipped downcountry in large quantities. In addition, seed potatoes grown in high pastures fetch good prices in lower valleys. This is because potatoes grown above 3000 m resist potato virus diseases (Saunders, 1983, p.27). They are marketed by AKRSP. That Hopar cultivators are gradually learning to produce and market to meet regional and national demand is an indication of the transition from peasantry to capitalism.

(1) Import of Cash – The fundamental import to Hopar is cash. It allows the community to participate in the local economy. Most currency is earned

through labour, although some comes from sale of produce. In addition, grants from government agencies and development institutions have been important sources of cash income. These are in the form either of outright gifts, or payment for development projects. Brushal village, for example, has received grants totalling 283,292 Rupees since 1959 (Semple, 1986, p.13). In purchasing power this sum is equivalent to about 50000 Canadian dollars.

(2) Import of Produce– Certain foodstuffs, including tea, sugar and salt, have always been imported to Hopar. Today a wider array of fruits, vegetables and sweets makes its way into Hopar. All villages have small shops which intermittently sell these goods, as well as trinkets, cigarettes and personal hygiene items. Government subsidized wheat is the most important imported food. Whiteman (1986, p.101) estimates that subsidized wheat accounts for 30% of cereal consumption in Gilgit District.

(3) Import of Agricultural Technology – Chemical fertilizers, introduced varieties of seed, and new breeds of livestock are all being imported to Hopar. Most farmers use some chemical fertilizer, primarily for nitrogen replenishment. Hybrid seeds which thrive on enriched soils have accompanied fertilizers. Varieties of potatoes and cereals indigenous to other high altitude environments have also been introduced. Both seed and fertilizer is subsidized by development organizations. Local varieties of livestock are well adapted to the environment but produce meat and milk inefficiently. Some effort has been made to import male sheep, goats, and cattle to improve the flocks and herds.

Brushal is currently arranging the purchase of twelve Canadian Jersey cows through AKRSP.

(4) Import of Manufactured Goods – The past twenty years has seen the introduction of many modern, mass produced goods. Today most clothing is imported, or at least made from imported cloth. Traditional wooden, horn, or bone farm implements and kitchen utensils are being replaced by iron, plastic and alloy equivalents from the outside. Many kitchens, especially in wealthier households have iron cooking stoves, rather than the customary hearth and smoke hole. Recreational items, such as radios and cassette players are also common imported acquisitions.

(5) Import of Organization – AKRSP Village Organizations are important economic inputs to Hopar. They provide a means to integrate individual households into a competitive economic unit. Their affiliation with AKRSP makes village organizations an effective vehicle for marketing produce.

(6) Import of Public Works – Government agencies have buil[illegible] have paid to build, several public installations in Hopar. These include a Northern Area Works Organization rest house, primary school, dispensary, and jeep road to Nagyr and the Karakoram highway. Some villages have cisterns to store water during winter. Hakalshal enjoys piped water from a spring above the village. Other villages are planning similar piped water lines. The most significant public works are irrigation channels. These are not built by outside agencies, but their maintenance is facilitated by government or AKRSP supplied dynamite

and implements.

(7) Import of State Education - Male children and youths are increasingly exposed to lowland values through formal learning. A school in Hopar teaches to fifth grade. Girls do not attend, and boys are not required to enrol but most attend at least occasionally. A fraction of these continue to tenth grade in Nagyr, and some attend a degree college in Gilgit. About a dozen youths are currently enroled in university downcountry. Formal education is quickly becoming a factor in prestige and social standing in Hopar, especially because successful participation in the regional economy demands some literacy, and a moderate command of Urdu and arithmetic.

CHAPTER FOUR: IRRIGATION WATER SUPPLY AND DISTRIBUTION

4.1 WATER SUPPLY

4.1.1 Introduction– The people of Hopar Valley have, over 900 years, transformed a rugged and arid high mountain valley into an agricultural oasis of 280 hectares of cultivated terraces and 130 hectares of irrigated alfalfa pasture (see Figure 2.1.1). In so doing they have overcome the environmental challenges of rough and unstable terrain, low precipitation, short growing season and relatively distant, low quality water supply. Much of this accomplishment is due to the painstaking development of an irrigation network of over 200 kilometres of channels which link meltwater from snowfall above 3600m to terraces between 2500 and 3000 metres, where temperatures are warm enough for single crop cultivation.

The areal extent of intensive cultivation is generally limited to an upper threshold of about 3000 metres by altitudinal temperature gradients (see Whiteman, 1985, for a discussion of altitudinal cropping zones in the Karakoram). However, some potatoes, green-fed grain and fodder crops are grown at summer pastures as high as 3400m. Meanwhile, at and below these elevations agriculture is inhibited by low precipitation and high evaporation which combine to produce a negative moisture balance for the period of peak water need. Only by utilizing meltwater from snow and ice accumulating in the more humid environment above 3600 metres is agriculture possible. Most of this accumulation is released between mid May and early August. Thus, Hoparis are able to exploit climatic conditions from two elevation zones, one with favorable temperatures and the other moisture supply, to create a single favorable crop–growth environment.

Several conditions of Hopar's unmodified meltwater supply prevent it from being optimum for irrigation:

a) poor accessibility of water to fields, both vertically and horizontally;

b) uncertainties of timing, in volume and in consistency of discharge; and

c) water quality problems in the form of high sediment and low temperature, and

d) vulnerability to failure in slope materials above channels, and channel walls themselves.

However, irrigators are able to confront and modify, if not remove, these problems at three levels within the channel network:

1) primary channels flowing from the meltwater stream to the cultivated area;

2) village level channels distributing water within the lands of individual villages; and

3) field level ditches which channel water between and within individual plots.

The effect of manipulating the flow of meltwater at a series of levels is to create an irrigation supply which is increasingly clean and warm, less variable, more manageable, and more predictable as it flows toward the fields. This chapter describes Hopar's meltwater supply, and examines the way in which farmers ameliorate its negative characteristics and their attendant risks at various levels of the channel network.

4.1.2 Hopar Nala Basin– Most of Hopar's irrigation water is supplied by melt from permanent snow and ice patches, and seasonal snow cover accumulated in a series of cirques between 3600 and 4900 metres (see Figure 1.1b) Intermittant streams drain from these into a steep east-facing gully-cum-gorge cut by a meltwater stream, locally called a nala. The catchment area is approximately 11.5 square kilometres. About 2.1 square kilometres of this is covered by ice. Another 6 square kilometres is covered by permanent snow. Seasonal snow covers the entire basin in winter, but retreats from a lower elevation of about 3600m in early April to 4100m by mid July. Local persons indicate a maximum transient snowline retreat to 4500m. Above that altitude and in shaded or north-facing side-valleys accumulation appears to equal or exceed melting. Avalanche redistribution downslope from the higher, steeper areas contributes to dense, dirty snow deposits as far down as the mouth of the basin.

4.1.3 Snowfall Outside Hopar Nala Basin– Winter snowfall on the Western slopes above cultivation and outside of the main source basin supplies small quantities of meltwater to Hopar. These steep slopes receive direct radiation from sunrise to mid-afternoon, so that by the middle of May almost all snow has melted, except in a small area to the north of Hopar's main meltwater basin. This micro-basin, between 3800 and 4100 metres is sufficiently high and shaded to retain the majority of its snow until early July, after which it releases peak afternoon discharges of approximately 0.2 cubic metres per second (cusecs) until late August. Hoparis have diverted the small meltwater stream into their irrigation system.

The cultivated area of Hopar receives snow accumulations of 60 to 90 centimetres in the winter months, which,according to villagers, is usually gone by early March. In 1986, late snowfall occurred, but quickly melted, in early May. Germination and early growth in some fields relied solely upon moisture from that melt. The same was observed in May 1987 (Ken Hewitt, personal communication).

4.1.4 Hopar Nala Water Flow– Hopar Nala flows continually. However, between November and March discharge is less than 0.1 cusecs. It begins to increase near the end of March, when shallow snow patches and avalanche deposits near the mouth of the basin start to melt. Flows increase as greater radiation, and the upward migration of warmer temperatures, allow melting at altitudes with progressively deeper and more extensive snow accumulation. However, during March, April and early May melting is very uncertain and highly irregular. By late July melting occurs throughout the source basin. This includes avalanche deposits at 3600 metres and perennial snow and ice patches above 4900 metres. As a result, peak afternoon discharge then reaches 11 cusecs. Melting of this magnitude occurs into early August, causing rapid depletion of the remaining seasonal snow pack. Thus, in late August a decline in melting corresponds with diminishing snow surface and decreasing heat input until base winter flow resumes in November.

The period of substantial melt is prolonged by the existence, over a variety of aspects and elevations, of several types of snow ranging from seasonal snow through perennial snow and avalanche deposits to a core of about 2.5 square kilometres of glacial ice. It should also be noted that discharge variability throughout the season and between seasons, is relatively great because discharge through Hopar Nala is largely (not wholly) from seasonal snow, rather than perennial snow and ice (see Whiteman,1985 and Young,1977 for a discussion of melting variability with regard to snow density).

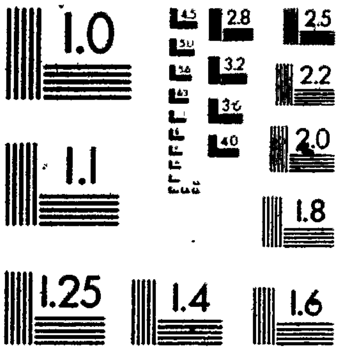
Several observations may be made concerning Hopar Nala's diurnal flow. The predominant aspect of the basin is easterly, so peak daily discharge occurs relatively early in the day; around 1400 hours in mid July (This contrasts with observations at Askole, a village in Baltistan with similar altitudinal characteristics but a south-facing aspect. There peak flow occurs around 1730 hours). Early onset of melting is also enhanced by particularly steep east-facing valley walls which allow almost perpendicular exposure to direct radiation early in the morning.

The presence of a variety of slopes, aspects and snow types has the same effect upon diurnal melt as it has upon seasonal discharge; it tends to prolong melting, and diminish peaks. Exposed ice and avalanche snow respond to energy input more quickly than seasonal snow, because they tend to have lower albedo. However, they may receive lower inputs of radiation because of their small area compared to mass, and their position down in the gorge where shade and cold air drainage inhibit warming. Relatively fresh snow reflects most incoming radiation, and is able to absorb considerable water before releasing it downslope (Young,1977). These factors combine to produce a broad, relatively flat discharge curve (see Figure 4.2.3).

As the melt season progresses snow both compacts and collects dust and debris. The consequent reduced albedo and higher absorption capacity results in a diurnal melt which shifts toward morning as the summer progresses. Increased exposure of dense and dirty avalanche deposits, perennial snow, and ice as seasonal snow melts enhances this trend (Young 1977). Discharge measurements taken in 1986 indicate that peak discharge migrated approximately two hours toward morning from mid May to late July. This migration follows the path of sun height penetrating the gorge as summer progresses.

4.1.5 Water Characteristics- Meltwater entering irrigation systems is characterized by low temperatures and high sediment. During the period of investigation temperatures at Hopar ranged from 0.5 degrees celcius where the highest channels cut off from the nala, to 7.0 degrees at the lowest cutoffs. Sediment studies were not conducted. However, it is apparent that steep and unstable slopes, and heavy avalanche activity contribute to high bed

2



and suspended loads in Hopar Nala.

4.2 WATER SUPPLY AND IRRIGATION DEMAND

4.2.1 Introduction– Meltwater flow through Hopar Nala is most useful to the community if supply meets demand with minimal input of capital and labour. This relationship is summarized under four categories: volume, timing, accessibility, and water quality.

4.2.2 Volume– Hopari irrigators require sufficient volume throughout the irrigation season, and predictable flows from year to year. The main nala carries abundant flow for the period of regular, intensive irrigation from June 15th to August 1st, and for the progressively lighter irrigation that occurs until potato harvest in September. Flow is insufficient from mid May to mid June. However, early melt from snow coverage outside the nala-basin helps to ameliorate water shortage in terraced areas, and triggers alfalfa growth on slopes above 3000 metres.

Volume of melt-season flow is more predictable in Hopar than in rainfed basins. Several studies indicate that glacier meltwater tends to regulate streamflow by compensating for vagaries in temperature and precipitation (Young, 1977; Meier, 1973). This statement holds true for Hopar, although it is primarily snow covered, because when seasonal snowfall fails perennial snow and ice melts more readily. It is likely that the result is a relatively consistent flow from year to year, which does not depend greatly upon variable

Karakoram precipitation conditions. Unfortunately for irrigated agriculture, this consistency applies more to total volume of seasonal melt than to its timing.

4.2.3 Timing- The average seasonal timing of meltwater supply to Hopar is excellent relative to precipitation timing in the agricultural zones of the Upper Indus River Basin. In contrast to precipitation, which occurs primarily during the cold season, melting above Hopar coincides well with maximum temperature, and crop water requirements (see Figure 4.2.3).

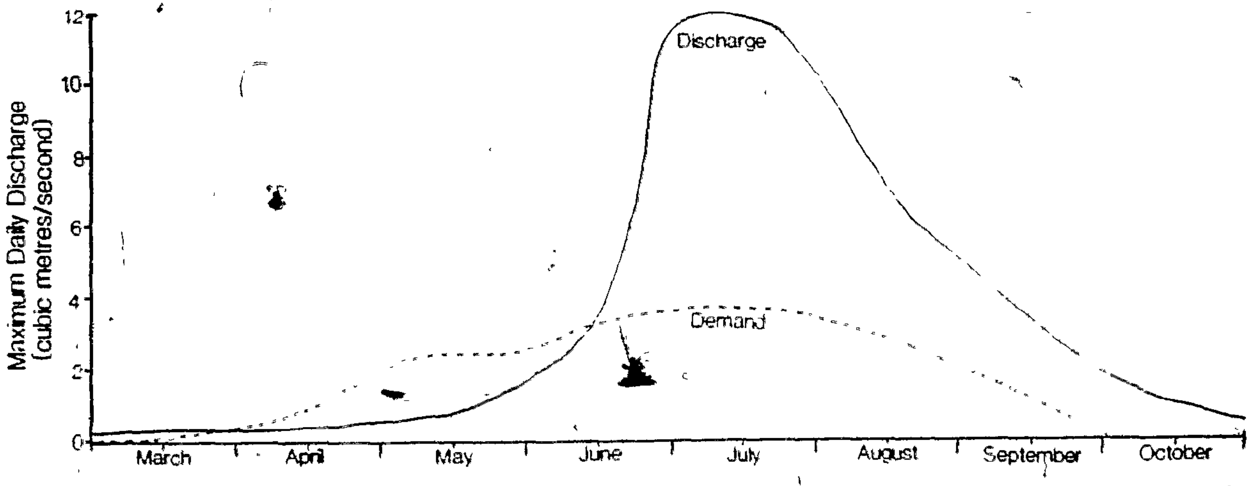
Average diurnal discharge is also close to ideal for irrigation. A relatively low, east-facing snow accumulation zone means that farmers can begin irrigation early in the day while evaporation is low, and finish before sundown. Since the release of meltwater peaks and declines gradually, flows rarely reach hazardously high levels, and irrigation can occur throughout the day.

Figure 4.2.3

HOPAR NALA DISCHARGE & IRRIGATION WATER DEMAND

Estimated Maximum Daily Values

(1986)



SOURCE: Field Investigation, Butz 1986

Spring climate was uncharacteristically cold and wet in 1986. Therefore, the discharge curve is skewed toward autumn.

While the timing of discharge suits irrigation demand on average, inconsistency in timing due to winter snowfall characteristics and summer melting conditions is problematic. If most winter snowfall occurs early, it will settle and accumulate a thin dusting of debris. The consequent decrease in albedo may cause peak melting before peak irrigation need. If, on the other hand, major snowfalls occur toward spring, melting will be inhibited by relatively great albedo (Meier,1973;Young,1977). In basins where fresh snow covers perennial snow and ice, low seasonal coverage causes earlier and higher summer melt. In addition, cold and cloudy spring conditions delay and inhibit melt. If certain conditions combine villages may receive most of their irrigation before or after peak irrigation demand. For example, in 1986 Hopar's spring weather conditions were unusually cold and wet, and combined with heavy and late winter snowfall. This produced seasonal flow which was, according to locals, exceptionally low until mid June, and slightly below average throughout the irrigation period.

4.2.4 Accessibility- The main part of the Hopar meltwater basin begins approximately 600 metres above and one kilometre distant from the upper limits of cultivation. It is therefore much more accessible than many Karakoram villages, especially since the nala dissects the lower end of cultivation. At the same time building, maintaining and repairing channels from the stream to cultivation across steep, rocky and extremely unstable terrain poses important financial, labour, and organizational difficulties to the community.

4.2.5 Water Quality- Crop cultivation is subject to two water quality problems: low temperature and high sediment load. Water temperatures never exceed two degrees celcius at the highest channel cutoffs, and remain between four and seven degrees at lower cutoffs. Unless these temperatures increase before water reaches crops, soil temperature and growing season are significantly decreased.

Meltwater irrigation systems are commonly subject to high sediment loads (Whiteman,1985). Hopar is no exception due to steep slopes, unstable terrain, and abundant avalanche activity. If sediment is not trapped above the cultivated area, it has the potential to clog channels, damage water mills, choke seedlings, and raise terraces. At the same time some sediment input is required to maintain non-organic soil constituents.

4.2.6 Summary- The community of Hopar depends on a water supply which seems in some aspects ideal for irrigation, and in others very problematic. The following sections examine how the irrigation system ameliorates water supply problems through levels of increasing meltwater manipulation and adaption.

4.3 PRIMARY CHANNELS

4.3.1 Introduction- Hoparis begin controlling and distributing flow at the level of primary channels. This involves overcoming important physical problems, and maintaining certain social imperatives. Physical problems include:

a)directing water from the mainstream into channels;

b)finding and constructing a route from cutoffs to terraces; and c)maintaining channels against geophysical hazards.

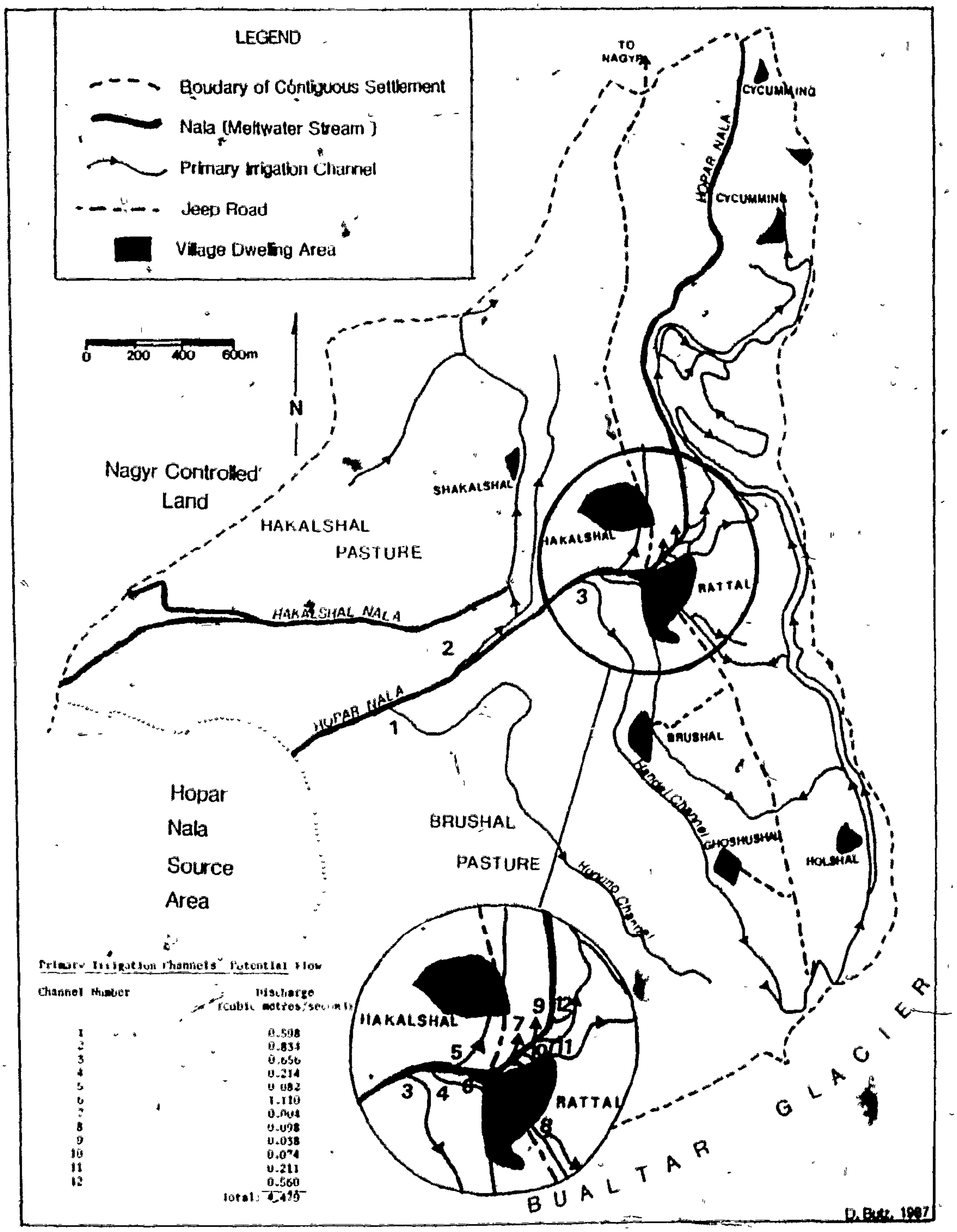
These are discussed below. Section 4.3 examines the following social necessities of primary channel water distribution: a)efficient labour organization; and b)equitable allocation of water among villages.

4.3.2 Physical Problems- Twelve primary channels diverge from the nala between 3150 and 2550 metres, and direct water to a network of smaller channels within village areas. Potential flows range from .004 to 1.1 cusecs. Combined they provide a maximum of 4.5 cusecs to irrigated lands (see Figure 4.3.2a).

Channels which tap the nala at high elevations tend to be larger, longer and water greater areas than those originating where it cuts through cultivation. In fact, the four highest channels supply water to 60 percent of the cultivated area, and distribute 51 percent of irrigation flow. Due to their size, importance to agriculture, and the fact that they traverse steep and unstable terrain on slopes above terraces, these channels especially require special attention and skill in channel engineering and maintenance.

Primary Irrigation Channels

Figure 4.3.2a



Primary Irrigation Channels' Potential Flow

Channel Number	Discharge (Cubic metres/second)
1	0.598
2	0.834
3	0.656
4	0.214
5	0.082
6	1.110
7	0.004
8	0.098
9	0.038
10	0.074
11	0.211
12	0.560
	Total: 4.479

A major engineering problem encountered by irrigators involves directing water from the turbulent and variable meltwater nala into channels which require gentle and consistent discharge. If primary channel flow is not controlled from its source flooding, channel erosion, slumping of downslope walls, and inequitable allocation result. Control is achieved by merging channel and stream in the following way.

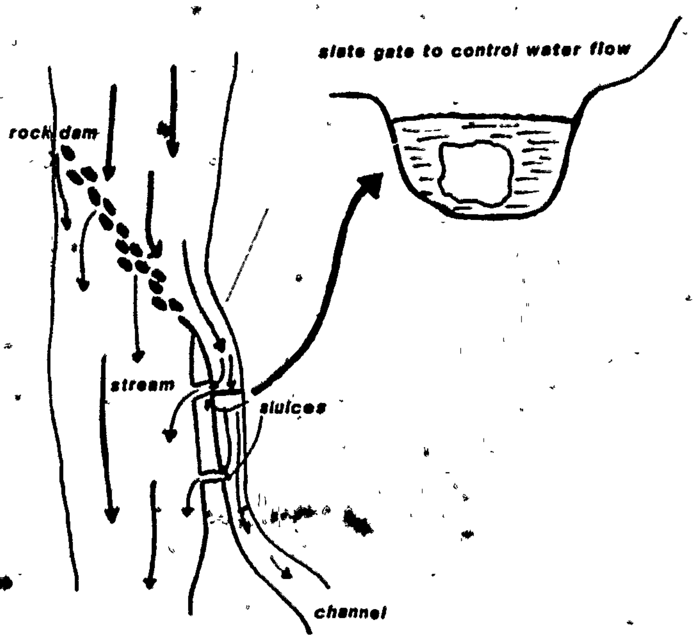
Channels are constructed to traverse gully sides above and almost parallel to the nala itself, but at a more gradual slope. Where the two meet rocks are piled across the nala following the angle of the merging channel, so that some water flows into the channel. Volume of water allowed to enter the irrigation system is controlled by altering the density of this simple dam. Small sluices built into channel walls directly downstream from the junction contribute to additional regulation of flow. Vertical slabs of slatey rock which block sluices can be raised or lowered to regulate water levels in the channels. Both cutoff dams and sluices ensure that water flows through primary channels at the desired level (see Figure 4.3.2b).

Lack of suitable cutoff sites within the upper elevations of cultivation, and the need for gravitational energy to transport water to slopes across the valley necessitates the construction of channels within and across the unstable and erosion prone nala gully. Slumping hazards within this gully are ameliorated by selective routing of channel paths, and resilient cross-sectional channel design (see Figure 4.3.2c). Irrigators perceive that a channel slope of about three degrees minimizes both erosion and sedimentation of channels. However a greater average slope is needed to transport water from cutoffs as high as 3150 metres to below 2900 metres. Hoparis utilize bedrock outcrops to overcome this problem. They dig channels across debris slopes at about three degrees until bdrock is encountered. Vertical grooves are blasted or chopped down the rock face, allowing water to fall several metres before entering a lower channel. Where outcrops are not available channels are lined with slabs of slate. This helps maintain erosion resistant channels between ten and 20 degrees. Occasionally long distances of bedrock must be traversed. In these instances channel builders blast flumes into the outcrop at slopes up to twenty degrees. By alternating short distances of carefully located steep flow with long almost horizontal sections, channels avoid potential erosion and traverse the distance from nala to terraces. Villagers accept a certain amount of sedimentation as a necessary evil involved with preventing the much more catastrophic effects of erosion. Sediment can be cleared from channels without major disruption of flow. In addition, a thin layer of fine silt helps prevent saturation through channel walls.

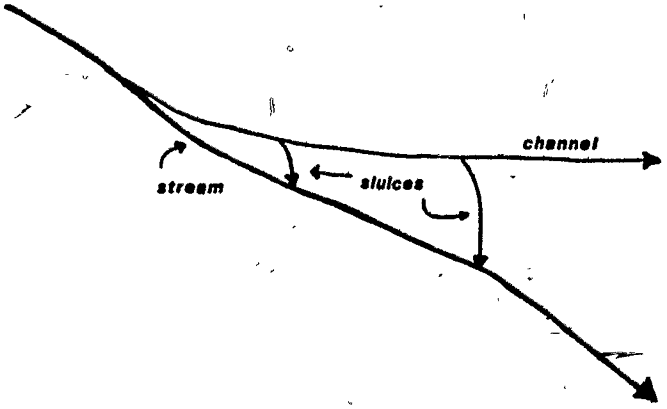
Channel Cutoff

Figure 4.3.2b

Top View



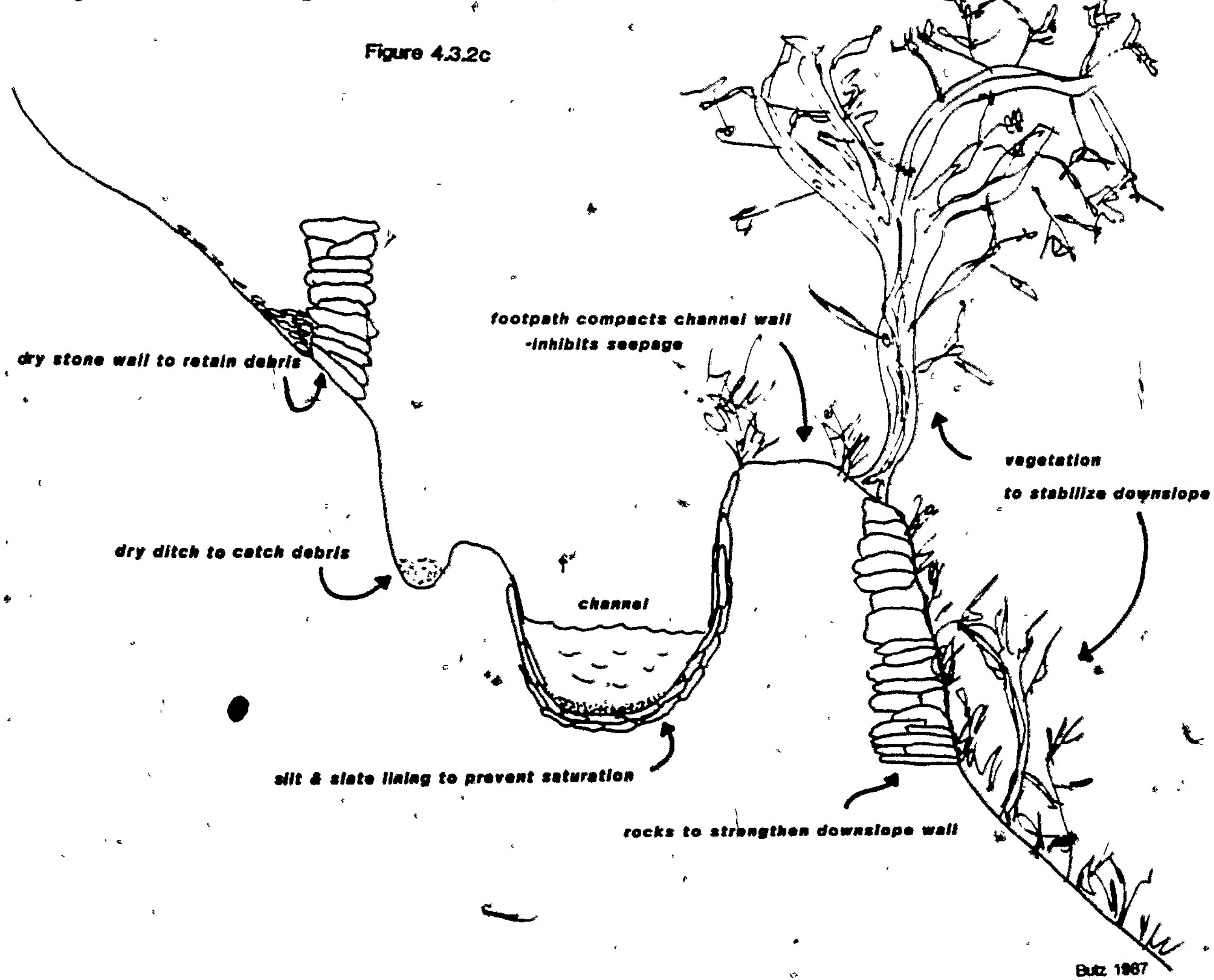
Side View



Butz 1987

Primary Channel Design -Measures to prevent hazard damage

Figure 4.3.2c



4.3.3 Response to Geophysical Hazards- Design and construction are only the first steps in the process of supplying water through primary channels. The greatest part of time and effort is spent maintaining channels, and repairing damage caused by mass wasting of channel walls, or obstruction by eroded material from above. Channel failure is caused by:

a) erosion of channel beds resulting from rapid flow;
b) downwasting of channel banks due to overflow;
c) saturation of channel walls caused by extended periods of flow; and
d) fracture of channel walls as a result of seismic and nearby dynamite blasting activity.

Channel design minimizes these stresses. In addition vulnerable sections are patrolled regularly, so that flow can be diverted back to the mainstream when signs of potential failure appear. Even so, severe tremors, saturation, and accidental overflow occasionally cause channels to break. When this occurs manpower must be organized to repair the damage quickly (see Section 4.3.4).

Obstructions caused by activity upslope from channels span the entire frequency/magnitude continuum. Small sand and debris runs are most frequent. Their disruptive effect is virtually eliminated by building drystone walls and digging ditches just upslope from channels. These are cleared periodically without stopping water flow. High magnitude but lower frequency events are the most serious impediment to irrigation. Avalanche triggered debris flows destroy tens and sometimes hundreds of metres of the highest channels almost every winter. Occasional summer landslides have even greater disruptive impacts because they occur during times of high water need.

Dam burst floods are a high magnitude, but extremely low frequency hazard. In 1979 the meltwater nala was blocked by some obstruction, probably avalanche debris, above the highest irrigation channel cutoff. Meltwater forced a tunnel through the dam, so that water flowed into the irrigation system as usual. Hopar villagers were not aware of the obstruction. Melting upstream from the dam exceeded discharge through the dam's opening, and a lake formed. Eventually, the force of the meltwater reservoir burst the dam, causing a major flood and mudflow. Several villagers were killed, 60 to 70 households were left homeless and 30 to 40 hectares of irrigated land were covered with debris. Some of the farmland has not yet been reclaimed. Moreover, the entire irrigation system suffered major disruption; channel cutoffs were washed away, and primary channels were covered with debris. Villagers cannot prevent natural dams in the upper area of their meltwater basin. Gabion baskets were constructed subsequent to the event to contain floodwaters if another damburst occurs. However, it is unlikely that they will work. Villagers can prevent loss of life and property by predicting the occurance of these events. They can diminish losses of agricultural produce by quickly reclaiming land and reconstructing channels and channel cutoffs.

Reconstructing, and sometimes rerouting, sections of channel buried under several metres of rubble is the largest single task villagers face in their efforts to maintain a consistent supply of water to cultivated lands. Large requirements of labour, as well as capital for tools and dynamite, stress community resources, and exceed the organizational capability of several Hopar villages. Section 4.4.2 examines this problem in terms of villages' ability to organize manpower.

4.3.4 Social Structures- Both equitable water allocation strategies and effective means of organizing labour are necessary at the level of primary channels. The first is achieved smoothly and efficiently according to the traditional system of water rights. Conversely, labour organization has become a major problem in recent decades. Traditional structures of leadership and authority have disintegrated. This inhibits the ability of villages, and the whole community, to maintain and repair vulnerable high channels.

Hopar historically formed a part of the feudal kingdom of Nagyr. Under this system all land belonged to the mir, who granted it to villages (see Chapter 2.3.2). Numbardars (village headmen) in each village acted as the mir's representative, and were responsible for organizing labour to build, repair, and maintain terraces and channels. With feudal authority behind them these leaders could rapidly assemble channel building and repair teams from within the village population. When the damage was beyond the capability of a single village the feudal system's centralized power united teams from several villages.

The feudal authority of Nagyr, and elsewhere in Northern Pakistan, has diminished since partition in 1947, and it is no longer officially recognized by the Pakistani government. This has resulted in many improvements for Hoparis, however it has had the negative effect of removing the traditional chain of authority and social structure without replacing it with another. Numbardars and an advisory council of elders still exist, but without their traditional influence as representatives of the mir. What customary authority they retain now competes with the increasing power of Islamic maulvis, retired army subardars, jeep drivers, shopkeepers and other villagers who have cash resources and access to political and economic influences outside the community. Members of similar age, social, and economic strata support certain leaders and certain objectives. Many of these objectives involve pursuing occupation in the cash sector of the regional economy, rather than traditional subsistence agriculture. The consequent non-integrated community structure has neither the cohesiveness nor the immediately available labour needed to reconstruct large sections of damaged channels. The result has been a gradual disintegration of the highest and most vulnerable sections of the irrigation network.

The history and trend described above is common to many high Karakoram villages. In 1983 the Aga Khan Rural Support Program recognized the situation and began to encourage villages throughout the region to develop self-governing organizations which would pool human, agricultural, and capital resources to the benefit of the combined subsistence/cash economy (See Appendix VII). AKRSP efforts have had varied success in Hopar, depending mainly upon the willingness of different authority figures to work together. At least three of Hopar's five villages claim to be benefitting from increased organization. That Hopar's highest channel underwent major reconstruction in 1986, bears out these claims. In addition, there is talk of building another large cutoff further upsteam. While these initiatives have had success in organizing labour to rebuild they cannot solve the problem of an agricultural work force which is decreasing in size while demand for their labour increases.

Irrigation demand never exceeds about two-thirds of the capacity of primary channels. Therefore, allocation at the inter-village level of these channels is necessary only between May 10th and June 15th, when demand exceeds meltwater supply. For the rest of the irrigation season villages may tap primary channels at any time. Allocation procedures during the period of shortage are summarized in Table 4.3.4 (see Figure 1.1c when referring to this table).

Table 4.3.4

PRIMARY CHANNEL WATER ALLOCATION
(All Hopar Villages)

DEFICIT CONDITIONS- Early April to Mid June

- -Hununo channel, which waters only alfalfa, is not opened until June 15th. Other channels bypass alfalfa pastures. During this period alfalfa gets some moisture from melting directly upslope. In addition, alfalfa is considered hardier and less important than food crops.

- -The five largest of the remaining channels receive water each day at consistent levels throughout daylight hours. These levels vary from day to day depending on daily melting conditions.

- -The remaining six channels water very small areas. During periods of water shortage they flow only a few hours each day, or once every several days.

- -Handel channel supplies water to three villages, so it flows consistently every day. Villages share the right to tap flow from Handel. Brushal receives water for three days, Ghoshushal for two, and Holshal for three. This timetable continues throughout times of shortage.

- -At night all major channels receive low volumes of water. This distributes some water to all households and villages. No field irrigation occurs after sundown. Seven of the primary channels converge in Cycumming, a wooded area at the low, northeast end of the valley. This area is irrigated by residual flow each night.

- -Farmers have no water rights apart from their turn as members of a village. Farmers who water out of turn are fined by the village organization. At times, especially in spring, when some channels in a village are not clean or repaired no villager may use water for irrigation.

- -In times of shortage water flow is diverted to mill races. This is particularly common during early spring when channels first begin to flow at low levels.

SURPLUS CONDITIONS- Mid June to October

- -Main channels flow consistently each day.

- -Smaller channels flow as the water is needed.

- -Any village may tap water from a primary channel at any time.

- -Night flow is used only to irrigate Cycumming, and for household purposes.

Personal Communication With Villagers (1986)

4.4 SECONDARY CHANNELS

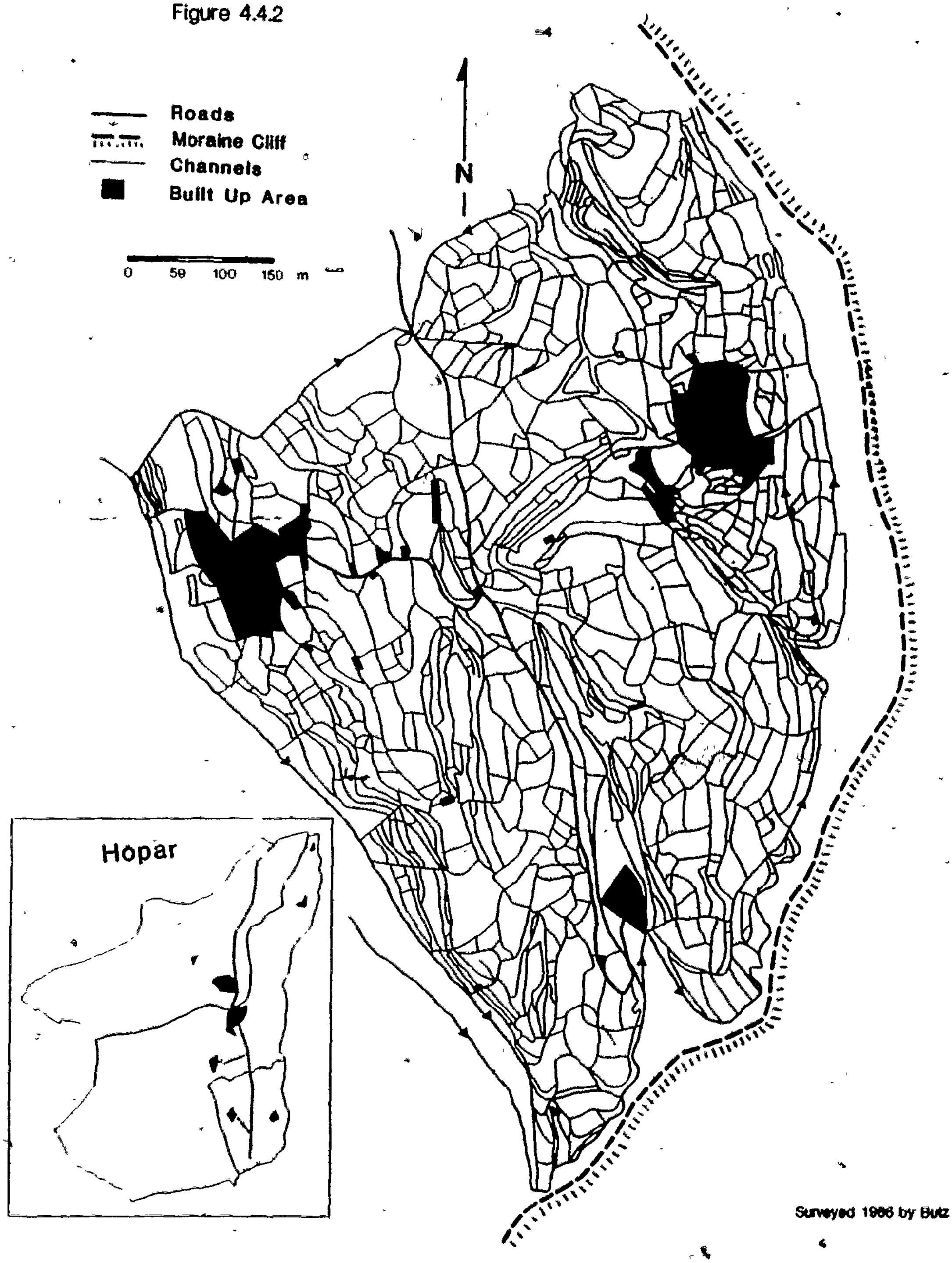
4.4.1 Introduction– The greatest access and control problems of Hopar's irrigation system are dealt with through primary channels. They deliver an equitable and predictable supply of meltwater to the periphery of cultivated lands. Secondary channels distribute that supply within individual villages to all fields. These channels flow through a well developed and geologically stable terrace network, so the hazards which plague primary channels are not significant at this level, except for a long narrow strip at the far east side of cultivation (see 4.4.3). As a result irrigators are able to develop a secondary system that increases control and access, and improves the quality of water entering fields. The following discussion refers to:

a)physical characteristics of the secondary system;
b)maintenance and repair; and
c)water allocation

4.4.2 Physical Characteristics of the Secondary System– The channel network of Hopar's two smallest villages, Holshal and Ghoshushal, is illustrated in detail on Figure 4.4.2. This area provides an example of the geophysical and landscape characteristics of Hopar's cultivated area.

Channel Network in Ghoshushal & Holshal Villages

Figure 4.4.2



Surveyed 1986 by Butz

Channel patterns are closely related to terrace structure and distribution. Indeed, all channels follow terrace contours and border them on at least two sides. Very intensive terracing is necessary to grade natural slopes up to fifty degrees. In fact, the 40 hectare cultivated area of Holshal and Ghoshushal is dissected by 680 terraces, with an average area of .06 hectares. The resultant agricultural topography averages about five degrees, with maximum cultivated slopes of 20 degrees. It is this intricate terrace pattern which facilitates a dense and relatively stable water distribution network over 27 kilometres in length.

Individual channels flow slowly at shallow slopes with discharges ranging between .001 and 0.1 cusecs. Where water falls between terrace levels flat rocks line the grade to inhibit erosion. Irrigators ensure low velocity by constructing wide, shallow channels with a large perimeter/cross section ratio. This increases sedimentation, and allows maximum radiative and convective warming. In addition, each village has one or two shallow ponds which help to heat water and decrease sediment load. Ponds are used mainly for household purposes, and as low flow reservoirs, but they also release irrigation water downslope. The result of efforts to increase wetted perimeter of channels and ponds, and to decrease velocity of flow is a temperature rise of seven to ten degrees, and a noticeable drop in suspended sediment. Unfortunately, these measures have the negative impact of increasing evaporation from the secondary network. All irrigation water is supplied to Hopar from the west, however east and west-facing slopes as well as the valley bottom are cultivated. The problem this unique situation presents to a gravity fed irrigation system is overcome by two major channels which follow a circuitous path around the southern curve of the valley. The ridge these channels follow is broken occasionally, so stone, wood and earthen aquaducts have been built. Several other raised channels cut across the valley floor, and maintain the elevation needed to water lower eastern slopes. All main village channels on the south side of the nala converge in Cycumming, a steep wooded area at the north-east end of Hopar. Residual water, rather than being wasted, enters these 40 or so hectares and irrigates the main fruit and wood producing area. Forested slopes are relatively erosion resistant, and trees can survive large moisture variations, so water is left to flow among the groves at night, and whenever it is available during daylight hours.

4.4.3 Repair and Maintenance of Secondary Channels- Maintenance and repair at this level is uncomplicated, both technically and in terms of division of labour. Channels seldom require repair, other than minor reinforcement, due to their location in stable and well developed terrace soils. Maintenance is restricted to regular dredging, and occasional minor reinforcement of walls. Households owning terraces adjacent to channels are responsible for these duties. Specifically, since most channels follow the bottom of terrace walls on the same level as the downslope plots they feed, farmers must maintain sections directly upslope from the land they own. This division of responsibility is easily understood, and the task itself is neither time consuming nor difficult, so neglect and disrepair seldom occurs. When it does, usually in spring, it is because no single villager takes the initiative to clean his channel sections first. As a result entire villages put off dredging indefinitely. Members of villages with effective organizations take advantage of less co-operative villages by arranging to clean all of their channels early, so that they can utilize their share of the early melt, and claim the portion of those villages which are not prepared. No village may claim water until all of their channels have been cleaned.

One or two days each spring is devoted to emptying village ponds of silt and refuse. This is a big job, but villagers appear to look forward to it as a "rite of spring". There was no shortage of men or boys to man shovels and baskets at the pond cleaning we observed. Material hauled from channels and ponds is deposited on channel and terrace walls as a means of reinforcement.

The only significant exception to stability within the secondary channel system are lateral moraines forming a strip along the east side of cultivation. Continual rotational slumping on to the Bualtar Glacier has resulted in the loss of several hectares of land, and at least one major channel. Due to the magnitude of this activity land is, and will continue to be, irrevocably lost. Thus, colonization of new land, and construction of new channels elsewhere is the only way to maintain a constant area of cultivation. Holshal village has begun this process across the Bualtar Glacier.

Table 4.4.4

SECONDARY CHANNEL WATER ALLOCATION
(All Hopar Villages)

EXTREME WATER SHORTAGE- exceptionally cold and cloudy springs (ie. 1986).
- when slides or channel failure disrupts primary channel discharge.

-All water is used to irrigate wheat crops. Wheat is the community's staple crop, and is vulnerable to drought.

MODERATE WATER SHORTAGE-each year to mid June

-Each channel receives a period or portion of water flow corresponding to the area of cropland it supplies.

-Crops are watered on four to seven day rotations, depending on the extent of shortage, so all channels receive water at the same interval.

-Channels stemming from Handel channel receive water according to individual village rights to Handel water flow.

WATER SURPLUS-mid June to October

-Channels are fed according to moderate shortage schedule. Any flow above that requirement may be diverted to any channel. Most secondary channels receive water almost continuously during daylight hours.

-Individuals of any village may water out of turn without fear of disapproval, penalty, or damage to the allocation system.

-Evening flows are used only to irrigate Cycumming, and for household purposes.

Personal Communication with Villagers (1986)

4.4.4 Water Allocation- Strategies of water allocation at the village level vary according to availibility of supply. Periods of extreme shortage occur in exceptionally cold and cloudy springs, and when calamity disrupts primary channel discharge. Moderate shortage is common most seasons up to early July. Surplus conditions prevail throughout July, August and September. The allocation strategies associated with these supply conditions are outlined in Table 4.4.4.

4.5 CROP IRRIGATION

4.5.1 Introduction- When it finally enters fields water flow retains few of the characteristics of the original melt supply. Temperature is eight or more degrees higher than in the nala, sediment load is much reduced, discharge is low and easily controlled, and timing is predictable. It is important that at this final stage farmers apply water in such a way that these qualities are utilized. Field level water application is described below in terms of timing, volume, and method.

4.5.2 Timing of Water Application- Villagers state rather vaguely that crops on light soil are irrigated every seven to ten days, and that heavy soils of the valley floor receive water "somewhat less often". Observations from 15 test plots in two of the villages indicate that between May seventh and July 25th 1986, cereal grain crops were irrigated at an interval of six days or less. Some bean and potato fields went seven days between water applications. Almost all Hopar crops received water fifteen or more times from early May to late August.

According to field studies by Whiteman (1985,p.17), many other Karakoram villages apply water at intervals of ten to 15 days, resulting in relatively fewer irrigations per season. He cites Yasin (2450m) and Gilgit (1490m) as examples; they apply water ten to fifteen times, and eight to ten times, respectively. Whiteman concludes that the relatively infrequent and consequently high volume applications that are common leach unnecessarily high quantities of nutrients away from plants because as much as two thirds of water input seeps through the rooting profile to subsurface layers. In addition to wasting water and depriving plants of nitrogen and other nutrients, high volume-low frequency irrigation means that between applications crops must remove 50 to 70 percent of water available to roots (Whiteman,1985,p.17). Such moisture depletion can inhibit plant growth and reduce yield.

Several test plots in Hopar were measured for soil moisture. They show that moisture depletion between irrigations is not a significant problem. Even on the fifth day after irrigation, soil moisture at 10cm exceeded nine percent on light morainic soils. This is probably due to the exceptionally frequent water application practiced in Hopar.

The details of irrigation timing vary as the season progresses and from year to year. In springs of early valley floor melt some fields may be irrigated before cultivation to soften the soil and moisten it in preparation for ploughing and germination of seeds. The opposite occurred in 1986; the valley snow cover melted very late, so upper fields relied entirely on terrace level snowmelt until late May.

Farmers in Hopar always delay irrigation as long as possible after sowing seeds. This year barley was first watered May seventh, a full four weeks after it was sown. Other crops were initially irrigated during the following several weeks, depending on sowing or planting date. Potatoes were planted the first week in May, and consequently first received water in early June. Delaying initial water application serves several purposes:

a) Small seedlings avoid contact with cold water until well established;

b) plants grow several centimetres before the clogging effect of sediment deposition is introduced.

c) root development is enhanced by the search for moisture;

d) potential erosion is delayed until roots consolidate topsoil; and

e) available discharge can be diverted to watermills, and wooded areas.

Irrigators are reluctant to apply heavy volumes until June, when plants are mature enough to withstand the stress of cold and siltation. By mid-June demand, supply, and plant hardiness correspond to allow regular intensive irrigation until, one after another, crops begin to ripen.

4.5.3 Volume- Irrigators inundate fields to a depth of about one centimetre during application. Rough field experiments indicate that about one quarter of application time is spent providing the volume needed for that top centimetre.

Since water enters fields at a ~~constant rate~~ about 40 millimetres of water is applied each irrigation. This value varies with infiltration characteristics, and ratio of discharge to demand area. Our estimates are probably somewhat low, because test plots were small, resulting in high discharge per area irrigated. In any case, 40 millimetres per application can be accepted as a rough estimate. This means that at least 650 millimetres of water are applied throughout the growing season. This approximates Whiteman's (1985,p.17) estimates for single crop areas, however because small ammounts are applied more frequently, effectiveness per unit applied is above the norm. Farmers enhance this utility by irrigating early and late in the day when evaporation is low.

5.5.4 Application Technique- Hopar villagers employ two plot irrigation techniques common throughout the Karakoram region, borderstrip and furrows. Borderstrip irrigation requires the construction of ridges or bunds along the direction of prominent slope. These are handmade before spring sowing or planting. Spacing averages about 2.5 metres apart, but varies according to water supply characteristics. Water flows downslope between bunds, so that irrigation occurs strip by strip across the field. The effect is to irrigate small sections rapidly so that the upper area of a plot does not experience leaching while water flows over it to downslope extremities. Leaching becomes less of a problem with passing time as infiltration rate naturally decreases due to compaction and sedimentation. Consequently, border strips are lengthened periodically. Whiteman reports that strips which initially range from three to five metres, may be increased to over 30 metres by mid July (1985,p37).

Furrows are less common than borderstrips on relatively flat, even terrain. However, because they can be dug with little effort by ox-plough they are favored on upper terraces where slopes are steep and topography is uneven. Furrows direct water on an angle diagonal to predominant slope so that crops never receive water directly, but rather absorb it laterally as it seeps downslope. This technique permits less water to reach roots, but has the advantage of protecting crops from siltation. Furrows are adjusted in the same way as border strips to accomodate infiltration rate and slope conditions.

4.6 CONCLUSIONS

Agriculture in Hopar depends upon successful exploitation of the climatic conditions of two elevation zones. Crops must be grown below 3000 metres due to altitudinal temperature gradients. At the same time, crop moisture requirements are met by snow and icemelt above 3600 metres. Intensive subsistence cropping is possible only because a sophisticated irrigation system transports meltwater from its source above 3600 metres to crops between 2500 and 3000 metres.

Water entering primary channels is cold, dirty and extremely variable in terms of timing and volume of flow. These characteristics impede effective irrigation. At each consecutive level of the channel network their magnitude is reduced, so that when it enters channels, water bears little resemblence to the original meltwater supply. Temperature has risen by at least eight degrees, suspended sediment is substantially lower, timing can be predicted and manipulated within minutes, and volume of flow is between .0001 and .001 cusecs per channel.

This level of control is not achieved through great inputs of western technology, capital, or even exceptionally high labour. Rather it is a result of increasing adaption, manipulation, and regulation of flow as water travels through the system. Hoparis ability to do this is based on thorough understanding of water supply and demand.

Irrigation in Hopar is not flawless. Every spring there is too little water; poor control sometimes results in flooding; occasionally channels break or are blocked and no water flows at all. Even more important than these problems is the fact that subsistence agriculture does not, and cannot support the community of Hopar. The example of increasing high channel disrepair implies that this is the result of disintegration of certain parts of the traditional socio-agricultural system, rather than any inability of that system to deal with geophysical conditions and hazards. The same example also shows that thoughtful development can begin to reverse the trend towards cultural and agricultural disintegration.

CHAPTER FIVE: CROP DISTRIBUTION IN HOLSHAL AND GHOSHUSHAL

5.1 INTRODUCTION

5.1.1 Introduction – Chapters Two and Three set irrigated agriculture into the physical and social circumstances of Hopar. Water supply and distribution are described in Chapter Four. The present chapter narrows the scope of discussion further. It outlines crop requirements, and describes the relationship among physical and agricultural inputs to meet these requirements. The purpose of Chapter Five is to evaluate the way that crops and cropping techniques have been matched to micro level environmental conditions. Thus, much attention is devoted to comparing distributions of agricultural variables within a cultivated area. The role of irrigation as a variable, and as a factor influencing other variables, is emphasized. This evaluation is possible only because the Hopar agricultural system does not include frequent crop rotation.

5.1.2 The Study Area: Holshal and Ghoshushal – The entire cultivated area of Hopar is too large to study intensively in a three month period. Therefore, crop observations were limited to the fields of Holshal and Ghoshushal Villages. This terraced area is approximately 40 hectares, and contains approximately 680 fields. It comprises only fourteen percent of Hopar's total cultivated area, yet it is a representative study area for several reasons:

1) Cultivated lands represent all cropping aspects of Hopar. Fields are divided

relatively evenly among north, east, and west-facing slopes. A few south-facing fields border an ancient moraine deposit.

2) Elevation of crops ranges between 2750 and 2950 m. Other villages have higher and lower fields, but most cropping occurs within this zone.

3) All main crops are represented in the Ghoshushal/Holshal area.

4) Irrigation channels which feed fields range from primary channels less than one kilometre from the nala, to fourth and fifth level ditches more than three kilometres removed from the nala. This diversity is important with relation to water temperature.

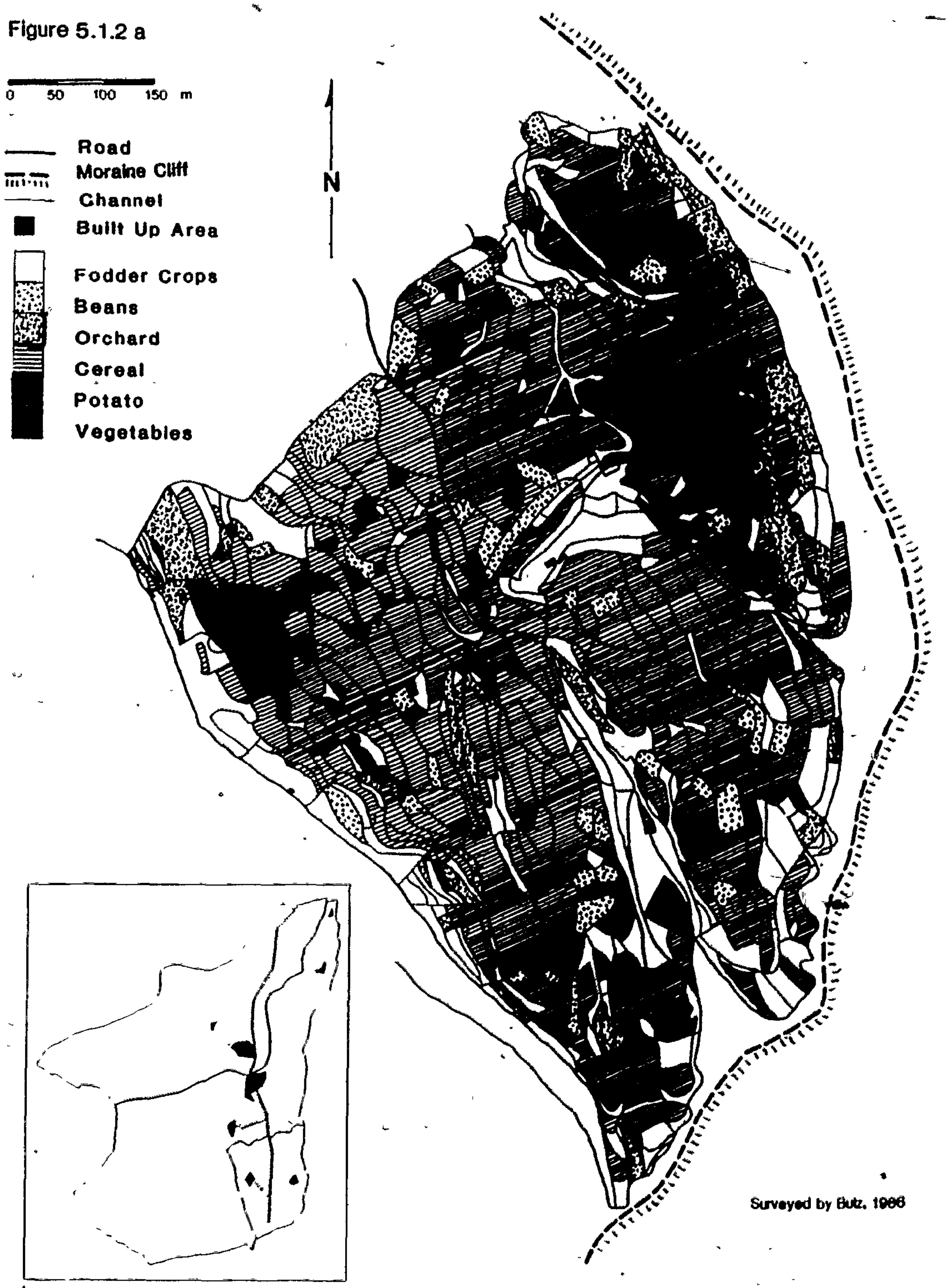
5) Field slope and terrace height represent the full range found throughout Hopar. Terrace walls on east facing slopes exceed 2 m, with plot slopes greater than 15° . On the other hand, valley bottom terraced walls are sometimes less than 5cm, and separate fields with slopes under 0.5° .

In addition, Holshal and Ghoshushal are small villages, located close to our camp. This means that cropping information could be collected on two complete village systems relatively efficiently. It was also possible to keep abreast of agricultural and other activities occurring within the village areas.

The entire area of Holshal and Ghoshushal was mapped at 1:2500. Included in the map are all irrigation channels, fields, crops, terraces and isolated buildings (see Figure 5.1.2a and 5.1.2b). Fifteen individual plots within the mapped area were selected for detailed study (see Figure 5.1.2c). Test plots included three fields of wheat, one barley, three broad bean, three potato, three alfalfa, one pasture, and one mixed pasture/orchard. They include all field crops grown in Holshal and Ghoshushal in roughly equivalent proportions. .

Land Use in Ghoshushal & Holshal Villages: Hopar Valley, Pakistan

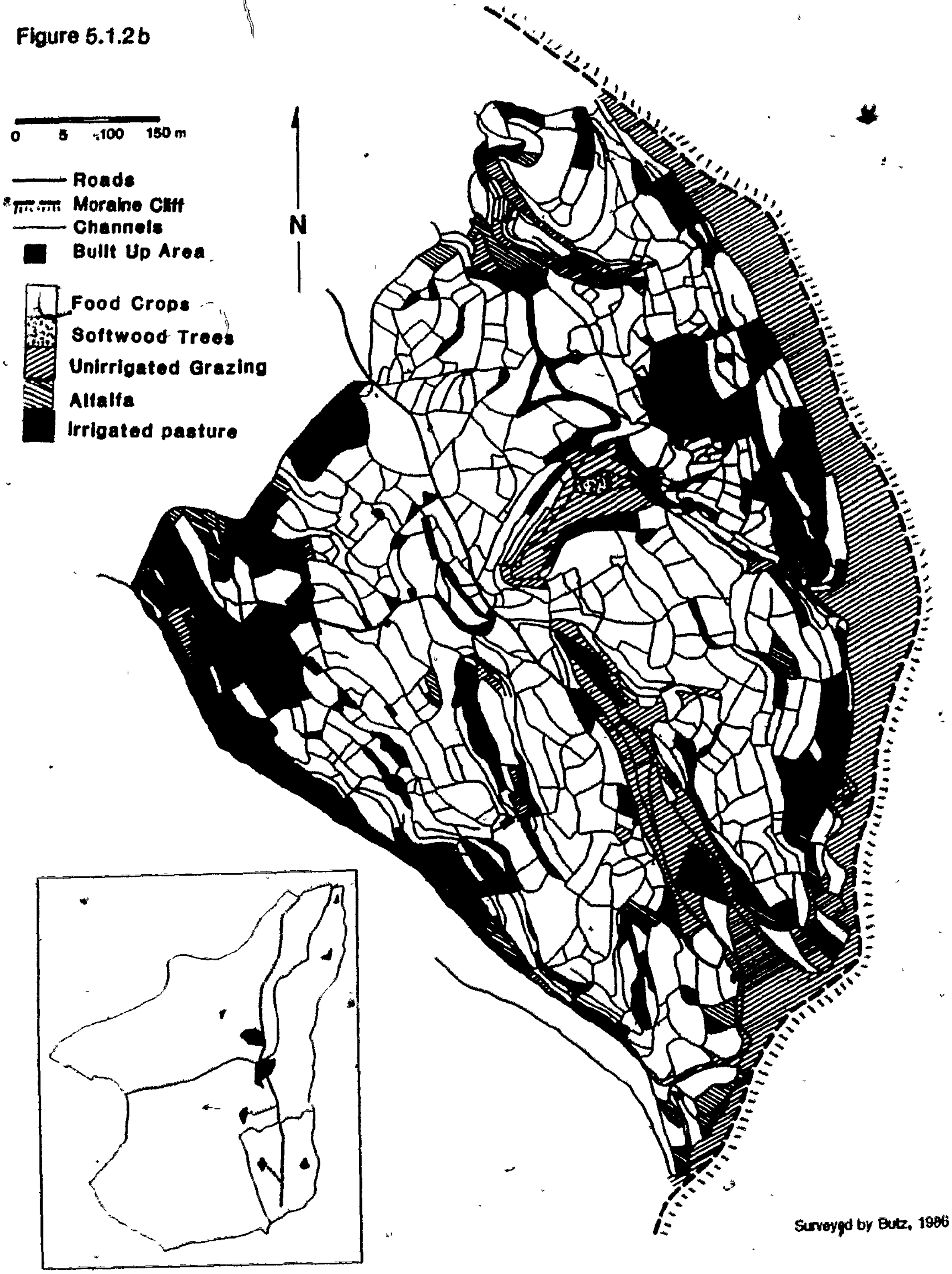
Figure 5.1.2 a



Surveyed by Butz, 1986

Land Use in Ghoshushal & Holshal Villages: Hopar Valley, Pakistan

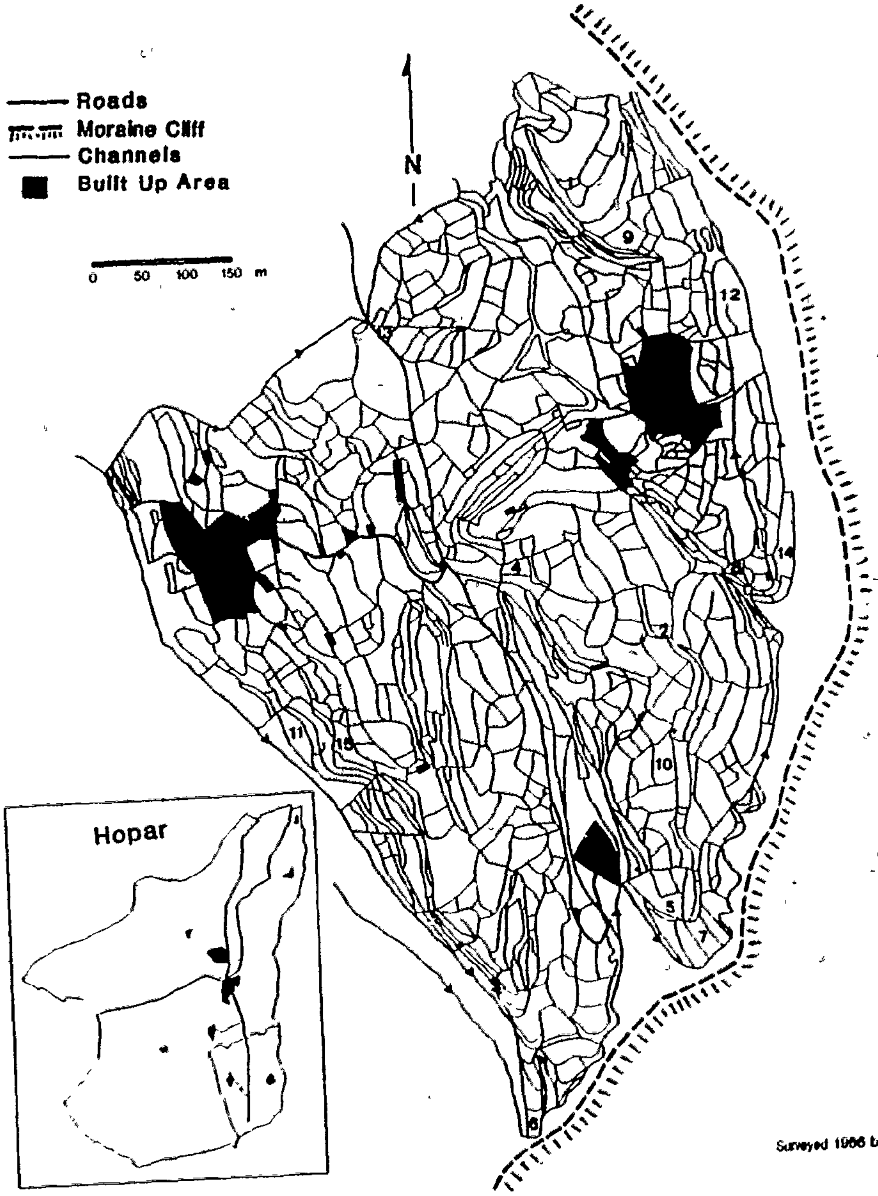
Figure 5.1.2b



Surveyed by Butz, 1986

TEST PLOT LOCATIONS

Figure 5.1.2c



Surveyed 1986 by Butz

TEST PLOT LOCATIONS

1 Potato 1
2 Potato 2
3 Potato 3
4 Alfalfa 1
5 Alfalfa 2
6 Alfalfa 3
7 Pasture 1
8 Orchard/Pasture 1
9 Bean 1
10 Bean 2
11 Bean 3
12 Wheat 1
13 Wheat 2
14 Wheat 3
15 Barley 1

5.2 CALCULATING AGRICULTURAL POTENTIAL

Numerous physical inputs contribute to the potential of any agricultural plot for crop growth. Those which are important to Hopar's agricultural system, and which could be investigated in the 1986 field season are listed in Table 5.2.a. Despite limitations of time and equipment these inputs address the main crop growth parameters identified by Conway et al (1986), Saunders (1983) and Whiteman (1985), in their reports on Karakoram agricultural systems. Wind is not included because wind measurements in the test area were consistently less than 3 m/s. Inputs are categorized under three main headings: heat, soil, and water.

An increase in the value or utility of <u>any</u> individual input (within certain thresholds) raises agricultural potential of the plot. However, some inputs are more important than others, and many have overlapping effects upon crop growth. Unfortunately, without concentrated crop biology fieldwork the extent of interplay among inputs, and between crop and individual inputs cannot be quantified. While the purpose of the chapter is to assess relative growth potential of plots, any attempt to numerically compare inputs could result in significant magnification or neglect of certain crop growth parameters. In order to avoid this, seven variables are chosen to identify important aspects of crop growth potential at the level of individual plots. Each variable is represented by a single input which is assigned a number between one and fifteen, relative to other test plots. The potential of each plot is represented by a suite of seven rankings (Table 5.2.b). A similar process is used to produce Table 5.2.c, which ranks inputs from one to four according to the four predominant crop types: potatoes, fodder, beans and cereal. Since it is statistically incorrect to average rankings a single numerical value of overall agricultural potential is not produced. However, the rankings for individual variables do allow a valuable qualitative discussion of crop growth potential.

Table 5.2a

INPUTS TO AGRICULTURAL POTENTIAL OF TERRACED LANDS

RADIATION VARIABLES	MOISTURE VARIABLES	SOIL VARIABLES
SUNSHINE HOURS/DAY	HUMIDITY	NITRATE
ASPECT	EVAPORATION	PHOSPHORUS
SOIL TEMPERATURE	SLOPE	POTASSIUM
SURFACE TEMPERATURE	PLOT SIZE	CALCIUM
AIR TEMPERATURE	DISTANCE FROM NALA	MAGNESIUM
ALTITUDE	WATER HOLDING CAPACITY OF SOIL	MANGANESE
		ALUMINUM
		SULFATE
		IRON
		ORGANIC MATTER
		pH

Table [illegible].2b

AGRICULTURAL POTENTIAL, RANKING OF SELECTED VARIABLES FOR ALL TEST PLOTS

TEST PLOT	Potato 1	Potato 2	Potato 3	Alfalfa 1	Alfalfa 2	Alfalfa 3	Orchard 1	Pasture 1	Bean 1	Bean 2	Bean 3	Wheat 1	Wheat 2	Wheat 3	Barley 1
DIURNAL HEAT INTENSITY (Soil Temperature)	[illegible]	5	2	6	11	1	14	3	15	12	13	9	10	4	8
GROWING SEASON DURATION (Altitudinal Variation)	3	4	11	2	12	15	7	14	5	6	10	9	[illegible]	13	8
PHOTOSYNTHETIC POTENTIAL (Sunshine Hours/Day)	11	10	3	8	4	1	12	7	12	9	5	14	[illegible]	15	6
WATER TEMPERATURE (Distance From Vala)	2	4	15	8	10	12	5	11	2	[illegible]	12	6	1	9	14
WATER UTILITY (Plot Size)	2	4	1	7	10	9	3	5	13	11	14	15	6	12	8
EVAPORATION (Plot Evaporation)	13	11	5	7	1	12	[illegible]	2	5	6	4	9	8	14	10
SOIL QUALITY (Nitrate Content)	4	2	1	13	15	14	5	8	11	6	3	7	9	12	10
IRRIGATION FREQUENCY (Days)	8	10	10	13	15	20	7	7	6	6	6	6	7	7	6

Table 5.2c

AGRICULTURAL POTENTIAL: RANKING OF SELECTED VARIABLES FOR CROP TYPES

CROP VARIETY	POTATO	FODDER	BEANS	CEREAL
DIURNAL HEAT INTENSITY (Soil Temperature)	1	2	4	3
GROWING SEASON DURATION (Altitudinal Variation)	1	4	2	3
PHOTOSYNTHETIC POTENTIAL (Sunshine Hours/Day)	2	1	3	4
WATER TEMPERATURE (Distance From Nala)	2	4	1	3
WATER UTILITY (Plot Size)	1	2	4	3
EVAPORATION (Plot Evaporation)	3	2	1	4
SOIL QUALITY (Nitrate Content)	1	4	3	2
IRRIGATION FREQUENCY (Days)	9.3	12	6	6.5

Table 5.3a

SOIL INPUTS TO AGRICULTURAL POTENTIAL: RANKING FROM BEST TO WORST

TEST PLOT	POTATO 1	POTATO 2	POTATO 3	ALFALFA 1	ALFALFA 2	ALFALFA 3	ORCHARD 1	PASTURE 1	BEAN 1	BEAN 2	BEAN 3	WHEAT 1	WHEAT 2	WHEAT 3	BARLEY 1
NITRATE	4	2	1	13	12	14	9	8	11	6	7	7	9	12	10
PHOSPHORUS	1	1	1	1	1	1	13	14	10	1	1	10	1	14	12
POTASSIUM	8	1	2	14	10	10	12	14	9	14	12	7	3	6	9
CALCIUM	5	4	6	15	5	5	12	9	[illegible]	[illegible]	11	1	12	2	12
MAGNESIUM	9	7	10	14	14	7	1	10	[illegible]	10	10	1	3	3	3
MANGANESE	5	3	4	7	7	7	1	1	7	4	7	13	15	13	7
ALUMINUM	2	7	2	12	13	2	2	8	9	13	13	9	1	9	2
SULFATE	5	1	4	4	4	1	4	4	3	4	4	4	4	4	4
IRON	2	6	6	6	6	6	6	2	6	6	2	2	6	1	6
ORGANIC MATTER	13	3	5	1	1	9	3	11	8	5	10	15	12	5	14
pH	14	1	3	11	9	11	14	11	3	9	3	3	1	3	3
IRRIGATION FREQUENCY (DAYS)	8	10	10	13	13	20	7	7	6	6	6	6	7	7	8

Table5.3a

RADIATION INPUTS TO AGRICULTURAL POTENTIAL   RANKING FROM BEST TO WORST

TEST PLOT	POTATO 1	POTATO 2	POTATO 3	ALFALFA 1	ALFALFA 2	ALFALFA 3	ORCHARD 1	PASTURE 1	BEAN 1	BEAN 2	BEAN 3	WHEAT 1	WHEAT 2	WHEAT 3	BARLEY 1
SUNSHINE HOURS/DAY	11	10	3	8	4	1	13	2	12	9	5	14	7	10	6
ASPECT	9	2	11	9	15	11	6	6	7	5	13	2	1	4	13
SOIL TEMPERATURE	7	5	2	6	11	1	14	3	15	12	13	9	10	4	8
SURFACE TEMPERATURE	8	5	2	3	10	1	14	5	12	13	9	12	11	7	4
AIR TEMPERATURE	12	6	7	2	3	1	14	7	15	9	10	4	12	5	10
ALTITUDE	3	4	11	6	12	15	[illegible]	14	5	6	10	9	1	12	8
IRRIGATION FREQUENCY (DAYS)	8	10	10	12	13	20	7	7	6	6	6	6		7	6

WATER INPUTS TO AGRICULTURAL POTENTIAL   RANKING FROM BEST TO WORST

TEST PLOT	POTATO 1	POTATO 2	POTATO 3	ALFALFA 1	ALFALFA 2	ALFALFA 3	ORCHARD 1	PASTURE 1	BEAN 1	BEAN 2	BEAN 3	WHEAT 1	WHEAT 2	WHEAT 3	BARLEY 1
HUMIDITY	12	12	7	9	14	6	4	10	5	3	2	11	1	15	8
EVAPORATION	12	11	2	7	1	12	---	2	5	6	4	9	8	14	10
SLOPE	3	1	4	4	8	11	12	10	6	6	13	9	1	11	15
PLOT SIZE	2	4	1	7	10	9	3	5	13	11	14	15	5	12	8
DISTANCE FROM NALA	2	4	12	8	10	14	6	11	2	9	12	5	1	7	12
WATER HOLDING CAPACITY OF SOIL	2	2	9	5	12	14	12	2	2	1	2	9	2	9	12

Table 5.3b

RADIATION INPUTS TO AGRICULTURAL POTENTIAL: RANKINGS FOR TOTAL HOLSHAL/GHOSHUSHAL CULTIVATED AREA

CROP VARIETY	POTATO	FODDER	BEANS	CEREAL
SUNSHINE HOURS/DAY	4	3	1	2
ASPECT	2	3	1	4
ALTITUDE	1	4	2	3
IRRIGATION FREQUENCY (Mean number of days)	9.3	12	6	6.5

WATER INPUTS TO AGRICULTURAL POTENTIAL: RANKINGS FOR TOTAL HOLSHAL/GHOSHUSHAL CULTIVATED AREA

CROP VARIETY	POTATO	FODDER	BEANS	CEREAL
SLOPE	1	4	2	3
PLOT SIZE	1	4	2	3
DISTANCE FROM NALA	2	4	1	3
IRRIGATION FREQUENCY (Mean number of days)	9.3	12	6	6.5

5.3 INDIVIDUAL VARIABLES OF AGRICULTURAL POTENTIAL IN PLOTS

Discussion is based on Tables 5.2.a to 5.2.c. Inputs other than those selected to represent the seven crop growth variables are occasionally mentioned. Rankings for these inputs are listed in Table 5.3.a. Table 5.3.b contains information on several inputs which were measured for the entire Holshal/Ghoshushal cultivated area.

5.3.1 Intensity of diurnal heat- Heat is an extremely important input to plant growth. Growth rates for most temperate crops increase steadily with increasing temperature to a threshold of about 20 ° C mean daily temperature. Beyond that heat stress begins to inhibit growth. In Hopar mean daily temperatures occasionally approached, but never exceeded 20 ° C.

Several inputs can be used to measure diurnal intensity of heat, including air, surface, and soil temperature. All three measures are influenced by the effect ~~of albedo, so to~~ an extent temperature values reflect crop cover as well as characteristics of the plot itself. Soil temperature was chosen to represent this variable because it responds slowly to short-term changes in cloud cover, wind, shade etc. Soil temperature records represent close to an average value. In addition, soil heat is more critical to plant growth than heat at the surface or above crops.

Potato plots had the highest soil temperatures for the period of May through July 1986. Fodder crops, cereals, and beans ranked second, third and fourth, respectively. This ranking may be explained in part by the albedo of crops themselves. Potatoes are the least dense of all crops, so heat is absorbed rapidly into exposed soil. Beans are extremely dense, and foliage is highly reflective. Relatively less radiation reaches soil in bean plots. Cereal and fodder crops are denser than potatoes, but less reflective than beans, so they lie in between.

An examination of air temperature data shows fodder crops ranked highest, followed by cereal, potatoes and beans. Since air temperature at one metre is affected less by albedo than soil temperature, it seems that in terms of plot location, fodder crops occupy the hottest areas, while beans are grown in relatively cooler spots.

A trade-off is made among potatoes, fodder and cereal with regard to diurnal heat. Potatoes, which convert radiation to heat most effectively, are grown in cool locations. Cereals, because of their high albedo are grown in the second warmest locations. Fodder is an indigenous crop of the Hopar micro-climate. As such it converts heat to growth very effectively with low moisture and nutrient requirements. Thus, farmers grow it on the hottest and least shaded plots; indeed, in places where other temperate crops would approach heat-stress conditions. Beans thrive in less extreme heat.

5.3.2 Duration of Growing Season– A second measure of heat available for crop growth is length of growing season. It is of critical importance in Hopar, due to its temperate latitude and high altitude, which combine to produce long winters and great seasonal temperature variation. The range of growing season in the Hopar cultivated area is best described in terms of micro-level altitudinal variations. Whiteman (1985, p.25) estimates the frost-free growing season lapse rate at about four days per 100 m rise in altitude. Therefore, growing season varies by about 10 days within the Ghoshushal/Holshal test plot area alone. Variation for the whole Hopar cultivated area is close to a month.

Potato test plots ranked highest in terms of growing season duration, followed by beans, cereal and fodder. Measurements for all plots in the Ghoshushal/Holshal cultivated area yielded the same rankings. These rankings reflect farmers' knowledge of plant requirements. Alfalfa is adapted to convert strong sunlight and heat to plant tissue. It requires an intense, rather than long, growing season. Beans are better suited to a milder climate. They are close to their growing season limits in Hopar. Thus, farmers grow beans in relatively low, but topographically and vegetatively shaded plots. Similarly, potatoes require a long growing period. Cereals, like alfalfa, have evolved to exploit the natural conditions of the Karakoram's agricultural zone. Indigenous strains of wheat and especially barley grow and mature rapidly under conditions of high radiation. Therefore, duration of growing season is less critical.

5.3.3 Photosynthetic Potential- Radiation is important to crop growth, not only as a heat source, but also as the vital input to photosynthesis. The photosynthetic role of sunlight is compounded in Hopar, where indigenous crops are remarkably efficient users of intense high-altitude radiation.

Two inputs were measured which can be used to represent photosynthetic potential: duration of sunlight per day, and aspect. Neither input reveals major differences from plot to plot. Due to Hopar's situation in a broad flat depression, duration of sunlight reaching plots varies by one hour at most, or about seven percent of total diurnal sunshine. Cultivation in the test area occupies all aspects, but again the gentle relief of most of the settlement diminishes its impact. In addition, terraces themselves are almost all virtually horizontal.

That no clear indication of photosynthetic potential can be drawn from these measurements is evident from the rankings for sunshine hours/day. Test plot rankings show fodder first, potatoes second, beans third, and cereals last. Measurement of the total area rank beans first, followed by cereal, fodder and potatoes. A similar lack of correlation exists for aspect measurements. All other cases where inputs were measured for test plots and total area, the two sets of rankings correlated closely.

Total rankings for duration of sunlight may be somewhat representative of photosynthetic potential relative to distribution of crop variety. However, the conclusion must be drawn that, while photosynthetic potential is an important input to crop growth, the measures chosen do not vary significantly at the micro-climatic level.

5.3.4 Water Temperature- The temperature of irrigation water entering fields can significantly influence crop development particularly during germination and early growth. In Hopar, where snowmelt irrigation water is ten or more degrees below unirrigated soil temperature, this influence is always negative. However, since irrigation occurs at intervals of 6 to 20 days, the impact is in the form of periodic shock, rather than continuous stress. The shock occurs as water contacts seedlings and abruptly lowers soil temperature during and directly after irrigation.

Irrigation channels are constructed so that water warms quickly as it travels from nala to field. The farther a field is from the meltwater source, as the channel flows, the warmer the irrigation water it receives. Distance of plot from nala is used here as the input to represent water temperature.

Beans receive the warmest irrigation water, followed by potatoes, cereal and fodder. Again farmers have matched crop type with plot characteristics. Fodder and cereal are indigenous crops which have evolved to tolerate the stress of cold water. In addition, they have sufficiently short growth periods to absorb the setback of periodically reduced soil temperature. Potatoes and beans are both adapted crops. Potatoes have been introduced to high altitude snowmelt irrigation zones within the last fifty years (Mott, 1987, personal communication). Beans are indigenous to the Karakoram, but are better suited to lower single crop altitudes. Both beans and potatoes have long growing periods. Thus, they benefit from warmer irrigation water.

5.3.5 Water Utility– Several plot characteristics contribute to the effectiveness with which irrigation water is utilized. Included among these are evaporation, slope of terrace, plot size, and water holding capacity of the soil. Evaporation is a loss of moisture to the atmosphere. It is examined in 5.3.6 below. The other three determine the downward loss of water and nutrients. The greater the slope of a terrace, the more runoff of irrigation water, and erosion of topsoil. This gathers in low spots or is lost to adjacent terraces. The larger the plot, the more distance water must travel to reach all areas of crop. In a large plot, irrigated portions continue to receive water which flows over saturated topsoil to unirrigated areas. Some topsoil becomes oversaturated; water and nutrients leach through the rooting zone and are lost to the subsoil. Small, almost flat plots are desirable. The ability of soil to retain water in the root zone depends on soil texture and organic content. Soils with high clay percentages and high organic content absorb and retain water effectively. Sandy soils, and those low in organic matter allow rapid percolation of water and nutrients.

Plot size was chosen from among these inputs to represent irrigation water utility. In contrast to water retention capacity of soil, it was measured accurately for both test plots and the total test area. Slope is a less appropriate measure because it often varies within plots. It is worth noting that plot size and slope are directly related; larger plots tend to have greater total slope.

Potatoes occupy the smallest plots. Fodder and cereal are second and third, respectively. Beans are planted in the largest fields. Potatoes' high ranking is explained by their vulnerability to oversaturation. Potatoes rot if soil moisture is too high. In addition, they benefit more than other crops from soil nutrients, which may be leached out of larger plots. Fodder's second place ranking is probably not a result of moisture conditions. Rather, because it is a low labour intensity crop it is grown on small, poor quality terraces with steep slopes. Basically, fodder gets bits of land not suitable for more intensive and higher prestige crops.

5.3.6 Evaporation– Evaporation represents the loss of water to the atmosphere. Bean plots had the lowest evaporation, followed by fodder, potatoes and cereal. At first glance it seems that these results reflect density of crop cover rather than characteristics of the plot itself. Crops with dense foliage allow less evaporation. However, humidity at one metre is not determined by crop cover, and low evaporation relates closely to high humidity. Plots located in areas of relatively high humidity lose less water to evaporation. Thus, beans lose much water to percolation, but little to evaporation. Cereal crops fare poorly in terms of both evaporation and leaching through the root zone.

5.3.7 Soil– The final physical variable of crop growth potential considered here is soil quality. Table 5.3.a shows the rankings for eleven soil constituents. All essential nutrients are included, as well as pH and organic content. Samples were also analysed for a selection of six micro-nutrients. It was not considered necessary to test for the full range of micro-nutrients; only those that could be analysed at the Wilfrid Laurier University physical geography lab were tested.

Most important among soil constituents is nitrogen. It is also the limiting soil factor in growth potential throughout the Karakoram; all other constituents are usually present naturally in adequate quantities (Whiteman, 1985). Nitrate concentration is used to represent soil quality, although reference is made to other constituents.

Potato crops have the highest nitrate content, followed by beans, cereals, and fodder. These rankings result from a combination of farming practices and regeneration of soil by leguminous crops. Potatoes, because they are a high intensity, high yield crop receive larger and more frequent applications of manure and chemical fertilizer than beans, wheat, or fodder. This is evident in potato plots' relatively high organic content. Only fodder crops have more organic matter. However, they do not lie fallow each winter, so conversion of organic matter to nitrate is inhibited. In addition, phosphorus and potassium, also fertilizer constituents, are highest in potato crops. Beans have high concentrations of nitrate because the plant itself returns nitrogen to the soil. Potassium ranking is low, indicating that farmers apply little chemical fertilizer to beans. Wheat and barley receive some manure but little chemical fertilizer. Finally, alfalfa fodder ranks low for nitrate despite leguminous nitrogen production. Fodder crops are perceived as low capital and low labour crops, so they receive neither chemical fertilizer, nor manure.

Although nitrogen levels are the result of farming practices, they coincide well with rankings for other soil constituents. Potato crops ranked first for nitrate, and first or second for eight of the other ten soil inputs. Fodder crops, which had the lowest nitrogen levels, were third or fourth for eight of ten other inputs. Farmers clearly consider soil quality when they match plots and crop type, and fertilize to enhance the best soils. Potatoes and beans profit most from chemical and organic fertilizer. Indigenous cereal and alfalfa are well adapted to natural soil conditions. They require less fertilization.

5.4 THE DISTRIBUTION OF CROPS WITH RELATION TO AGRICULTURAL POTENTIAL

Rank data cannot be manipulated arithmetically to produce an overall ranking. However, from the variables discussed, it is apparent that potato crops occupy land with the greatest agricultural potential, at least among those plots tested. The high ranking for potato plots is due in part to high levels of manuring and fertilization. Nitrate, phosphorous, and potassium levels were considerably higher for potatoes than for other plots. These three nutrients are primary fertilizer and manure components. Organic matter, which is a function of human input and the crop itself, is also high for potato plots.

Overall, test potato plots occupy the most fertile soil in the most favourable location both in terms of radiation and water utility. This conclusion corresponds with results of measurements that were made for the whole Holshal/Ghoshushal cultivated area. Potatoes exploit high water utility, and relatively great heat receipts, although bean fields tend toward greater sunshine per day, and a more southerly aspect. They are close to their growing season threshold, and therefore require the advantage of a favourable exposure. Potato plants, on the other hand, benefit from shorter periods of sunlight diurnally and seasonally, since they require large variations in temperature for maximum carbohydrate production.

Beans and cereals occupy land with similar agricultural potential. In both cases high albedo and dense soil cover inhibit the effective utilization of incoming radiation. Indeed, albedo measurements show that wheat and especially barley reflected more short-wave radiation than other crops. In addition, humidity readings were low above cereal crops. Cereals ranked only slightly behind potatoes for micro-nutrients (calcium through iron), and had a more favourable pH. However, their nitrate, phosphorous, and potassium levels are considerably lower, reflecting less manure and chemical fertilizer application than potato fields.

Beans are located close to their temperature and moisture limits so they require high radiation and water utilization inputs. Only by occupying plots with choice climatic positioning can they grow and mature especially since their foliage inefficiently converts incoming radiation to soil and surface heat. It is natural that beans and wheat occupy plots with similar agricultural potential, because they are often grown together. In most cases beans are thinned out for fodder in late June, after releasing some leguminous nitrogen to the soil. Occasionally, on plots especially suited to bean requirements, the wheat is thinned. Only a few fields of beans are required to fill the role as a winter-time dietary supplement. They are also used as a means of periodically replenishing nitrogen deficient soil. Ironically, farmers seem to exaggerate the nutrifying effects of bean crops. Nitrogen levels in bean plots are high, but other soil nutrients are relatively low.

Wheat occupies 70% of Hopar's terraced area, so it is definitely the community's staple crop. There are several reasons for its continued predominance. Unleavened wheat bread is the traditional and preferred staple food. Wheat is grown as a field, rather than vegetable crop. This means that it requires low human and capital (ie. fertilizer, manure) input to yield high returns. Finally, local wheat varieties produce great quantities of straw, which is an important winter fodder. Barley shares these qualities. These reasons contribute to farmers' reluctance to give up any cereal space to other crops. However, as potatoes become more important as a food and export crop, they are grown on the best plots, and receive greater inputs of fertilizer and labour. Thus, farmers compromise by trading quantity for quality in their cereal and potato production. Such compromise is insightful, since potatoes respond more strongly than wheat to climatic and nutrient inputs.

Pasture, orchard and alfalfa plots are considered together because the main ground cover for all of them is alfalfa. Potential for fruit production cannot be derived from the rankings because inputs beyond one metre above and .5 metre below the soil surface are very important. For the purposes of this discussion orchard, pasture and alfalfa are all alfalfa fields of different intensity. They occupy the poorest agricultural plots, both for test plots, and the entire area. However, in terms of total radiation inputs alfalfa is ahead of beans and cereal. All other crops receive lower radiation inputs. This indicates that only potatoes are more effective converters of incoming radiation to heat. Alfalfa is grown in fields with greater sunlight, but correspondingly lower water and soil inputs. It tends to occupy recently colonized terraces which are highly exposed to sunlight, but which have poorly developed soils, and are remote from warm, clean water. In addition alfalfa and pasture receive very low human and fertilizer inputs: no manure is applied except by grazing stock; two crops of hay are harvested each year, after which they are severely overgrazed; and even natural nitrogen supplied by the plant itself has a negligible nutrifying effect.

Hopar farmers wisely apply manure and water to other crops at the expense of alfalfa. All other crops respond more vigorously to artifically nutrified soil and increased moisture. Alfalfa is an indigenous plant well adapted to utilize high radiation, and overcome other deficiencies. This can be seen by the lush crops both in the terraced area and on unterraced and frugally irrigated slopes above cultivation.

Farmers in Holshal and Ghoshushal appear to have a good sense of crop growth potential for individual crops. Their matching of plots and crops follows a definite trend; potatoes occupy the best plots; cereal crops and beans are grown in slightly less fertile locations; fodder crops appear in fields with low agricultural potential. That this trend is not always strong is more likely due to circumstances of tenure than to ignorance of crop requirements. For instance, each household devotes some land to wheat, alfalfa, potatoes, orchards, and maybe beans. One household's best potato land may be considered wheat land by wealthier or more fortunate landowners, but farmers must grow crops on the land they possess. Indeed Hoparis have developed a remarkable ability to compromise to achieve maximum productivity for all crops. Potatoes are an introduced crop that is increasing in importance. At the same time wheat remains the preferred and staple foodstuff. Farmers compromise by devoting better land and more fertilizer to potatoes, rather than greater space. This is an ideal solution since wheat thrives on relatively poorer soil, if radiation is sufficiently high. Similarly, alfalfa is grown on poor plots, not because it is perceived as unimportant, but rather because it requires less in the way of moisture and soil fertility. Farmers perceive that balanced production yields greater productivity over time than maximum production from any crop.

5.5 AGRICULTURAL POTENTIAL AND WATER APPLICATION

Irrigation frequency is a crop growth parameter which, more than any other, can be controlled and manipulated by the Hopar farming community. Therefore, it is expected that farmers choose the interval between irrigations in a way that balances inputs to various crops, and as a means of increasing overall productivity. Tables 5.2 and 5.3 compare the frequency of water application with rankings of other variables. The three bean crops received water every six days on average. Cereal crops average 6.5 days between applications. As with overall agricultural potential, beans and cereal are similar in frequency of water receipt. Potatoes are irrigated much less frequently; every 10 or 11 days, Alfalfa plots averaged over 13 days between irrigations. Both the orchard and pasture plots were watered much more often. In all but two cases the orchard was irrigated by a trickle method, so only apricot trees received water. It was discovered part way into the season that the tested pasture was an anomoly in terms of irrigation. It is located adjacent to an aquaduct which often overflows. Most irrigation of the plot was probably accidental. These results show that the relationship between crop type and frequency of water application is stronger than crop type and any other measure of agricultural potential. Farmers clearly recognize water application interval as an important means to enhance productivity of specific crops, and to balance agricultural potential among crops. Potatoes are invariably grown on the best land, but receive relatively infrequent irrigation. Wheat, the staple crop, occupies less fertile areas of the village, but is ensured abundant moisture. This tradeoff increases overall productivity. Potatoes suffer from waterlogging of soil. High soil moisture increases the risk of disease, and decreases diurnal soil temperature variation which is necessary for high carbohydrate production. Indigenous cereal crops are well adapted to the local soil conditions, but benefit from increased water application. Beans receive water most frequently. This is an indication that farmers perceive them as a specialty crop requiring special attention. Beans also respond quickly and strongly to heat and moisture inputs.

In addition to its strong relationship with crop type, frequency of water application relates with certain parameters of agricultural potential;

1. A rough correlation exists between frequency of water application, and surface and soil temperature. Potatoes, which were irrigated least frequently, have the greatest soil, and second greatest surface temperatures. Alfalfa field three was watered only twice in forty days. Its soil and surface temperatures were substantially higher than other crops. Beans, which were irrigated most frequently, had the lowest soil and surface temperatures. The cooling effect of frequent water application is enhanced by the high albedo and dense crop cover of beans.

2. Fields that were irrigated more frequently had greater humidity readings. This relationship holds true for all crops. One expects a corresponding relationship between water application and evaporation, but this does not appear to occur.

3. Larger plots were watered more frequently than small plots. This may be because large plots are more difficult to water effectively. They comonly have steeper slopes, and always require water to travel over longer distances to reach all portions of the plot. Part of this relationship is explained by the crop itself. Bean fields were largest and potato plots smallest. Beans require more moisture than do potatoes.

4. With the exception of potato fields, there appears to be a rough relationship between decreasing distance from the meltwater stream and increasing frequency of water application. Those fields farther from the meltwater source are irrigated more often. This reflects farmers' concerns that cold, sediment laden water stresses crops. Potatoes require the nutritious soils of eastern slopes and the valley bottom, but do not need to exploit the benefit of frequent application of relatively warm and clean water.

5. There is no apparent correlation between frequency of water application, and soil fertility. Any supplementary effect that meltwater sediment has upon soil fertility seems to be offset by leaching of nutrients through the soil.

The frequency with which farmers irrigate their fields is strongly and directly related to the type of crop being grown. In addition, other crop growth parameters are influenced by timing of water application. Thus, farmers are able to exploit irrigation water as a tool for balancing inputs to each type of crop. The effectiveness with which they utilize water and other inputs to crop growth is a measure of their knowledge of micro-environment, and their skill as farmers.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

This paper has been concerned with describing how a mountain agricultural community lives. It has not attempted to prove or disprove any central hypothesis, nor has it concentrated on suggesting changes in the way of life of villagers. Description of the community has, however, been directed by two guidelines: the discussion has focused on agricultural land and water use, and an attempt has been made to present material as components in the cultural ecology of Hopar. This involves characterizing the community through crucial culture/environment interactions. Chapter 6.2 synthesizes the previous chapters into a summary of Hopar's agricultural ecology. Chapter 6.3 proposes some recommendations to developers, for it is development agencies who are most involved in this area, and who have the potential to improve or impair the lot of Hoparis.

6.2 THE CULTURAL ECOLOGY OF AGRICULTURAL LAND AND WATER USE

6.2.1 Summary- The five villages of Hopar have traditionally survived mainly, if not totally, from subsistence agricultural production. In the past century the community has become less dependent upon what they could produce themselves, and more involved with the regional monetary economy. This change from peasantry to capitalism occurred slowly during British colonial rule, but has accelerated in the past four decades under Pakistani neo–colonial government. Today, Hopar is far from self sufficient, in terms either of agricultural produce or total requirements. Still, most food is grown in the villages, or is obtained from other communities in exchange for Hopar produce. Thus, the health and wealth of Hopar continues to depend, to a large extent, upon the ability of villagers to, individually and collectively, interact effectively with the natural environment.

Geophysical conditions which are most important to agricultural adaption in the Karakoram are altitudinally controlled temperature regimes, local terrain, and water supply. Altitude is primarily a large scale agricultural control. As altitude increases the number of potential food crops diminishes. Double cropping ceases at 2400 m. Single cropping continues to about 3000 m. Above that no existing complex of food crops yields well. Temperature gradients effectively limit farming to below 3000 m. Hopar, at the upper threshold of single cropping produces apricots, walnuts, wheat, barley, beans, potatoes, alfalfa, and small quantities of vegetable crops. Terrain limits the situation of agricultural villages within the broad constraints of altitude. Terraces are built only on relatively flat, and unconsolidated slopes, with some potential for rapid soil development. Thus, agriculture is limited to depositional features, primarily alluvial fans, but also moraine deposits, kame terraces, and ancient lake beds. The final and most local physical constraint upon agriculture is water supply. In the zone below 3000 m growing season evaporation exceeds precipitation, so agriculture occurs only where suitable terrain is accessible to meltwater from higher altitudes.

Exploitation of meltwater nalas for crop irrigation characterizes the cultural ecology of many Karakoram communities, including Hopar. It is a salient feature in the social, agricultural, and landscape characteristics of the settlement.

6.2.2 Landscape and Water Supply- Characteristics of Hopar's landscape reflect meltwater irrigation supply obviously and immediately. The pattern of primary channels defines the spatial extent of vegetation in the settlement, so that irrigated land is lush and verdant; a green oasis surrounded by debris. Broad patterns of vegetation within the irrigated oasis also reflect water supply and distribution. Specifically, willows, poplars, wild rose, thorns, and fruit trees line turbulent primary channels, and cover the steeply- sloped area of Cycumming, at the valley's north end. These species are able to utilize meltwater which has not yet warmed significantly. They also consolidate slopes and channel walls, which may otherwise erode. Stands of alfalfa above the terraced area serve the same purpose. They exploit cold and poorly controlled water, and bind unconsolidated slopes. At the same time they lay down a humus and nitrogen layer, for possible future terracing and food crop production. Food crops are grown only on lower slopes and the valley floor itself, where small flat terraces dominate the landscape. Terraces are inextricably linked to water supply and irrigation. They provide the terrain necessary to control and apply water effectively. Without terraces turbulent and variable stream discharge could not be manipulated into gentle, well-controlled, and high quality flow needed for safe and effective crop irrigation.

Other characterizing features of Hopar's landscape are also irrigation related. Aquaducts and raised channels criss-cross parts of the cultivated area. Primary and secondary channels define the boundaries of land controlled by villages adjacent to one another and provide routes for the network of paths which join all Hopar lands. All villages have ponds, which serve irrigation and household water uses. Land adjacent to ponds is often popular public space, and is usually the site of mosques and biaks (council meeting squares). Ponds and channels are structures whose primary purpose is irrigation related, but which have become important parts of the social and cultural landscape.

6.2.3 Water Supply and Social Structure- Social and political identity operates at three levels in Hopar: community, village, and household. Region and state are perceived as unimportant. It is significant that these important levels of socio-political interaction are intimately related to water supply and distribution. Regional and state government are uninvolved in Hopar's irrigation.

The five villages of Hopar form a community because they share and distribute water from a single stream. Today villagers' identity as Hoparis stems from their mutual dependance upon Hopar Nala. It is reinforced by formal and non-formal contact among villages, relating to policy and disputes over water distribution. Of course there are historical ties among villages which also unite them as a community. However, the mildly negative attitude which villages have toward one another indicate that historical ties may have deteriorated but for the necessity of shared irrigation water.

Sociopolitical unity is much stronger within individual villages than at the community level. Village councils are the centre of formal village sociopolitical affiliation. Distributing water effectively and equitably is one of their primary responsibilities. Major repairs and maintenance of primary channels and village ponds are undertaken at the village level. Water allocation is a village sociopolitical concern as well. Minor maintenance and repair, as well as timing of application is not overseen by council, but mutual dependancy among households leads to non-formalized social regulation at the village level. Such informal pressure among villagers manifests itself in individual households, where maintenance of minor ditches occurs, and where water is applied to crops. Prestige among fellow villagers depends to some extent upon their integrity and skill as irrigators. It is natural therefore, that farmers are careful not to use more than their share of water, or irrigate out of turn.

The social significance of irrigation and water supply extends, at the household level, to the division of labour by gender. Irrigation channels, and irrigation water itself are communal so they are perceived as part of the public domain. As such, they do not involve women, whose traditional place is in the private or domestic territory. Irrigation is the one important aspect of agricultural production that does not involve women. It is characteristic of

Hopar's gender conscious society that women play a dominant role in cultivating, weeding, thinning and harvesting crops, but may not irrigate them.

6.2.4 Cropping System and Water Supply– Water is one of three main components which contribute to crop growth and maturity. The others are radiation and soils. Radiation levels are very high in Hopar, and apart from altitudinally constrained growing season, approach their optimum for temperate crops. Soils are naturally well drained, and high in essential nutrient components except nitrogen and organic matter. Hopar's natural water supply is poor: meltwater is cold and dirty; it flows turbulently and variably; and it must be tapped several kilometres upslope from the main cultivated area. It is remarkable, therefore, that Hoparis have manipulated and transformed meltwater flow so that irrigation water is better adapted to individual circumstances than any other physical input. Because of this control, farmers use irrigation as a means to match specific crops to particular plots, so that long term productivity for the agricultural system is maximized. Frequency of irrigation water application is strongly related to crop type. Cereal and bean crops receive water most frequently. This not only meets their moisture requirements, but during times of water shortage compensates for the fact that potatoes benefit from better location in terms of radiation and soil fertility. Fodder crops are irrigated infrequently, because they thrive on small quantities of water.

Farmers recognize that cold water stresses crops, especially seedlings.

Those plots closest to primary channels, where water is still cold and dirty, are irrigated less often than valley bottom fields. Irrigators also adapt irrigation to plot size. Small plots can be irrigated more effectively, and with less danger of leaching and sedimentation, so they receive more applications than larger fields. This ability to alter irrigation to meet circumstances extends to method of application as well. Border strips and furrows are used selectively to meet soil and slope characteristics.

Irrigation application has some effect upon other inputs to crop growth. Frequent irrigation lowers soil and surface temperatures in plots, so that crop growth is retarded. Thus, in cool seasons farmers irrigate less to save water, and to increase the utility of incoming radiation. Irrigation water is also partly responsible for the continued fertility of terraced land. It continually deposits fresh sediment throughout the cultivated area. This accounts for the predominantly silty nature of Hopar soils.

6.2.5 Conclusion– Irrigation in Hopar, and its meltwater supply characterizes the cultural ecology of the community. The oasis-like built landscape of the settlement is a direct result of terraced agriculture. Physical features of water distribution, including channels, terraces, and ponds have political and social as well as agricultural significance. Hopar, as a sociopolitical unit, is defined by a shared water supply. The task of distributing that water effectively through primary, secondary, and tertiary channels is a major focus of formal and non-formal organization at the village level. Councils of elders, or village organizations, are primarily concerned with problems of irrigation and irrigated agriculture. At the household level irrigation is an important means of participating in mutual and communal obligation. It also represents an important component in gendered labour division. Finally, all crop growth depends upon applications of meltwater. Hoparis have overcome this constraint so effectively that the timing and application of irrigation water is their most maleable and versatile agricultural tool. In short, irrigation is the primary means whereby the community of Hopar adapts to its cultural and geophysical environment.

6.3 RECOMMENDATIONS

The Karakoram, and Hopar in particular, is an area that will see an increase in "development" work in the next decade. International agencies, including the United Nations Food and Agricultural Organization, and Aga Khan Rural Support Program are increasing their efforts in the Gilgit District. In addition, Pakistan's central government is slowly diverting development money and expertise to the Northern Areas. Development initiatives are bound to change the situation described in this study. At the same time, change is coming from within. Consumer goods, currency, and wage labour are increasingly important to the economic and social structure of Hopar and other high mountain communities. Most development encourages this by requiring agricultural inputs which are not indigenous. It is to the developers – the people who bring change to high mountain communities – that the following recommendations are addressed.

In his article "Peasant Society and the Image of Limited Good" (1965), Foster argues that peasants see good as a finite commodity in short supply. One household's gain is another's loss. This is true in a very real sense with regard to agriculture in Hopar: arable land and agricultural labour are scarce; during critical periods of the growing season irrigation water is also limited. So far Hopar has been able to balance land, labour, and water supply, to consistently increase yields. This overall balance is comprised of many individual tradeoffs: very little land is devoted to potatoes, but it is the best land; potatoes receive greater inputs of labour than wheat, but less water; alfalfa occupies much land, but only in poor, dry locations; imported wheat varieties respond more favourably to chemical fertilizer, but yield far less straw for fodder; and so on. It is important that developers recognize the perception and reality of limited agricultural inputs, and respect the delicate balance among these inputs, that the villagers have achieved. It may mean the difference between initiating a change which helps increase agricultural self-sufficiency in the long run, and one which has immediate benefits, but which, over time, increases the level of dependancy and cultural disintegration of the community. Take the example of potatoes. The AKRSP and FAO both recommend that villagers decrease cereal production in favour of tubers. At first glance this seems sound. Potatoes yield remarkably well in the Karakoram; per unit area their calorie production is several times that of wheat. They are in demand for seed and eating downcountry. In addition, wheat flour can be purchased at subsidized rates from the central government. The recommendation fails, however, to consider that potatoes require more labour, greater inputs of manure and fertilizer, and better land than cereals. Moreover, wheat flour is a more convenient and more nutritious food, as well as being more convenient. Caring for potatoes is mainly women's work. Greater potato production would mean increasing the already heavy workload of women, or keeping men from the high pasture or cash–earning jobs. Manure is in short supply, and would be more scarce because potatoes yield no fodder. Consequently greater quantities of fertilizer would be necessary, at a cost to farmers. In the end, increasing potato production is beneficial only if money from their sale matches the increased cost of fertilizer and subsidized wheat, and the opportunity cost of diverting labour from cash employment. Even so, the balance of labour has been altered, and the pastoral economy is jeopardized. Other initiatives show the same lack of appreciation for the balance of agricultural ecology in the Karakoram.

Chapters Four and Five clearly indicate that Hopari farmers understand and effectively utilize their water supply and agricultural land. With the exception of specific and limited technological inputs developers cannot improve upon indigenous mountain farming techniques. Development should concentrate on marketing, so that villagers benefit from the transition from peasantry to capitalism, and increase their chances for agricultural self sufficiency. In the past, surplus production has been marketed individually. Consequently, the timing and location of food [illegible]es has been random and haphazard. Revenue was collected individually, and spent individually, often on household consumer goods or other food stuffs. Villagers were at an economic disadvantage, often selling produce for less than its worth, and buying goods and produce at inflated prices. The AKRSP is devoting most of its attention to changing this situation, and has been successful in many villages (See Appendix V for a description of AKRSP work). In particular it encourages villages to form collective organizations which can exploit an "economy of scale" to market produce in Gilgit and downcountry. AKRSP supplies training in marketing and accounting; and lends money to begin the collective marketing process. Costs of shipping produce in large quantities are low for individual households. Returns are relatively great because produce is shipped to population centers where demand, and prices, are high. AKRSP representatives help village organizations to open savings accounts from which money can be drawn to improve collective installations (channels, link roads, cisterns), or against which loans can be made. The result is active and aggressive, rather than passive participation in the regional economy. In addition to improving the competitiveness of village agriculture AKRSP Village Organizations strengthen the traditional socio-political cohesiveness of communities. They provide an infrastructure similar to that which existed under the raja, which can be used to maintain and repair channels, and regulate other agricultural activities. Farmers know how to farm productively and ecologically. Developers can help most by organizing villages to produce and market food economically, within the limits of traditional culture.

One of the most puzzling things about studying traditional, but rapidly changing societies, is coming to grips with the gradual sacrifice of culture to "progress". It is very difficult to assess how Hoparis feel about their culture, and the loss of it. They are eager to partake of the material attraction of modernization, but there does seem to be some regret at the loss of traditional values. Those values are strongly represented in agricultural practices: the combination of agriculture and pastoralism; their mastery of irrigation; gender labour divide. If development is to be truly beneficial it must integrate traditional mountain communities, on their own terms, into the mainstream economy. It is important to develop initiatives which strengthen the characterizing attributes of the traditional society.

Development programs often confront individual physical agricultural problems without completing comprehensive examinations of entire agricultural systems. Consequently, initiatives are often inappropriate and unsuccessful. By identifying irrigation as a characterizing feature of the Hopar agricultural community, and relating other physical, agricultural, and cultural components of the settlement to it, this study has presented a balanced overview of Hopar's agricultural ecology which can be used to evaluate possible development recommendations. Developers should complete this type of preliminary characterizing study before recommending changes to traditional communities. It would save time and money, as well as traditional indigenous culture. A collection of such studies would contribute valuably to a currently sparse body of human geographical literature, and may reveal trends common to traditional, but rapidly changing farming communities in the Karakoram. This would introduce a necessary dynamic, and possibly predictive, dimension to developers' understanding of economic and agricultural change in the region. Hopar is a community which has been exposed to most external pressures of a regional economy. It is currently reacting to these pressures. A similar study in a less accessible valley, where outside economic and sociopolitical influence is weaker would be a logical step in developing an understanding of the dynamics of agricultural change in the Karakoram

According to Jack Ives, a prominent mountain geographer, gift exchange is the only beneficial type of development work (1986, personal communication). Hoparis can teach us far more about high mountain agriculture and meltwater control than we can teach them. It is important to erase the faint boundary between development expert and trainee. This study has suggested no important improvements to the agricultural system of Hopar. It did, however, inspire several recommendations to development agencies. These are applicable wherever modern technology meets proven practices and traditional values.

APPENDIX I: THE SNOW AND ICE HYDROLOGY PROJECT

APPENDIX Ia

OVERVIEW OF THE SNOW AND ICE HYDROLOGY PROJECT*

*Article by K. Hewitt, reprinted from Snow And Ice Hydrology Project: Annual Report 1985.

1. CONTEXT AND OBJECTIVES

The Himalayan Sources of the Indus:

More than 100 million people live within the Indus Basin, most in dry, sub-tropical lowlands of Pakistan. They depend upon the Indus streams for irrigation, power and groundwater recharge; for urban and industrial water supply. Most of the moisture comes from the river's Himalayan head waters. Only here, essentially above 2500m, is there a net moisture surplus anywhere in Pakistan.

The easterly tributaries of the Indus are mainly fed by monsoonal rains; the westerly ones by snow and glacier meltwaters. Pakistan, through the Indus Waters Treaty with India, has now become largely dependent on the latter. Moreover, most of their flow in the Plains is managed by series of large dams, barrages and great canals.

The Himalayan sources of the Indus are poorly known. Even so, water yield from the snow and glacier fed streams is as fickle as in the better known and monitored monsoonal areas. Unanticipated extremes of low and high river flow have already created severe national and local problems of water supply in Pakistan. Thus, there is an urgent need for better forecasting of the glacial regime rivers and on-going investigations of snow and ice conditions.

A Joint Venture:

Canada has a long, direct concern with cold environments and water resources derived from snow and ice. The present project is intended to apply Canadian experience to the research, training and planning needs of Pakistan in snow and ice hydrology.

This is a co-operative project between Pakistan's Water and Power Development Authority (W.A.P.D.A.); the International Development Research Centre (I.D.R.C.) in Ottawa, and Wilfrid Laurier University (W.L.U.). In Pakistan, project co-ordination is undertaken by the Hydrology and Research Directorate of W.A.P.D.A. in Lahore. In Canada, the project is co-ordinated within the Hazards and Resource Development Research Unit at W.L.U. There are contributing scientists from the Universities of Waterloo, Ottawa, British Columbia, and the Inland Waters Division of Environment Canada. A total project budget of some $1.6 million is shared about equally by Pakistan and Canada.

Major Objectives:

1. Initiate research into glacio-hydrologic aspects of the Upper Indus Basin relevant to water resource development and forecasting.

2. Introduce and test technical methods and models appropriate to the environment of the Himalayan Indus.

3. Define the terms of an on-going monitoring and forecasting system for snow and ice regime basins.

4. Train a core of Pakistani scientists/engineers to continue this work.

The Hydrological Problem:

Seasonal snowmelt[4] and glacier melting are both large contributors to the Indus.

Snowmelt: In most winters, 80 – 90 percent of the Upper Indus Catchment becomes snowcovered, though sometimes as little as 60 percent. The deep snow packs that yield most of the meltwaters only compose a fraction of this: essentially in areas between 2500 and 5000m a.s.l. Melting of the lower, thinner snow cover may be critical however, for spring sowings and when reservoirs are low. The main melt is usually in progress by late April. We suspect that it dominates flow until early July.

Glacier Waters: About 12 percent of the Upper Indus Catchment is covered by perennial snow and ice. There are thousands of glaciers, but the 35 or so largest ones, – some like the Siachen and Biafo, being of very great size, – dominate the hydrology. The glaciers originate in high snowfall areas, generally above 4800m a.s.l. Most of the water yield is from ice that has flowed to lower altitudes, mainly in the range 3000 – 5000m a.s.l., and during an intense period of melting that usually dominates river flow from mid-July until early September.

The absolute and relative contributions of snow and ice to the Indus flow will vary enormously from year to year. Sometimes they will compensate each other. More rarely, but critically, they may reinforce each other with either poor or exceptional yields of water from both sources. In any case, the timing of each is different, snowmelt usually being critical early in the summer, glacier melt in the latter part. The common coincidence of peak summer melting with the monsoonal rains must be noted. The scope of the melting that does continue through the winter is important at a time of water shortage.

The Mountain Environment: Of decisive importance is the natural influence of an exceptionally high and rugged mountain environment. Topography largely determines where snowfall occurs, the relative accumulations of snow and ice, and their patterns of release by melting. Two outstanding factors are the great variation of snowfall with altitude and the altitudinal migration of melting temperatures over the hydrological year. These two factors combine to ensure that only a fraction of the whole Upper Indus Basin, - probably less than 30 percent, - contributes perhaps more than 80 percent of the river's flow. In essence, all the hydrological 'action' takes place in the zones above 2500m, and for most of the basin, over 3000m a.s.l. Most of the actual yield of water to streams derives from a belt between those altitudes and 5000-5500m. Above that again there is often heavy snowfall and large stores of snow and ice, but little melting. Below 2500m there is generally little precipitation and very high evaporation.

Unfortunately, there have been no permanent or regular observations of hydrological conditions in the critical altitudinal zone, 2500 - 6500m a.s.l.

2. THE RESEARCH PROGRAMME

S.I.H.P. involves a three-year programme of studies that combine field-work, with applications of remote sensing, analysis of existing river discharge and meteorological observations, and development of a forecasting model. Both Pakistani and Canadian scientists are to be involved in all phases of the work.

Fieldwork:

Here the primary need is for investigations in the zone 2500 - 6500m a.s.l. We have to take account, also, of the range of environments within the

Upper Indus. These involve altitudinal and regional variations across the basin. Of course, while one would hope to obtain as representative a picture as possible, severe constraints of cost, time and the high mountain environment limit what can be done. Essentially, we are conducting a series of investigations concurrently in several basins in the main Himalayan and Karakoram Ranges, some predominantly involving sources of seasonal snowmelt and some of glacier meltwaters. In addition to basins receiving intensive study, reconnaissance surveys make short-run observations of parameters that we think are keys to extending the work to other areas. Considerations for which field work is most needed at the present stage of our knowledge are:

1. Glacier mass balance.

2. The behaviour, especially the melting of seasonal snow packs.

3. Altitudinal gradients in the input, storage, transfer and melting of snow and ice.

4. Factors most likely to cause variations in the above over time-frames from weeks to decades.

5. Differences in the above for the major contributing basins of the Upper Indus Catchment.

At the same time, the approach has to be 'investigative' in the sense of seeking to identify measures, equipment and procedures, the sites and networks for observation that will:

a) be dependable in this environment,

b) be capable of extending the usefulness of existing stations measuring river discharge and weather,

c) be capable of calibrating satellite-generated data,

d) help define the form and potential of a future monitoring network and inputs to the forecasting system, and not least,

e) lead on to a reasonable programme of continuing observations and investigations by the officers of the Water and Power Development Authority.

Other Data Sources:

Given the state of knowledge of the U.I.B. all sources of data that will add to our knowledge of the snow and ice-covered areas is of great interest. One essential task of the investigators has been to identify and sift through the large, ~~though~~ scattered and often old literature, dealing with the region. There have been hundreds of exploratory and mountaineering expeditions, and more than a dozen scientific expeditions from which useful pointers and some hard data can often been gleaned.

In order to obtain information of sufficient geographical extent or duration over time, we are also concerned with four particular sources for intensive desk work and analysis. These are:

i) topographic maps, especially for such areas as Nanga Parbat and the Biafo-Hispar watersheds where relatively accurate mapping has been carried out These are means to determine area-altitude relations, extent, size and morphological characteristics of drainage basins, glaciers etc., and for use in developing terrain models to be applied in forecasting.

ii) gauging station records - there are once-daily records of stream flow for the main stem of the Indus since 1868, and for two or more decades on several of the major Himalayan tributaries. These have fair to good rating curves for discharge. They provide evidence of the net water yield of the basins that concern us, and time-series indicative of the forms and scales of variation which, presumably, are mainly determined by events in the glacial source areas.

iii) weather station data - there are a number of weather stations within the U.I.B. with records of several decades for temperature and precipitation. Unfortunately, all are below 3000m and mostly well down in the semi-arid and arid areas strongly influenced by precipitation shadow and valley wind systems. Analysis may show, however, that they provide indicators of events at higher altitudes.

iv) satellite imagery - some two decades of images from space are available for the U.I.B. They offer the only comprehensive coverage of the basin at any given time, and are especially useful in showing the extent of snow cover, glacier surface conditions and gross changes in such things as glacier termini. Glacier and snowcover inventories from field work can be greatly assisted by satellite imagery, while the latter can be greatly increased in its value by appropriate field checks. Although there have been serious problems in obtaining good coverage from ERTS or LANDSAT because of the frequent heavy cloud cover over relevant areas of the U.I.B., satellites offer the most convenient and comprehensive method of observing temporal variations in snow cover. The commonest approach to date has been based on data from the multispectral scanner (MSS) aboard LANDSAT satellites. The hard copy or photographic images are interpreted in much the same way as air photographs. However, the full potential of satellite data is being realized through their manipulation in digital form to produce various types of enhancement. It is planned to use the facility ARIES II, Image Analysis System interfaced with a computer to perform such work on the U.I.B. imagery. This facility is available at the University of Waterloo. It should enable not only more precise delineation of snow and glacier edges, but acurate discrimination of different snow types, ice surfaces and other surface variations.

Forecasting:

Each of these data sources will be used in conjunction with information derived from field work to mutually improve the usefulness of both. However, the main project goal in exploring them, is their usefulness in forecasting. The river discharge and weather observation network of the Indus Basin is presently used to forecast river flow and especially flood risks through the Forecasting Centre in Lahore (see H.I.D. 1980). At the moment, virtually no data are employed here that directly involve snow and ice conditions. Some attempts have been made to relate total summer run-off to maximum extent of winter snow cover from satellite imagery. The effectiveness of such an approach is in doubt without data on area-altitude relations of snow cover, especially water- equivalents and the ability to separate seasonal snow from glacier melt.

Nevertheless, the river records, climate stations and satellite imagery offer promising sources of data for testing a forecasting model in terms of periods of years and decades. In combination with a monitoring network of other observations, they will no doubt be major elements of the real time input to a future forecasting system. At the moment S.I.H.P. is exploring the application of the University of British Columbia Watershed model to the Upper Indus System. This model, developed by Dr. Michael Quick, is already in use for forecasting run-off from snow and ice melt in the mountainous basins of British Columbia, especially for the needs of B.C. Hydro's power generation.

Hazards:

While monsoonal conditions dominate flood and drought risk for most of Pakistan's population, snow and ice meltwaters generally influence the severity of these problems. Meanwhile, some of the greatest historic floods on the Indus have derived from glacier dams in its Himalayan head-waters. Development and installations in the Northern Areas are at risk from avalanches, sudden glacier advances, local floods and river changes, and severe erosional processes such as great mudflows associated with the mountain snow and ice conditions. S.I.H.P. will be reviewing these problems, and making an inventory of their occurrence and suggesting measures to offset them.

APPENDIX I: THE SNOW AND ICE HYDROLOGY PROJECT

APPENDIX Ib

THE 1986 FIELD SEASON*

*From an article by K. Hewitt in Snow and Ice Hydrology Project: Annual Report 1986.

As originally planned, the major effort in 1986 was in field investigations. These had both a research and training function. Fifteen Canadians and seven WAPDA officers took part. Several Northern Areas college students provided invaluable field assistance, while themselves learning about the methods and purposes of glacial hydrology.

In terms of expenditures, 1986 field costs are the largest components of S.I.H.P. It may be noted that this follows from a basic belief concerning present research and training needs. It does not imply that we expect field investigations to be the heart of the sort of monitoring and forecasting system WAPDA will require in future. But these investigations are essential to specifying the form and data requirements of the latter. And we think that forecasters, who may well spend little time in the high snow and ice areas later, need a basic grasp of conditions there that is only to be achieved by direct experience.

The work this summer was largely targeted for altitudes above 2600 m and in a roughly northeast-southwest transect from the high Karakoram to the Himalayan Front Ranges (Fig. 1). Although we anticipate some important variations in hydrological conditions from east to west across the U.I.B. and in basins such as the Chitral and Shyok, logistical and security problems preclude a broader scope at present. The background to the choice of locations and activities will be found in S.I.H.P. Working Paper No. 1 and Chapter One in Part II of the 1985 Annual Report of S.I.H.P.

The parts of the field programme where Canadians were involved most directly are tabulated below.

CENTRAL KARAKORAM (Hunza and Braldu River Basins)

1) Upper Biafo, Hispar and Khurdopin Glaciers (May-August)

Snow accumulation, snow chemistry and high altitude (4500-6500m) glacial and climatic conditions.

2) Middle and lower Biafo Glacier (May–August)

Ablation zone mass balance observations, continuing and expanding 1985 pilot programme. Gradient studies of climatic variables on and off ice. Glacier movement.

3) Barpu-Bualtar Glacier Basin (May-August)

a) Mass balance and related weather variables. Transient snow line survey, gradient studies of climatic variables on and off ice (2600-5000m). Glacier movement.

b) snow resources, runoff and irrigation of mountain communities (Hopar)

c) Glacier-related hazards: avalanches, ice-dammed lakes, rapid glacier flow and preliminary mapping of large glacier-related landslides along the Bualtar Glacier.

4) Hunza, Hispar and Braldu Rivers (May-August)

Studies of discharge, electrical conductivity and sediment transport, mainly at stations set up by H.I.D./WAPDA officers in November 1985.

NANGA PARBAT

5) Middle and Lower Rakhiot Glacier (June-July)

Mass balance, transient snowline and climatic gradient studies: runoff, influence of debris covers on melting, continuing work of 1985.

KAGHAN VALLEY

6) Naran area (May-July)

Studies of avalanche hydrology and hazards continuing from 1985.

7) Saiful Maluk Valley (May-July)

Studies of area snow covers, transient snowlines, patterns of snow melt and climatic gradients.

APPENDIX II: FIELDWORK FROM MAY TO JULY 1986*

*Reprinted article by David Butz in Snow And Ice Hydrology Project: Annual Report 1986.

Information presented in the present paper was collected in Hopar between the dates May 8th, 1986 and July 23rd, 1986. Research undertaken during that period was divided between collecting thesis related information, and recording climatic and water supply data for the Snow and Ice Hydrology Project. Personal and project investigations often overlapped. They may be divided into five components:

1. Meteorological measurements
2. Reconnaissance of Snow Accumulation Area
3. Land use, water use and topographic mapping
4. Irrigation water measurements
5. Agricultural test plot studies

In addition extensive qualitative observations were made of cultural and agricultural practices, both in the village area, and in high summer pastures above the ablation areas of adjacent glaciers.

1. METEOROLOGICAL MEASUREMENTS:

Hopar Valley's main meteorological station was located at Holshal base camp (2849m). Manual measurements of dry and wet bulb temperature, cloud cover, barometric pressure, precipitation, evaporation, and irrigation water temperature were augmented until June 29 by automatic hydrothermograph readings of temperature and relative humidity. To begin, measurements were the responsibility of Butz, and local assistant Shaffi Ahmat; however, since both had other duties manual readings could be taken regularly only at 0800, 1200 and 1600 hours. They were supplemented by hourly measurements when either member was in camp.

After June 14, Arib Azhar took care of the base camp meteorological station, and responsibly recorded readings hourly from 0900 to 1900 daily. When Azhar departed June 29th, hourly measurements were continued by Hopari geography student Beshharat Hussein until July 25.

Several gradient studies of wet and dry bulb temperature, wind speed and direction, and cloud cover were undertaken up the western slopes of Hopar Valley. Butz completed three such studies to 4030m from base camp at 2849m, on May 28, June 1 and July 23. In addition on May [illegible] Engineer Inamullah Khan and Shaffi Ahmat took gradient measurements up to 3550m. These can be used in co-ordination with others collected by other project members elsewhere to establish a temperature and humidity gradient for a range of elevation throughout the Barpu/Bualtar study area.

Finally, an evaporation pan and rain gauge were set up on the western slope above Hopar at 3150m with the aim of comparing moisture differences between upper pasture land, and valley floor cultivated fields adjacent to Hopar base camp. Unfortunately, shortly after the equipment was installed, blasting of a high channel blocked safe passage to the site, so precipitation and evaporation could be recorded only intermittently at this high station.

2. RECONNAISSANCE OF SNOW ACCUMULATION AREA

The irrigation network of Hopar Valley is fed by seasonal snowmelt from an accumulation area above 500m on the western slopes above cultivation. It was important to obtain some indication of the gross extent and depth of this snowpack, and its recession throughout the season. The project could not support a detailed investigation of the basin, but it was possible to establish photo stations at 4030m and 28850m, from which the basin was observed and photographed, and basic meteorological measurements were taken. These stations were visited three times throughout the season, on May 28, June 21 and July 23; often enough to monitor the snow's recession and map it on Mott's 1:250,000 map of the region. These reconnaissances, though infrequent, are sufficient to describe, in a general manner, the supply side of Hopar's irrigation network, and to allow comparison with the broader investigation of S.I.H.P.

3. LAND USE, WATER USE, AND TOPOGRAPHIC MAPPING

The entire Karakoram region is very poorly mapped, especially at the large scale necessary to interpret water and land use. Consequently, the 1986 field work included mapping Hopar Valley at two scales. The entire valley, surveyed at 1:10,000 shows contours, streams, main irrigation channels, agricultural land use, and other cultural features of the landscape such as village clusters, and roads. The map encompasses an altitude range of 1550 m from 2500 m to 4040 m, and depicts a total plane area of 700 hectares. The farmland of the two most southerly villages, Ghoshushal and Holshal, was mapped in much greater detail at 1:2500. The larger scale allows all irrigation channels, fields, crops, terraces, and isolated buildings to be included. In addition, direction of channel flow, as well as terrace height and slope were surveyed.

Plane table, allidade, and abney level were used for surveying, after baselines of 930 m, 535 m and 406 m were measured between three prominent points with theodolite and laser distance measuring equipment. The plane table method, although slow and painstaking, requires that the map be drafted in the field; an advantage in an intricate terrace and irrigation system when surveying error is always a threat.

4. IRRIGATION WATER MEASUREMENTS

The Hopar Valley Irrigation Network is fed by twelve main channels which direct water from the natural meltwater stream to smaller ditches among fields. It was important to discover how much water flows through main channels into the agricultural system, and how that flow fluctuates diurnally, and throughout the irrigation season.

The measurement program began with the selection of sites near the head of each channel after which channel characteristics were used to solve Manning's equation for velocity. This allowed calculation of both potential and actual discharge through each channel. Two sites were then monitored at half-hourly intervals until it was determined that waterflow through main channels does not vary significantly throughout the day. With that knowledge it was reasonable to reduce gauging measurement at each site to a more practical three-day interval, in order to monitor fluctuation over the irrigation season. Water temperature, cloud cover, wet and dry bulb temperature, wind speed and direction, and suspended sediment concentration estimates were all recorded at each site at the same interval; providing additional data about changing atmospheric conditions throughout the cultivated area (See Figure 1).

Figure 1: Method For Determining Irrigation Channel Discharge

A. Manning Equation for Velocity

$$\tilde{v} = \frac{R^{.66} \times S^{.5}}{n}$$

where: R =hydraulic radius
=channel cross section/wetted perimeter

S =water surface slope

n =Manning's resistance co-efficient
=(n0 + n1 + n2 + n3 + n4) x m5

n0= bed material

n1= surface irregularity

n2= cross-section variation

n3= effect of obstructions

n4= vegetation

m5= meandering

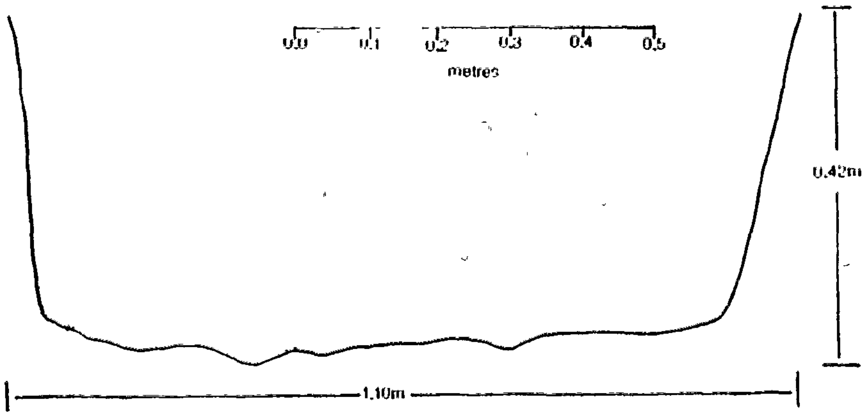
B. Example of Primary Channel Discharge Measuring Site

Channel Characteristics (Manning Co-efficient Values):

bed material: coarse gravel (.028)
surface irregularity: minor (.005)
cross-section variation: gradual(0.0)
effect of obstruction: negligable(0.0)
vegetation: none (0.0)
meandering: minor (1.0)

cross-section area: $0.349m^2$
wetted perimeter: 1.72m
channel slope: 3.5°
hydraulic radius: 0.23m
potential velocity: 2.12m/s
potential discharge: $0.834m^3/s$

Primary Channel 2: Cross-section



Unfortunately, the main meltwater stream is too wide, turbulent, and variable in its bed to permit the accurate use of Manning's equation for calculating discharge. The problem was partially remedied by estimating the percentage of total stream flow entering each channel. Thus, at the end of each measurement round, the total stream flow, and percentage of stream flow entering the irrigation system was roughly calculated.

5. AGRICULTURAL TEST PLOT STUDIES

A total of fifteen individual fields throughout the Holshal/Ghoshushal cultivated area were studied in detail. Included in these test plots were three fields of wheat, one barley, three broadbean, three potato, three alfalfa, one pasture, and one mixed pasture/orchard field. Slope, aspect, soil constitution, adjoining fields, terrace height, internal irrigation pattern, and texture were determined for each plot initially. Then, again on three-day intervals, soil temperature at ten cm, surface temperature, wet and dry bulb temperature at one meter, cloud cover, shade conditions, wind speed and direction, and crop growth were measured. Occasional evaporation readings were collected for each field and can be compared with one another and with the continuous evaporation record at base camp. In addition, soil moisture samples were taken daily between irrigations on several plots.

A photo inventory of all plants, including weeds, growing in each plot was conducted July 12. At the same time biomass and plant density was sampled. These density measurements supplement those recorded earlier in the season on June 16. We attempted to estimate irrigation infiltration rate on several plots. Water was allowed to enter an enclosed area of cropland at a controlled volume at a rate approximating that used by local irrigators. Length of time between initial water input and infiltration of all surface water was then recorded. Estimated infiltration can be coupled with irrigation timing data to estimate volume of water required to irrigate a particular plot.

COMMENTS:

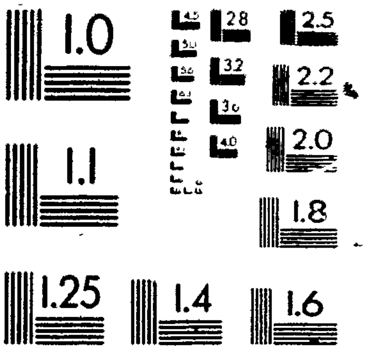
The Hopar Valley irrigation water and agriculture program provided considerable empirical and qualitative data useful both to understanding the local level of water supply from snow melt, its controls and variability. Valuable insights also derive from human use of meltwater in the region, and act as a supplement to the research conducted on adjacent glaciers.

Snow accumulation studies would be improved by snow thickness and density measurements, as well as more frequent meteorological and snow recession monitoring. Constraints of manpower and equipment prevented such studies. Nevertheless, as stated earlier, the work that was done, though infrequent and unsophisticated, is sufficient for the general description of the supply side of Hopar's irrigation system.

Meteorological measurements yield valuable climatic data which are related to crop growth and water supply conditions in the valley, as well as to melting and summer accumulation conditions in the Barpu/Bualtar Glacier Basin. We were particularly pleased with the performance of the hydrothermograph; it is unfortunate that it could not remain in camp all summer, but it was urgently needed at high altitudes. Manual readings, when taken, were accurately and carefully done: however, there are blanks in the recording book, indicating lack of commitment. Careful selection of readers from among the local population, and the incentive of promptly and regularly paid wages could solve a good part of the problem. Evaporation measurements taken hourly throughout the day are a valuable contribution to existing knowledge of plant growth conditions in the area.

We originally hoped to use v-notch weirs to measure discharge through these and smaller channels; however, it was impossible to maintain a tight seal around the perimeter of weirs on many channels. Sedimentation upstream, and erosion downstream, from the site proved to be hazardous to the irrigation network. In addition, channels often flow so close to capacity that overflow behind weirs was unavoidable, resulting in disruption both of the irrigation systems, and of data collection. The second choice, Manning's velocity equation, worked well in primary irrigation channels. It was easy to find suitably straight sections of each channel with the constant slope, uniform cross-section and stable bed material needed to calculate co-efficients of flow. The resulting data yields considerable insight into irrigation water supply, its fluctuations, and patterns of water allocation. Nevertheless, program aims would have benefitted from a longer period of study, and measurement of secondary

3 of/de 3



irrigation channels. Once sites have been chosen and coefficients calculated taking readings is simple, so in future seasons, villagers could be employed to read a greater number of sites over a longer time period.

The most serious gap in our knowledge of irrigation water supply is the lack of any accurate data on mainstream discharge. Turbidity, steep slope, extremely variable flow and unstable bed material combine to prevent the use of current meters or analyses based on cross-sections or channel characteristics (such as Manning's equation). Dye-dilution is the only apparent method of measuring this type of flow. It was used successfully by Keeley on the Barpu Glacier meltwater stream, and with experimentation could prove equally suited to use on Hopar Nala.

Test pilot studies compliment other parts of the program by introducing the field – often perceived as a closed agro-ecosystem – into the larger and less controlled environment of meltwater supply, irrigation network, and community agricultural society. In this way many quantitative measurements completed in the plots can be related to a more qualitative understanding of the larger system.

Time and effort spent mapping the study area was particularly fruitful. The maps are among the most detailed available for an agricultural community in the Karakoram, and as such will be a valuable contribution to the scholarly knowledge of this region. Additional large-scale mapping of the community should be a priority of further field work in Hopar, not only due to the scarcity of accurate maps of the Karakoram, but also because surveying and mapping demands a recognition of detail, patterns and spatial relationships which would otherwise go unnoticed by researcher and reader alike. Plane tabling is an excellent way to survey this landscape, especially since good vantage points are easily occupied. A telescopic allidade should be considered if more such mapping is anticipated. It would increase both accuracy and efficiency of mapping.

CONCLUSION

On the whole, the 1986 Hopar Valley irrigation water and agricultural program was successful both in terms of collecting hard data for the primary goals of the Snow and Ice Hydrology Project, and in providing considerable insight into a high-Karakoram irrigated agricultural system. The data collected appears to be accurate, applicable to problem solving, and – with regard to existing Karakoram water supply literature – original. Shortcomings in the program may be attributed mainly to constraints in time, manpower, and equipment money.

APPENDIX III: LITERATURE WHICH IS RELEVANT TO THE CULTURAL GEOGRAPHY OF HIGH MOUNTAIN AREAS

1. TRADITIONAL MOUNTAIN GEOGRAPHY: ENVIRONMENTALIST APPROACHES TO MOUNTAIN SOCIETIES

Most geographical literature perceives mountain people as products of their physical environment. Publications range from descriptions of specific regions (Grohman, 1879; Schomberg, 1936) to the entire world (Barnes, 1958; Peattie, 1936; Price, 1981). All of it is produced by and for lowlanders. In addition, the most widely read works attempt to examine all aspects of mountain environment and society. As a result perspectives offered by traditional mountain geography tend to be romantic, simplistic, and condescending, particularly as they relate to human/environment interaction.

During a period between the late 1800s and 1960, numerous regional geographers travelled into the Himalayan Ranges and published their experiences. These accounts range from Pant's (1935) highly anecdotal, but detailed, narrative on land and life in the Kumaon Himalaya, to Schomberg's (1936) description of Chitral, which is more empirical, but which reveals less about human geography. Such investigations are interesting and offer some valuable background information. The fact that they often deal with much information in few pages discourages authors from including information that is detailed enough to be useful for specific topics (Biddulph, 1880; Cressey, 1960; Drew, 1875; Visser, 1926- also Dainelli (1914) in Italian). Nevertheless, Pant (1935) and Schomberg (1936) do explain that a common source of irrigation water is high altitude snow and ice. They, as well as Workman (1905), Stephens (1953), and Douglas (1958) describe the non-structured irrigation and terracing common in semi-arid, high altitude Himalayan slopes. Thus, some specific information can be gleaned from the works of these early mountain geographers.

During this period similar studies were undertaken in Europe and South America. They are less essential to an understanding of these areas because the Alps and Andes have been studied more recently and more extensively than Himalayan regions. Works by Grohman (1879), Denkschrift des Akademischen Senats der Universitat Innsbruck (1918), Arbos (1923), and Leitgeb (1938) in Europe, and Bowman (1916) in South America all agree with publications by geographers studying the Himalayas, that cultural and agricultural activities of high altitude peoples are direct effects of a single 'harsh' environment that is somehow common to all mountain regions. This literature is characterized by condescension which delights in stressing 'quaint' differences among mountain dwellers, but which insists that all native inhabitants of high altitudes are characterized by similar deficiencies in intelligence, ambition, morality, and innovativeness. The common view of Himalayan peasantry as timid people controlled by a daunting habitat stems from early work by regional geographers (Pant, 1935; Schomberg 1936). It is interesting that European alpine folk have been viewed more favourably, if just as romantically. This is illustrated by the familiar theme of resilient independent Swiss mountaineers seeking inspiration from their lofty homes (Arbos, 1923; Grohman, 1879). One cannot help but think that ethnocentricity plays a part in characterizing mountain peoples: the Alps are much closer to home in the history and perception of most western geographers.

Mountain explorers share the attitude that geophysical habitat has created a variety of high Himalayan societies that, with the possible exception of Nepal's Sherpas, are inferior to lowland peoples. (Bruce, 1910; Cockerill, 1922; Durand, 1910; Knight, 1893; Younghusband, 1896, 1924). Mariani (1961) and Rowell (1977) in particular describe the inability of Baltis to sympathize with noble deprivations and hardships associated with mountain climbing. No doubt it was frustrating to be reliant on native porters who did not share the desire to explore and conquer mountain peaks. Unfortunately, this frustration prevents them from communicating any true understanding of native farmers and their use of land and water. Shipton (1969) avoids this problem by dealing less in opinions and more in observations and descriptions. His work offers brief but informative accounts of meltwater irrigation and agricultural land use. The result is a valuable array of information about mountain agricultural villages. Unfortunately, Shipton spent most of his time above the zone of cultivation. Other mountaineers such as Mueller (1958), Dyhrenfurth (1955), Chascinski (1966), and Barnes (1958) limit their accounts to mainly geophysical information and the climbing experience itself.

In summary mountain climbers and explorers have tended to report on cultural activity in a random, and often negative, fashion. As a result comprehensive information is scarce in this type of report. Despite those shortcomings, the writings of early regional geographers and mountaineers alike do convey a general knowledge of the Karakoram, and provide a 'feeling' for the study area. This 'feel' is enhanced by the excellent photographs that are often a part of mountaineering accounts.

The past quarter century has continued to produce studies in the regional geography of mountain areas. Recent work tends to be more specialized, more scientific, and more scholarly than previous investigations. Nevertheless, except for a portion identified specifically as geo-ecology, it continues to concentrate on physical processes, and their role as cultural determinants (see Alford, 1974; Barry, 1979, 1981; Billings, 1979; Grover, 1974; Ives and Barry, 1974). Billings, (1979) for instance, devotes twenty of twenty-five pages to purely geophysical and biological processes. Grover (1974) does stress the human component of high mountain environments, but concentrates solely on the effect of altitude upon physiological functions. Even Staley (1982), who spent years studying Karakoram peoples is vaguely deterministic in his description of nature's impact upon communities. His work is discussed in more detail below. This is a shame, for it spoils an otherwise informative and perceptive narrative, especially of agriculture and meltwater use.

Mountain overviews by Peattie (1936), Herzog (1956-French), Barnes (1958), and Price (1981) also tend to stress physical conditions and processes at the expense of cultural understanding. This seems odd since, despite their content, they are not written for physical geographers, but rather present geophysical information in understandable layman's terms. If only they had complemented competent description of landforms and climate with perceptive analysis of human interaction with those conditions! Hewitt (1983 p. 96) states in his important review of Price (1981) "the treatment of human behaviour and societies is sketchy, stereotyped and conceptually weak. Much of it slips into a crudely environmentalist view." Hewitt goes on to criticize Price's neglect of human behaviour, and in so doing provides an assessment true of almost all traditional mountain geography. Namely, climate and landforms are treated competently and comfortably, but all aspects of human existence and interaction with environment are treated superficially. Thus, he declares "One can only ask why the most profound and far-reaching of all the activities of intelligent life - how it conceives, represents and values, its world - has become the stuff of pleasant titillation or dusty scholarship, while even the muck in a solifluction terrace receives a fierce commitment to detail, precision and generality?" (Hewitt, 1983, p. 97). In concluding his review Hewitt pleads for contemplative analysis of the interface of human and environmental understanding (p. 102). Indeed, he suggests that geographers, and other social scientists, have little to offer otherwise. Unless traditional geography overcomes environmentalism, and abandons its preoccupation with geophysical conditions, it will continue to offer only random and superficial insights into human interaction with mountain landscapes.

Himalayan cultural geography before WWII is exemplified by Schomberg's book Between The Oxus And The Indus. Colonel Reginald Schomberg was a British army officer serving in Gilgit Agency during the 1920s and early 1930s. Although he had no geographical training his book is a semi-scholarly attempt to describe the history, people and landscapes of the Karakoram area. Much of his time was spent in Hunza and Nagyr, near where the present study was undertaken. Most of Schomberg's description is based on personal observation, although he does reference literature by other army officers, as well as several scholarly anthropological works.

The book deals briefly with all aspects of society, including folk-lore, marriage customs, cultural habits, religion, agriculture, economics, social and military history and physical geography. Schomberg has a keen ability to observe and describe. However, the work loses value because it lacks an organizing theme. There seems to be no selection or synthesis of observations. Without such a theme the book remains an unfocussed collection of recollections. This is characteristic of much literature from the colonial period. Most authors were soldiers or adventurers with no articulate scholarly objective or perspective. As a result they could not generalize from specific observations.

Often unsubstantiated environmental determinism substituted for any other generalizing theory. Schomberg tainted environmentalism with condescension for the inhabitants of the Karakoram. He writes of the people of Hunza (Schomberg,1936,pp129-130):

> One of their bad points is their quarrelsomeness... they are selfish toward their families. A Hunza man will go away from home to earn his living, but will seldom send money or even a letter to his relations. Their besetting sin is avarice. Nothing, not even the granting of their most extravagent demands will satisfy them. There is, too, an effrontery in their extortions that is repellent...The good and bad qualities of Hunza men come from the land in which they live, where there is great congestion, existence is a struggle and land and water are both inadequate.

This environmentalist explanation of cultural attributes is simplistic. The way that it is offered as an excuse for "undesirable" traits misrepresents village culture. As a result, much of what Schomberg writes must be discarded, not as untrue but as unrepresentative.

Recent geographical work in the Karakoram is more sympathetic of village culture, but still views high mountain society in a vaguely environmentalistic way. John Staley's (1982) book Words For My Brother is characteristic of the current approach. Staley, and his wife Elizabeth Potts, both geographers, travelled in mountainous Northern Pakistan over a period of several years, ending in 1972. Their wanderings were sponsered by several university and government agencies, both English and Pakistani.

The objective of their travels, as stated in the book's preface, was "a study of this extraordinary physical environment, and of the kind of life which people have made for themselves there" (1982,preface). The result is a tender, almost poetic, description of physical geography, agricultural adaption, social customs, and intellectual outlook of mountain comunities. Unlike Schomberg, Staley obviously developed great affection for the landscape and people; because of that his book offers a strong sense of place.

Words For My Brother is a narrative. However, it is a carefully and smoothly structured narrative. Staley begins by introducing the reader to physical environment, specifically the mountains and their climate, geology and topograpy. He then introduces humans through the built environment, namely transportation networks and agricultural oases. He briefly, but competently introduces the relationships among snowmelt, altitude, topography and agriculture, and then describes the cycle of agricultural activity. It is in this section that Staley suggests a direct causal relationship between geophysical habitat and society. However, because the description is always based on observations, examples and quotations from villagers it does not become blatantly environmentalist. The description of agricultural labour leads easily into a discussion of family life, customs and religious beliefs. Since the dominant Islamic faith is mingled with leftovers from earlier beliefs, a description of mythology and history follows. Finally, political history and current politics are discussed.

It is apparent that Staley sets out to write a captivating account of existence in Pakistan's high mountains. He succeeds. However, as a scholarly account his book lacks substance. It gives many convincing examples, and suggests credible relationships, but it covers too much without providing enough detail on any of it. Words For My Brother is an excellent introduction, but not a conclusive report on any aspect of high mountain life.

2. MOUNTAIN ECOSYSTEM FRAGILITY STUDIES

Studies describing mountain ecosystem degradation are part of a larger literature which deals with environmental stress in general. Concern for stressed environments and their implications for humanity peaked in the late 1960's and early 1970's with the publications of popular (Meadows, 1972; Strong, 1973) and scholarly (Emmel, 1977) works. Since that time public concern has diminished, but scholarly research continues, especially among geographers (see Allen and Barnes, 1985; Brabin, 1985; Nir, 1983; Smith and Baillie, 1985; Young, 1985). The portion of this work relating to developing countries offers a Malthusian argument; erosion, deforestation, and agricultural degradation are attributed to poor farming and ecological practices by ignorant and expanding rural populations (Allen and Barnes, 1985; Nir, 1983; Warren and Maizels, 1977; Young, 1985).

In the mid 1970's Eckholm applied the argument of population pressure to mountain environment deterioration (1975, 1976). Others had done this earlier, but without receiving the attention given to Eckholm (see UNESCO, 1974; Cool, 1967; Kaith, 1960). His main points have become the basis of mountain deterioration literature (Eckholm 1975,pp766-767):

1) Widespread erosion coupled with decreasing carrying capacity of agricultural and pastoral land is evident in all developing mountain regions.

2) Overgrazing, deforestation, overcultivation, and land fragmentation causes degradation in African and Asian ranges. This in turn is the result of recent population explosions due to natural increase and migration from crowded lowlands.

3) Degradation in the Andes stems from depopulation of upland areas, and overcrowding in intermontane valleys. Migration out of high altitude zones is accompanied by loss of soil conservation lore, and the ability to maintain physical agricultural structures. As terraces deteriorate farmers rely increasingly on pastoralism. Over-grazing exacerbates erosion and decreases carrying capacity.

4) Mountain communities are particularly susceptible to economic and political pressure to change. When villagers abandon traditional agricultural systems, indigenous methods to prevent degradation are lost.

Since Eckholm's widely publicized efforts, other geographers have attempted to explain mountain ecosystem degradation. Many of the results are published in the journal MOUNTAIN RESEARCH AND DEVELOPMENT. Most studies concentrate on particular locations, or specific aspects of the problem.

Investigations of Himalayan areas concentrate on deforestation and overcultivation (Bachman, 1983; Bajracharya, 1983; Karan and Iijima, 1985; Kienholz et al, 1984; Klimek, 1984), while Andean studies tend to describe problems associated with overgrazing (Bahre, 1979; Browman, 1983; Fuentes, 1984; Guillet, 1981; Millones, 1982). Other mountain regions are only poorly represented (see Benchinfa, 1983; Mikesell, 1969). Some Himalayan ranges, including the Karakoram are ignored.

Location-specific and symptom-specific literature on mountain degradation contributes to human geography by stressing relationships between natural highland ecosystems and human communities. Interaction with, rather than reaction to, the geophysical environment is emphasized. This is important in a field dominated by environmentalist perspectives. Indeed, many authors take determinism to the other extreme by implying that environmental change is dependent on human activity alone. An article by Karan and Iijima (1985) on Himalayan degradation blames deteriorating ecological conditions solely upon human activity. Others go just as far (Bajracharya, 1983; Bencherifa, 1983; Browman, 1983; Fuentes, 1984; Klimek, 1984). Consequently, literature on environmental degradation in mountain areas portrays highland folk as ignorant and incompetent at worst, and at best careless victims of their own circumstances. Bajracharya (1983, p.230) quoting Robbe (1954) declares of Nepalese communities:

> Inadequate manuring, lack of water for winter crops, and the poor seeds keep yields extremely low, and force the farmer to cultivate a large

> area...if the present situation is not soon improved, the stability and the very life of the country will be threatened.' Although aware of the problem, the local people 'are caught up in a vicious circle which, unaided, they cannot break.

It seems that this negative portrayal of mountain peoples is a function of the topic' rather than the intention of authors, for their tone is usually sympathetic, and external national or international stresses toward negative change are often mentioned (Bencherifa, 1983; Bachman, 1983; Bajracharya 1983; Kienholz et al, 1984). Yet, these are dealt with hastily and peripherally, as if discussion must not stray from the theme of peasant action/environmental reaction. The effect is twofold. First, all publications dealing with mountain fragility tend to repeat the same constricted themes. Consequently, the usefulness of valuable research is constrained by the limited perspective presented in print. Secondly, emphasis on negative land use practices creates an unrepresentative impression of farming lore and knowledge. In Hopar, for example, there is little evidence that land use significantly degrades the stability of the landscape, especially compared to natural processes. If anything, terracing and irrigated vegetation have stabilized slopes. While human ecological research reveals this to be the case in other areas, authors of location - specific mountain degradation studies have been reluctant to admit it. (It is encouraging that a very recent study by Ives (1987) illustrates that land use is sometimes a remarkably stabilizing influence over time.)

An article by Bencherifa (1984) in Mountain Research and Development entitled "Land Use and Equilibrium of Mountain Ecosystems of the High Atlas of Western Morocco" exemplifies geographical studies in mountain ecosystem fragility. Bencherifa, a geographer at Mohamed V University in Morocco examines the Atlas' Upper Naffis Valley. He attributes degradation of the ecological system to overcropping and overgrazing. Both are seen as the result of increasing population.

The article begins with a brief description of the mountain environment, particularly bio-climatic altitudinal zones. It then describes the complementary relationship between natural environment and the traditional agropastoral production system. This section stresses the interaction of environment and culture, and the ecological balance which villagers have maintained for centuries. In the past population was low and stable, herds were small, and terraces received high inputs of manure and labour. The next section of the paper introduces the destabilizing influence, population growth. Since the early 1950s population has increased by up to two percent per annum. Villagers are forced to introduce new crops, and grow two crops per season. At the same time, despite overall population, many young men and youths are migrating to urban areas. Consequently, cultivated land is farmed more intensively, but with less labour input. Cropland is being stressed beyond its limits.

Similar stresses degrade mountain pastures. More animals are grazed on less total pasture land. Instead of being stall fed in winter they now remain at high pastures all year. When snow covers the ground, they eat shoots and branches from trees. In addition, forests are exploited for firewood and charcoal at increasing rates. The article concludes on a dismal note (Bencherifa, 1984,p279):

> Therefore, the biological foundations of pastoral activities, as a basic component of the Upper Nafis Valley agricultural system, are seriously threatened. The study area provides a classic example whereby a traditionally limited naturally resource base that was utilized over many centuries comes under the pressure of population increase. In such a limited system pressure on any one component endangers all other components, and even outmigration provides no relief because it seriously disturbs the labour force required to maintain the basic system.

Bencherifa's article achieves its objective; it presents a traditional balanced environment/culture interrelationship, introduces a stress and discusses the negative consequences. The tone of the paper is sympathetic to villagers' plight, but because the objective is to describe stress and degradation, too little emphasis is devoted to traditional ameliorative measures which may have been employed in the past to diminish imbalances, and which may villagers may be employing now.

Articles by Thomas (1979) Ives and Messerli (1984) and Messerli (1983) look beyond particular locations and symptoms of degradation, and attempt to identify common inadequacies in the approaches of other authors. In so doing, they have also abandoned the constricted themes outlined above. Ives and Messerli (1984) specifically, challenge the assumptions of previous investigations. They conclude that degradation is real, but that it may not result solely from the commonly accepted chain of circumstances. They stress that "only the comparatively tractable physical elements of the problem have been used for the present [commonly accepted] argument; the institutional, cultural, socio-economic, and political aspects may prove even more critical, especially if a systematic approach to their evaluation is not soon initiated."(Ives and Messerli, 1984, p. 68). In essence, the easy work has been done; more complex investigation may yield different answers. They continue by saying that "it is necessary to determine the relative importance of man-dominated processes, compared to nature-dominated processes...in order to reduce the likelihood for the adoption of measures to check the former when the latter may be shown to predominate (Ives and Messerli, 1984, p. 70). The paper concludes with a plea to narrow the chasm betwen natural sciences and human sciences in the study of mountain environments, and to fill the gaps in both branches. If researchers are able to achieve this, studies on mountain degradation will increasingly contribute to lowland understanding of highland communities.

3. DEVELOPMENT RELATED LITERATURE

Numerous reports and articles describe development programs and outline recommendations for mountain areas. They usually focus on agricultural systems at the village or community level, and often concentrate on irrigation networks as vehicles of development (see Coward, 1980; Malhotra, 1982). Development studies are essentially geographic; however, they commonly incorporate expertise from other disciplines, specifically anthropology, sociology, agronomy, economics, and political organization.

Several characteristics of development literature detract from its ability to describe and explain traditional agricultural systems. Investigations seldom look above the field level agroecosystem, so detailed descriptions of natural processes are lacking. Gornick and Kirkby (1981) examine interactions between crop and livestock production in detail, but do not discuss physical inputs to those agricultural factors. Similarly, studies describing irrigation development tend to discuss water flow through channels and into fields without considering source, or the climatic and landform conditions affecting that source (see Malhotra, 1982; Mohammad, 1965; Newhouse et al., 1980; Quiroga, 1984). In fact, it seems that much development research is unversed in geographical processes, except as they relate directly to crops. Levine, in an article which describes the operational problems with irrigation networks designed by development agencies (1980, p.53), makes this point: "Our knowledge of crop water requirements for maximum yield is good. But our knowledge of field rather than crop level is less satisfactory because of the variability of local physical conditions..."

Development is devoted to changing and improving existing situations (Freeman et al, 1982). The attempt to do this often means altering relationships between two agricultural components without understanding all social ramifications. Levine (1980, p. 61) notes that "a philosophy has evolved that irrigation modernization can take place only with radical departures from traditional practice... Attempts are made to tailor a physical solution to a specific problem. In doing so, social constraints are either ignored or treated in a general, non-specific manner". Thus, the crop/soil interaction is improved by fertilizer, or the crop/moisture relationship is enhanced by warabundi (collectively structured) allocation. This single-minded approach leads to extensive knowledge of a few key relationships, rather than the total agricultural system (see Berry, 1980; Mohammad, 1965). The result may be unnecessary destruction of traditional practices, and unsuccessful development initiatives. Examples of these are well documented (Ahmed, 1980; Baker, 1976; Johnson, 1982; Quiroga, 1984).

Levine (1980, p.51) states that "our knowledge of the interrelationship between water and plant growth far exceeds our knowledge of the interrelations between water and the human component as a factor in water-use crop production." This is true except as it relates to the administrative aspect of this human component. Much recent development work has an administrative focus (see Bryant and White, 1982; Coward, 1980; Hoben, 1980; Mohammad, 1965). Preoccupation with administration is particularly evident in water management investigations. These emphasize large physical and bureaucratic frameworks (Malhotra, 1982; Newhouse et. al., 1950) and seem to stem from work by Wittfogel (1957) which discusses centralized irrigation states, and reinforces the notion of irrigation as a problem of resource administration. This is not the case in many high mountain communities. Small irrigation systems throughout the Karakoram allocate water flexibly and uniquely. Such systems do not fit models developed for large-scale British-engineered schemes in the Punjab (see Newhouse et al., 1950), or centrally controlled despotic systems in ancient states (Wittfogel, 1957). Failure to describe agricultural practices in terms of village farming detracts from the value of much mountain and irrigation development literature. Moreover, what seems best from the point of view of irrigation engineering, is not always optimum from a farmer's point of view (Levine, 1980, p. 58).

The Karakoram region, specifically Gilgit District, of which Hopar is a part, has inspired several development studies (AKRSP, 1984, 1986b; Conway, 1985; Saunders, 1984; Semple, 1986; Whiteman, 1985). They are superior to most development research in that they avoid administrative models. In addition, several of these investigations have carefully examined traditional farming methods, and found that they are often superior to introduced techniques. Whiteman (1985) devoted three years in the Gilgit area to examining agriculture and its potential for development. His detailed report gives more attention to describing and praising existing lore, than it does to suggesting improvements. This is uncommon in development literature. He also takes care to carefully describe climate and landforms as they relate to agriculture. Saunders (1984) takes a similar approach.[1] His report is oriented toward development, yet it examines potential initiative in the context of ethnographic geophysical/agrarian interrelationships. Both Whiteman and Saunders contribute to general understanding of agricultural communities in the Karakoram. They also provide specific information which is cited in following chapters. However, because they do not concentrate on any characterizing relationship, their work does not provide a model for the present study.

The Aga Khan Rural Support Program (AKRSP) has been responsible for a number of development studies of the Gilgit area. AKRSP is particularly interested in economic development in the region. Their work emphasizes the integration of traditional village agriculture into the regional economy. Since much of the field work is carried out by educated villagers, and almost all AKRSP personnel are the same minority Moslem denomination as most local peoples, their recommendations are extremely sensitive to cultural factors. Even investigations undertaken by westerners for AKRSP emphasize culture. Semple's (1986) research in Hopar's Brushal Village is a noteworthy example. He describes both social causes of irrigation network disintegration, and social ramifications of development initiatives.

An important fault of AKRSP work is that emphasis on economic relations tends to be at the expense of attention to community/environment interaction. For example, the third annual AKRSP review (1986b) devotes over one hundred pages to economic and social factors, but does not mention geophysical conditions. Similarly, Conway (1985) neglects climate and landforms in his analysis of Karakoram Region agroecosystems. Nevertheless, they both offer important insights into the culture and economy of Karakoram villages, as well as into factors relating to crop growth and water supply at the level of fields.

Conway's (1985) report for the Aga Khan Rural Support Programme, entitled <u>Agroecosystem Analysis and Development For the Northern Areas of Pakistan</u> is characteristic of both the strengths and weaknesses of many development works. The report stems from a workshop on agro-ecosystem analysis sponsored by AKRSP and chaired by Conway. It concentrates on applying agro-ecosystem analysis to the development of two agricultural villages in the Gilgit District of Northern Pakistan. Conway describes agro-ecosystems as follows (1985,p2):

> In agricultural development, natural ecological systems are transformed into hybrid agroecosystems for the purpose of food and fibre production. The transformation involves several significant changes. The systems become more clearly defined, at least in terms of their biological and physico-chemical boundaries. These become sharper and less permeable; the linkages with other systems are limited and channelled. The systems are also simplified by the elimination of many species and various physico-chemical elements. A good example is the wheat field in the Northern Areas of Pakistan: the stone walls form a strong, easily recognizable boundary, while the irrigation inlets and outlets represent some of the limited outside linkages. The key functional relationships are essentially ecological in character, involving such processes as competition, herbivory and predation. But overlying these are new processes, cultivation and harvesting,

> subsidy by means of fertilizer or manure, and control of water or pests. The new complex system is what I call an agroecosystem.

The main strength of Conway's approach is that it systematically examines linkages among a variety of agricultural components; it recognizes the physical, the social, and the agricultural and it explores their interaction. However, in its very concept, the approach chooses to ignore all but the most obviously related variables. It creates a closed system out of what should be considered open. When this conceptual selection is coupled with minimal data collection (information for the two villages in Conway's report was collected in a single day), the result is superficial perceptions and recommendations.

When Conway's team was asked about the potential for catch crops (short season crops to replace the fallow period after harvest and before winter) they offered the following recommendation (p28):

> Guidelines:
> They must fit in from July/August to October
> Animals must be kept off
> Add organic manure/fertilizer or grow legume crops
> Working Hypothesis:
> Peas, radish, turnip, vetch and lupin are likely to be suitable
> Implementation:
> Conduct trials with these crops

The recommendations make no attempt to discover a)whether there is available manure to fertilize these crops, b) whether there is surplus money to buy chemical fertilizer, c) if the land is needed to pasture animals during fall, or d) why villagers have not planted these catch crops in the past. Without asking these types of questions the recommendations of Conway's agro-ecosystem analysis may cause more harm than good.

In summary, the main contribution of all development research to understanding mountain communities in highland areas is at the level of individual fields and crops. Economic and bureaucratic relationships between highland villages and lowland regions are also thoroughly covered. Unfortunately, the latter often results in unsuitable application of western models for resource management and distribution. Most investigations neglect general agriculture/ environment interaction. Saunders (1983) and Whiteman (1985) in the Karakoram are exceptions. They deal exhaustively with climate and topography, as well as with cultural variables.

APPENDIX IV: POPULATION CHARACTERISTICS FOR GILGIT DISTRICT AND HOPAR

Census data for the Northern Areas of Pakistan are limited to gross population figures. The AKRSP has supplemented these with demographic statistics gathered at the level of administrative districts. Some information is categorized to delineate major valleys. Only total population figures exist for individual villages.

Appendix IVa is an unpublished AKRSP report entitled Population, Labour Force and Occupations. It presents population estimates and breakdowns for Gilgit District. Some information is presented specifically for Nagyr. The estimates presented in this report approximate the situation for Hopar. Appendix IVb presents population estimates for the villages of Hopar. The estimates stem from personal communication with Hopar villagers, as well as with AKRSP personnel Nabil Malik, Tariq Hussain and Noor Mohammad.

APPENDIX IVa

POPULATION, LABOUR FORCE AND OCCUPATIONS*

*Unpublished AKRSP report.

I. SCOPE AND LIMITATIONS OF THE STUDY

I.A. Objectives and Methodology

Reliable demographic and occupational data on Gilgit District are scarce and unhelpful: detailed results of the 1981 Population Census are not yet available, and information from existing secondary data is not generalizable. This paper first presents 1985 estimates, for urban and rural population, adults and minors, male and female population, and the number of villages and rural households. Next, there is a brief discussion of population characteristics, such as growth rate, migration, literacy, etc. Finally, there is a mostly non-quantitative overview of the household and non-household activities of the rural population.

District-level estimates for the population, and the various groups within it, were obtained, as much as possible, by reasonable extrapolation from 1981 Census figures. Where Census data were not available as, for instance, for different age groups, the estimates were constructed by using ratios derived from national statistics and small, local surveys. Local surveys, field observations and numerous plausible assumptions were employed in guiding the discussion on labour force participation and occupations.

I.B. Data and Limitations

Preliminary estimates from the Northern Areas Population Census, 1981, are available for total, male, female, urban, rural and sub-divisional populations; the number of villages in each sub-division is also known. Estimates of sub-divisional population are presented alongside estimates of geographical area; the areas were calculated by planemeter, from a sketch map. The age-distribution of the population is estimated through comparison with similar distributions for rural Pakistan, taken from the Pakistan Economic Survey, 1984. All estimated data are necessarily approximations which can be made more accurate promptly once Census details are published.

District-level data on demographic and health-related indicators are practically non-existent. Any figures that are cited below must be treated as orders of magnitude established by comparing small-survey results. Data that proved to be useful in this regard came from surveys by: the Commonity Basic Services (CBS) Programme of UNICEF, Government of Pakistan and the Aga Khan Foundation (20 villages covered in each of two phases during 1982-84); The AKRSP Women's Section (40 Women's Organisations); the Monitoring, Evaluation and Research Section of AKRSP (7 villages, 1,200 households, 1983); the Social organisation staff of AKRSP (1983-84); and the Local Bodies and Rural Development (LB&RD) Department of the Northern Areas Administration (regional survey, 1978). International statistics for comparison were taken from the World Bank's World Development Report, 1984.

Figures on labour force participation should be considered with even more scepticism, since they are built up entirely from assumptions. The assumptions are explicitly stated below. The section on women's activities depends, in large measure, on the report of an Aga Khan Foundation consultant.

II. SUMMARY POPULATION STATISTICS

II.A. Population Aggregates

Estimates of the 1985 population are listed in Table 1. The total population of the District is projected to be just over 255,000, of which 53% are men (the percentage is the actual figure from the 1981 Census). The 13% of the population classified as urban is all in Gilgit town: the surprising feature of the urban population is that, according to the 1981 Census, 62% of the residents are men. The reasons for male preponderance in Gilgit town are unclear at present. The rural population is spread over an estimated 295 villages, in an area of just over 28,000 sq. km (Table 2). The 1985 population density for the district as a whole is 9.0 persons per sq. km; in 1981, the population density was 7.9 per sq. km. In contrast, the 1981 figure for the sparsely-populated Baluchistan Province was 12.5; for Pakistan as a whole, it was 105.8.

The pattern of human settlement in the district follows the numerous narrow valleys that have been opened up by mountain streams and rivers over the centuries. The present five administrative sub-divisions each group together two or three major, contiguous valleys. Estimates of sub-divisional areas and populations are given in Table 2. These show that Hunza (including Gujal Tehsil) is the most sparsely populated region, while Nagar and Gilgit, the most densely populated parts, have estimated population densities of 14-19 per sq. km.

II.B. Miscellaneous Population Characteristics

Although the present report assumes a population growth rate of 3% per annum, no reliable data are available for recent years. (The change in Census figures during 1972-81 implies a 4% growth rate, but this result is questionable.)

Based on information supplied by village women during informal interviews, many women bear 4-8 children each. The infant mortality rate appears to be among the highest in the world, and almost certainly is in the range of 150-200 per thousand; by comparison, the figure for Pakistan as a whole is 121 per thousand. (The highest infant mortality rates in the world are in the neighbourhood of 200 per thousand, and were reported in Afghanistan, Guinea and Sierra Leone.) No separate information could be found on child death rates in the district. Similarly, there are no data on other life expectancy and fertility-related indicators.

Average adult literacy is widely reported to be 10%, while only 2% of the women are said to be literate. Near Gilgit town, however, literacy could be as high as 30% - 40% for men, and 8% - 12% among women. There appears to be an increasing migration of educated men out of the district, though no systematic figures have been collected so far. There is indirect evidence, however, that anywhere from 5% to 15% of adult men are studying or working outside their villages at any one time. The upper end of the interual would probably be applicable to villages with exceptionally high literacy rates, or those high-altitude villages where only one crop can be grown in a year. In addition, single-crop villages witness significant out-migration of men in the winter months.

As a result of male migration, several villages in the upper valleys of Gilgit now have large numbers of households managed entirely by adult women. The effects this is having on family structure and the rural economy have not been investigated.

III. RURAL LABOUR FORCE AND OCCUPATIONS

III.A. Labour Force Participation

Census data imply that 87% of the population of Gilgit lives in rural areas. The overwhelming majority of rural families is that of land-owning farmers, though some villages might have landless families that total up to 5% of the village population. Almost all rural families depend on agriculture as the major source of livelihood. However, there is suggestive evidence that perhaps 20% of the households obtain significant cash incomes from non-agricultural employment, including trading, government employment and manual labour. Other than in household activities, the employment of women in the non-agricultural sector is extremely rare; such employment is usually found in teaching.

In the absence of any data on labour force participation by sex, one needs to proceed by making assumptions that seem reasonable in view of what one knows about the area. Some of the more influential assumptions are:

- allowing for students, the weak and the elderly, 80% of the resident adult male population is in the labour force;

- among adult women, 55% are either pregnant or lactating (CBS data), and are thus not available for non-household activities; of the remainder, 90% participate fully in the production of goods and services outside the house;

The major implications of the preceding assumptions are:

- there are about 3 dependents to every working man and woman;
- women account for 30% - 40% of the agricultural labour force.

The entire discussion in this section must be viewed as tentative and exploratory. There seems to be great potential for systematic analysis of labour force participation, occupational choice and the sources and magnitudes of income.

III.B. Women's Activities

Very few women in the villages - perhaps 2% - are employed in non-agricultural production activities. Because of their participation in both household and agricultural tasks, it is believed that women often work 4-5 hours more, per day, than men (AKRSP data).

The agricultural tasks performed by women are both seasonal and daily. However, aside from the sale of limited quantities of eggs and chickens, there is generally no production by women for cash income. On a daily basis, women are engaged, in particular, with poultry and livestock - they are involved with milking cows, goats and sheep, collecting fodder for the cattle and feeding and watering them, processing dairy products, and raising chickens. The major seasonal activities include: cultivating, collecting and processing vegetables, weeding the cereal crops, stripping maize cobs from stalks, cleaning grain prior to milling, and, in some areas, threshing, and running high pasture settlements, and picking and processing fruit.

In addition to an active participation in agriculture, women are in exclusive charge of all domestic activities. Moreover, where the men have migrated to seek employment elsewhere, women have taken up almost all the traditionally-male agricultural functions, including ploughing and threshing.

TABLE 1

GILGIT DISTRICT

ESTIMATES OF POPULATION (1985)

A. Urban Population (Gilgit Town)

	Estimate	Remarks
Male	20,349	62% of urban population
Female	12,405	38% of urban population
TOTAL	32,754	13% of District's population.

B. Rural Population (Aggregates)

	Estimated	% of Rural Population
Boys (under 15)	51,126	23
Girls (under 15)	48,904	22
UNDER-15 TOTAL	100,030	45
Adult Men	64,019	28.8
Adult Women	48,904	26.2
ADULT TOTAL	122,259	55
TOTAL POPULATION	222,289	100
- Male	115,145	51.8
Female	107,144	48.2
No. of Households	26,685	
No. of Villages	295	

C. Averages per Village (Rural)

Children (under 15)	339
Adult Men	217
Adult Women	197
TOTAL POPULATION	753
- Male	390
Female	363
No. of Households	90

*SOURCE: AKRSP, "Regional Statistics Note No. 2. Population Estimates, 1985," unpublished mimeo. Based on preliminary statistics from the 1981 Population Census.

D. Averages per Household (Rural)

Children (under 15)	3.75
Adult Men	2.40
Adult Women	2.18
Size of Household	8.33
Male Members	4.31
- Female Members	4.02

TABLE 2

AREA & POPULATION OF GILGIT DISTRICT

SUB-DIVISIONAL ESTIMATES, 1985

SUB-DIVISION	AREA** SQ.KM.	%	POPULATION* '000	%	NO. OF VILLAGES+	POP. PER VILLAGE	POP. PER SQ. KM.
HUNZA	9,826	34	32	12	52	615	3.3
NAGAR	2,844	10	53	21	73	726	18.6
GILGIT (RURAL)	4,012	14	56	22	40	1,400	14.0
PUNIAL-ISHKOMAN	4,065	14	38	15	47	809	9.4
GUPIS-YASIN	7,711	27	43	17	83	518	5.6
TOTAL RURAL	28,188	99.8	222	87	295	753	7.9
TOTAL URBAN	65	0.2	33	13	11		
GILGIT DISTRICT	28,253	100	255	100	306		9.0

SOURCES

** AKRSP Engineering Section Estimates

* Extrapolated @ 3% per annum from 1981 Census figures

\+ 1981 Census

NOTE

1. The areas have been estimated from maps, using planemeter.
2. It is quite likely that the urban population has grown faster than the rural population. Thus, 13% may be an under-estimate of the proportion of the population that is urban. This figure is based on the 1981 Census, and no inter-censal figures are available.
3. The number of villages is less than the number of potential Village Organisations that AKRSP might support. Large and clearly divisible villages will often have more than one Village Organisation.

APPENDIX IVb:

ESTIMATED POPULATION: HOPAR VILLAGES

VILLAGE	# HOUSEHOLDS	POPULATION
Rattal	100	800
Hakalshal	200	1600
Brushal	105	840
Ghoshushal	35	280
Holshal	40	320
TOTAL	480	3840

APPENDIX V: INTRODUCTION TO THE AGA KHAN RURAL SUPPORT PROGRAMME*

*Article originally printed in Aga Khan Rural Support Programme (1984) First Annual Review 1983: Incorporating The Fourth Progress Report.

1. The AKRSP Strategy

The ultimate aim of AKRSP is to evolve an innovative and replicable model of development for high mountain valley areas. Towards this end, the Management Group of AKRSP have articulated a strategy in which three interdependent principles of village-level development administration define the spectrum of activities sponsored by AKRSP. The first of these principles is that productive physical infrastructure projects should usually precede any other development effort. This principle is simply a recognition of the importance that farmers everywhere attach to permanent increases in their individual and jointy-managed stocks of physical capital. Since it can usually induce the sort of broad-based village participation that is so essential to the success of any development effort, a productive physical infrastructure project is normally the first project sponsored by AKRSP in a village. The second principle followed by AKRSP is that an administrative infrastructure going down to the village level should be created to provide villagers with agricultural inputs and with sound advice on the use of these inputs. This type of infrastructure serves to increase the productivity of the material and human resources of a village. The third principle states that smallholders can overcome the handicaps of their subsistence holdings only by collective action through broad-based, multi-purpose organisations. This principle calls for the creation of a social and economic infrastructure, i.e. a series of village organisations that help smallholders fully utilise available physical and administrative infrastructures.

Consequent to the strategy outlined above, four types of programmes are being undertaken simultaneously for the development of smallholder agriculture in the Northern Areas:

Construction of productive physical infrastructure at the village level, according to needs identified by villagers.

Dissemination of knowledge at the village level, and upgrading of agricultural and managerial skills through training.

Creation of accessibility to modern inputs and machinery for village-level groups of smallholders.

Provision of credit to groups of smallholders who otherwise would not have access to credit for agricultural development.

AKRSP has the ability to activate its development programmes in half the villages in its project area by the end of 1983, and to extend coverage to all villages by the end of 1984. Seed money provided by the Aga Khan Foundation will carry AKRSP part of the way towards the fulfillment of its potential. The potential can be fully attained, however, only if AKRSP can draw resources from other organisations willing to invest in the development of the

Northern Areas.

2. The Village Organisation

The mechanism through which AKRSP implements its development programmes at the village level is the Village Organisation. The Village Organisation is a mass coalition of all those residents of a village whose common economic interests are best served by organising as an interest-group. The organisation is formed around the first AKRSP-sponsored project that draws a village's commitment to implement and maintain the project. The project serves as an entry point for a wide range of development activities that are undertaken jointly by AKRSP and the Village Organisation. The thrust of AKRSP's contribution is this partnership for development is towards creating a self-perpetuating institution through which villagers can act in concert to manage their material and human resources so as to attain progressively higher standards of living. The Village Organisation is just such an institution: it is a disciplined organisation of all beneficiaries of AKRSP's activities in a village. All members of the organisation are required to attend a weekly meeting where work done to date is reviewed, plans are made for the future and savings are deposited by all members. ~~In short,~~ the Village Organisation is AKRSP's executing agency for all village-level projects.

The Village Organisation is assisted and supervised in its work by AKRSP Social Organisation Units (S.O. Units). There are three such units in Gilgit district and another one is contemplated for Chitral. Each S.O. Unit comprises a Social Organiser, a Sub Engineer and an Agriculturalist, and is AKRSP's field unit for the region in which it is based. The S.O. Units are in frequent contact with the management Group which is responsible for the management of AKRSP's development programmes.

3. The Programming Cycle

Programme activities of AKRSP generally follow the pattern outlined in the AKRSP Programming Cycle. Like project cycles everywhere, the Programming Cycle covers five broad phases of activity: identification, preparation, appraisal, implementation and completion.

The distinguishing feature of AKRSP as a development agency is the belief and experience of its Management Group that a self-sustaining development process in the countryside can be built only on the skill, wealth and organisation of village residents. In practice, this philosophy means that every step of the first three phases of activity—identification, preparation and appraisal—proceeds through a series of interactive dialogues between villagers and AKRSP. Together, the first three phases of programme activity constitute the Diagnostic Survey.

The Diagnostic Survey starts with a visit by the Management Group to a village whose residents have agreed to meet with AKRSP staff. The General Manager initiates the first dialogue by explaining the OJECTIVES AND METHODS

OF AKRSP to the villagers. He then invites them to identify an income-generating project that would benefit most of the households in the village and that can be undertaken by the villagers themselves. Almost invariably, villagers are able to agree on a project of over-riding importance to all villagers. Thus, the result of the first dialogue is the IDENTIFICATION of a small, productive project by the residents of a village.

The identification of a project is followed by the second series of dialogues. The first step here involves a FEASIBILITY SURVEY of the proposed scheme. Supervisory responsibility for this technical assessment rests with the Programme Senior Engineer or Programme Senior Agriculturalist. Responsibility in the field devolves on the Social Organisation Unit. This unit works with informed village residents to assess the feasibility of proposed project and to obtain data on prices of locally available inputs/material. it is on the basis of information obtained locally that BLUEPRINTS and COST ESTIMATES are prepared by the field unit and sent to the Management Group for finalisation.

The finalised scheme is taken to the villagers by the Management Group and discussed with them. This starts the third dialogue, in which AKRSP and the residents of the village explore the TERMS OF PARTNERSHIP that would characterise the relationship between the two entities. On behalf of AKRSP, these terms of partnership are explained as general principles of rural development that have proved successful elsewhere in the world. In turn, the villagers could demonstrate their ACCEPTANCE of these terms by spelling out precisely the manner in which they would organise to plan, implement, manage and maintain specific projects that involve physical works, skill development and the creation of equity capital over time. At this stage, a Village Organisation is formed, consisting of all beneficiaries of the project. The formation of the organisation is followed by an ASSESSMENT OF PROJECT BENEFITS, conducted by concerned members of the Management Group. This completes the Diagnostic Survey.

Programme activity now enters the implementation phase. The EXECUTION of the scheme is undertaken by the Village Organisation. Concurrently with execution, a BASE-LINE SURVEY for evaluation is carried out under the supervision of the Programme Economist. With the start of the implementation phase, a Village Organisation begins to follow a set schedule of weekly meetings. The records of such meetings, together with the personal participation of members of Social organisation Units provide information that enables the MONITORING of specific schemes by the Management Group. Weekly village meetings and fortnighly extension classes for village representatives are the media through which Management Group members and the personnel they supervise impart TRAINING AND SUPERVISION to village residents. Both monitoring and training and supervision are ongoing activities that follow an interactive process geared towards improved management of the village economy.

Once a specific scheme has been executed, the responsibility for its

MANAGEMENT becomes completely vested in the Village Organisation: Villagers become responsible for all aspects of managing the scheme they had identified, helped plan and executed. If and when necessary, a POST-PROJECT SURVEY for evaluation is carried out under the Programme Economist's supervision. The continuous monitoring of Village Organisations and the ongoing processes of training and supervision, together with specific surveys provide the Management Group with the information it needs for a LONG-TERM EVALUATION of persistence of results.

4. Monitoring

Since AKRSP projects are implemented and managed by Village Organisations, it is these organisations, too, that are ideally located to monitor project activity. Village Organisations perform the monitoring function by meeting each week to review in detail the work done and the expenditure incurred, and to discuss any problems that might have come up during implementation to date. Problems of a technical nature, and logistical problems that cannot be solved locally, are referred to the member of the AKRSP Social Organisation Unit who is present at the meeting. In turn, matters requiring the attention of the Management Group are reported promptly to Gilgit by the Social Organisation Units. Since village-level projects typically take only about six to twelve weeks to implement, AKRSP field staff are encouraged to communicate problems verbally to the Management Group and concerned members of the Group are expected to respond on their own without delay.

As a management function, monitoring is one of the responsibilities of every member of the Management Group. In addition to solving problems of project implementation, the Management Group have developed a few, simple indicators that help in the ongoing evaluation of selected aspects of the Programme. So far, two broad areas of interest have been subjected to particular scrutiny—the viability of Village Organisation, and the (engineering) analysis of productive physical infrastructure projects. In the near future extension education, credit and input-supply programmes will also be brought within the purview of a formal monitoring system for purposes of ongoing evaluation. At present, all these programmes are discussed regularly in the weekly Programme Planning Meeting of the Management Group, and in the Monthly Review Workshop of AKRSP staff.

5. Evaluation and Research

The Management Group of AKRSP are committed to rigorous and continuous evaluation of all aspects of the Programme with respect to its objectives. The major obstacle they face in undertaking this exercise is the absence of reasonable base-line data. The establishment of base-line data is the principal task of the Programme Economist and takes precedence over any other research. However, it is the opinion of the Management Group that if AKRSP is to achieve the desired level of credibility among the villagers of Gilgit, and obtain accurate information from them, then surveys for evaluation and research must follow rather than precede implementation of projects. Thus, project-specific base-line surveys for evaluation are scheduled for the implementation stage. These will be supplemented over time with a smaller number of household panel surveys. These surveys will gather information from the same households over a number of years, a procedure that eliminates many of the theoretical and statistical problems encountered by evaluators, and cover three broad aspects of the farm-household, viz., human capital and labour supply, agricultural inputs and production, and income-expenditure patterns. Thus, internal and external evaluation would be able to draw on three sources of data--detailed project records maintained by the Management Group base-line surveys and household panel data.

The data that is being collected at AKRSP will provide material not only for evaluating the intended and unintended effects of the Programme, but also for research on a number of issues of interest to social scientists and development administrators. It is expected that the availability of a computerised data bank at AKRSP, together with the opportunity of working in an innovative rural development project, will attract researchers of a high calibre to the research endeavour at AKRSP. Institutional links may be forged with organisations and universities interested in undertaking applied research that is designed to illuminate policy issues.

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