PART II F4

Case Study:
Water based ecosystems services and poverty linkages within the Desakota Phenomenon:The case study of Arid Highland Ecosystems in the Balochistan Province of Pakistan

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Regional Description

The case study was undertaken in the arid highland ecosystems of the Balochistan province of Pakistan. The purpose of the case study is to provide an 'evidence-based story' to illustrate changes in impacts and opportunities in the Pishin-Quetta-Mastung corridor, in the context of a social, technological and institutional transition described as desakota in this report (Figure 1). The focus in this case study, as in the overall report is on delivery/management of water-based ecosystem services and livelihood/poverty patterns. The fulcrum of our narrative will be the ongoing transition in groundwater tapping technologies (from the ancient karez (qanat) system to tubewells) and the associated social, institutional and environmental changes. The impending climate change and associated scenarios provide the context within which, the ongoing trends must be interpreted. Towards that end, also included is a brief outline and review of the possible meso scale scenarios for the region. The case study will draw upon published and unpublished—grey literature in addition to the results of a rapid rural appraisal (RRA) conducted in the area.

The study region is characterised by dry winds, cold winters and hot summers (Chaudhry 2000). The average minimum temperature varies from 8-15°C and the maximum temperature varies from 24-31.5°C (IUCN 2006). The area has a variable rainfall, averaging 200 to 280 mm/year, with maximum rainfall occurring from January to April (70%) (IUCN 2006). There is only one climatic station in the region, located in Quetta (IUCN 2006), which recorded an average annual rainfall of 276 mm between 1990 and 1999 (EarthTrends 2003). A study of precipitation trends in Quetta showed that the cumulative probability of sufficient rainfall for spring sowing is 93% (Rees and Samiullah 2000). Precipitation varies topographically: the plains and lower highlands receive monsoon rainfall during July and August, whilst the upper highlands receive rainfall from storms arriving from the Persian plateau during February and March (Chaudhry 2000).

According to Chaudry (2000), evaporation rates in the region are between 3000 and 5000 mm per year, whereas IUCN (2006) quote potential evapotranspiration rates of 5.5 to 6.0 mm/day. These high potential water loss rates result in salt accumulation in soils (Irshad 2007) and, as a consequence of low precipitation and high evapotranspiration, there is little surface water. Short rivers originate in the hills of Balochistan and drain into shallow lakes or are absorbed by the sandy desert soils, but these have a small capacity (Majeed and Ali, undated). To increase surface storage, the Bund Khushdil Khan reservoir in Pishin district was built in 1890 and enlarged in

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1914, but this has a drastically reduced capacity as a result of siltation (BSSIP 2007). Low water availability has meant that the total cultivated land (2.09 million hectares) despite all the agricultural development, constitutes only 6 percent of the geographical area of Balochistan province, of which only 580,000 hectares are irrigated through perennial water sources. The remaining land is rain fed or flood/rain irrigated, also known as spate irrigation (IUCN, Govt. of Balochistan 2000).

The Pishin-Lora groundwater catchment supports three ecoregions, which vary in distribution with elevation and precipitation levels (see Figure 3). East Afghan montane conifer forests (classified as temperate coniferous forests) dominate east of Quetta, as the area is under the influence of monsoon rainfall (Olson et al. 2001). Forest composition changes with elevation: at lower elevations, lower rainfall supports dry coniferous species, such as *Pinus gerardiana* and *Quercus baloot*; whilst higher rainfall at higher elevations allows mixing of coniferous and deciduous species (Olson et al. 2001). North of Pishin, vegetation is classified as Sulaiman Range alpine meadow (montane grasslands and shrublands). This ecoregion is dominated by Alpine steppe forest, with sparse tree cover in gullies, and provides an important floristic transition zone between the Paleoarctic north and Indo-Malayan areas. Consequently, the ecoregion supports a high diversity of 50 mammal species (one endemic species) and 150 bird species (Olson et al. 2001). In the drier areas west and south of Mastung, Balochistan xeric woodland dominates. This medium-altitude arid to semiarid scrub forest supports a tropical steppe flora at lower elevations (below 1500m) and open xeric woodlands at higher elevations (1500 to 2000m)(Olson et al. 2001). These high elevation rangelands are critical to the pastoralist segment of the economy of the region. Province wide, pastoralism and agro-pastoralism constitute a substantial 30% but decreasing proportion of the provincial economy, while the sedentary agriculture dependent mostly on groundwater constitutes 35% but growing proportion. Although pastoralism based on small livestock—goats and sheept is diminishing as a proportion of the economy the absolute number of livestock had been doubling ever decade until the onset of the drought in late 1990s (Gils and Baig 1992). Since the abatement of the drought in 2005 the small livestock numbers are in the process of recovering to their pre-drought levels.

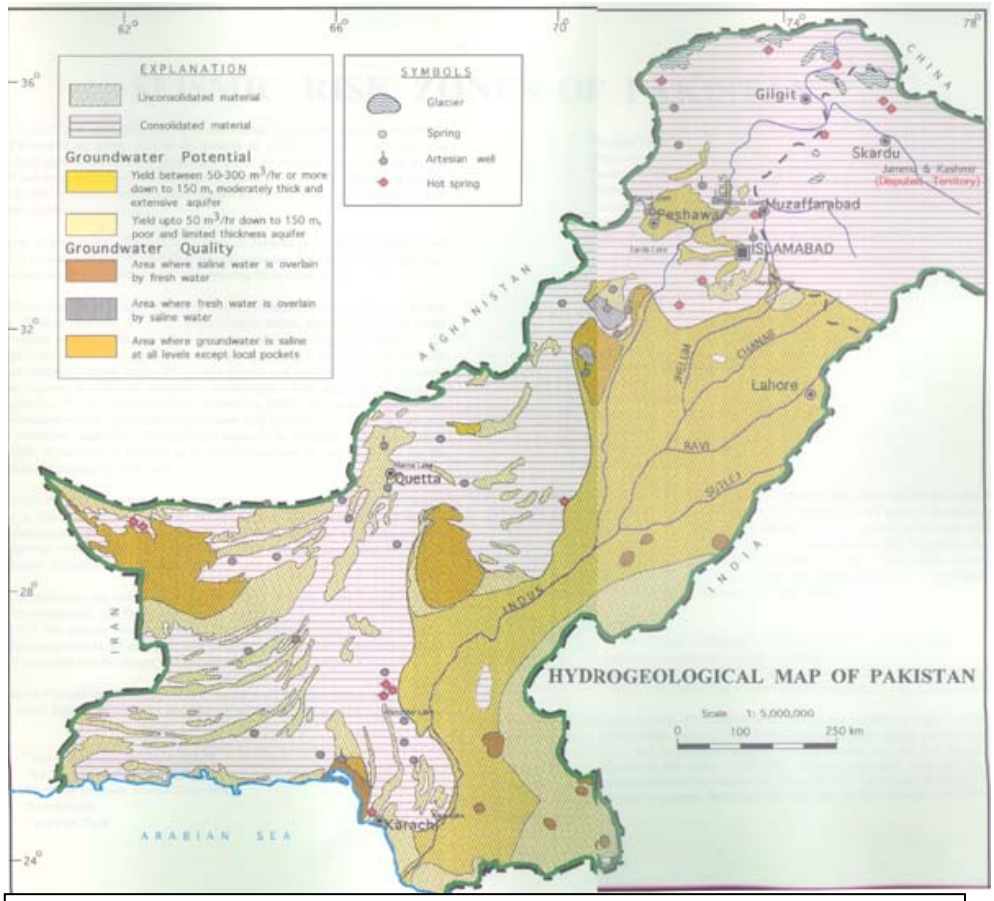


Figure 1: Hydrological map of Pakistan, illustrating the potential groundwater resource around Quetta (Geological Survey of Pakistan - http://www.gsp.gov.pk/pakistan/ground water.html)

The nd agro the provincial capital of Quetta and by the pastoralist and agro-pastoralist production systems in the Brahvi dominated Mastung district to the south-east of Quetta. The provincial capital Quetta has a population of 0.7 million? and is the regional center. While Mastung had been part of the princely state of Kalat, which was dissolved in 1973, Pishin had been part of British India and subsequently Pakistan. The region has progressively seen greater incorporation of its previously localized economies into the cash based national economy of Pakistan. In addition the Afghan war in the 1980s and then again since 2001 caused considerable security related issues in the area, which will be elaborated on in the sections below. The geopolitical tensions around the region have combined with the ethno-religious revivalism in the area to form a suitable environment for violent conflict. The degradation of ecosystem services and resultant increase in poverty is likely to further add the class dimension to the already unstable social environment of the region. The consequences of such developments in the region are likely to reverberate much beyond the boundaries of Balochistan, or even Pakistan, as we have learned from the recent events.

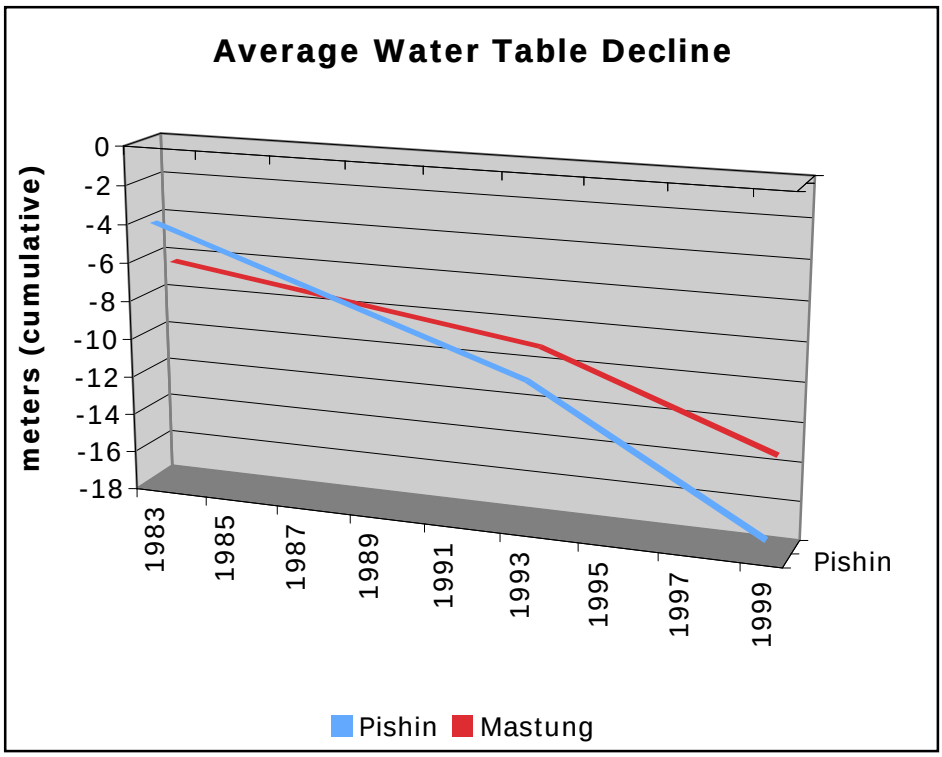
Characteristics of Desakota Systems in the Pishin-Quetta Mastung Corridor

Balochistan was accorded the status of a province in 1970 and the national electricity grid was expanded to the province. This heralded an era of state sponsored modernization of agricultural sector. In the case of arid zones of Balochistan, this manifested in the proliferation of tubewells for ground water exploitation and popularization of water intensive cash crops such as apple orchards and onions.

Apples alone require about 1393 mm of water in a region with a potential evapotranspiration rate of 2125mm (IUCN 2006). Other important crops are grapes, apricot, cherry, pomegranate, wheat, potato, onion and sunflower (IUCN 2006). The first tubewells were installed in the early 1970s with heavy subsidies for both their installation and operation (van Steenbergen and Oliemans 2002). Under the continued subsidy on tubewell operation in the form of flat monthly electricity tariff, the number of officially recorded tubewells had sprung up from around 2000 in 1970-71 to more than 14,000 in 2001-02 (Government of Pakistan (GoP), 2002). To this should be added the substantial number of private electric tubewells without a legal connection, as well as more than 11,000 diesel-driven wells in the valleys that were not yet connected to the electricity grid (GoP 2002). Area of land irrigated from groundwater in Balochistan has increased from 22% in 1989 to 34.5% in 1998, with tubewells alone accounting for 22.8% (Chaudhry 2000). The shift to tubewells has meant that the Pishin Lora groundwater catchment underlying the field area is now the most critically stressed in terms of groundwater exploitation in the northern part of Balochistan (Figure 2).

Table 1

Average declines in groundwater levels in the Pishin Lora basin



Source: Chaudhry 2000

As mentioned earlier the fulcrum of our discussion of the desakota type trends in the study region will be the transformation of the groundwater technology from the traditional karez system to tubewells. Karezes by virtue of their physical makeup, are highly labor intensive (Figure 3). The long underground tunnels and deep manholes warrant a large-scale use of the rudimentary technology of humans, animals and hand digging implements for both karez development and periodic repair and maintenance. The implication from a social organization perspective is that it was beyond the power of any individual to single handedly embark upon the development of this sole source of water, necessitating the forging of a collective to provide investment in the form of labor.

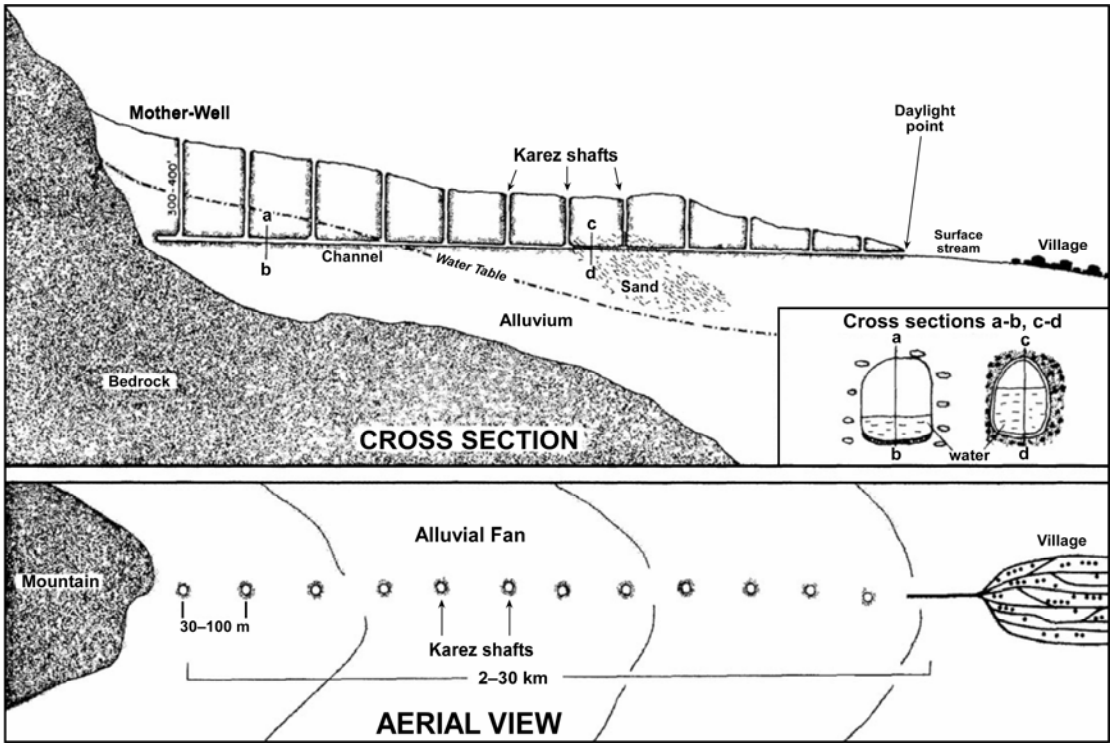


Figure 3: Schematic diagram of a typical Karez.

The water distribution in a karez is most often based on time division where a shareholder is entitled to the full flow of channel for a fixed period of time during a water cycle that revolves over 7 to 30 days, depending upon the cropping pattern. The magnitude of an individual water share is pro-rata to the investment made by the shareholder (or his forefathers[i]) in karez development. Similarly, the distribution of the onus of recurrent obligations for periodic repair and maintenance of the karez is also proportionate to the initial entitlement.

A single person or a committee of village dignitaries are responsible for the organization of labor for karez maintenance, levying of penalties on the defaulters, taking lead in resolving water related disputes and managing other aspects of water management. This person is known as *rais, hisabgar* or *mir-i-aab* who may inherit the office or be elected. The incumbent for the office may be compensated through the allocation of some extra water share or exemption from the onus of karez maintenance.

A remarkably equitable feature of karez system is the land distribution associated with it. Commonly, karez shareholders have landholdings distributed along the head middle, and tail reaches of the main irrigation channel downstream from the daylight point. This ensures that in addition to every shareholder retaining an equal stake in maintaining the entire length of the channel, all shareholders also equitably share in water scarcity.

The year 1998 saw the setting in of a very severe drought in large parts of central and western Asia including Balochistan that persisted till 2003. The lack of precipitation put further pressure on an already rapidly declining groundwater levels at a rate of 0.25 to 1.10 m/annum as recorded as early as 1992 (WAPDA, 1992). The already stressed aquifers came under immense pressure due to an acute absence of recharge and this led to sharp reductions in flow and subsequently the drying up of karezes. The richer farmers invested in installation of new - and further deepening of existing – tubewells as a drought coping mechanism. The ones who could not afford investing more in ground water extraction went off to other places in search of alternate sources of livelihood such as day labor, mining, casual urban jobs etc., This withdrawal of shareholders from an interest in karezes, in many cases, led to disintegration of the social organization around the karez. In these cases the fate of karez was sealed with little likelihood of people contributing in the rehabilitation of karez, even if the rainfall patterns improved.

Tubewell installation in the highlands of Balochistan was not just motivated by the positive reason of promoting 'modern' irrigation technologies but also by perceived inefficiency of the karez irrigation. Kemper *et. al.* (1979) was one of the earlier donor funded studies on karez irrigation which identified twenty four hour flow of water in a karez as wasteful and something which an arid region like Balochistan could ill afford. Kahlown and Hamilton (1994) identify, high seepage losses, and seasonal variations in water levels as additional problems with karez irrigation. The focus on such problems with karez irrigation was an additional motivating factor for initial promotion of tubewell irrigation in official policy. It is to the micro scale experience and perceived consequences of the transition from karez to tubewell irrigation that we now turn.

The social capital built around the karez system was the locus of livelihoods, material and cultural life in the region, particularly in the rural areas. As the karez declined because of groundwater overdraft and drought, the larger farmers and shareholders in the karez were the first ones to switch to tubewell irrigation (Mustafa and Qazi 2007). The overall agricultural productivity in the region did increase as a result of the switch but the smaller shareholders and marginalized farm workers were the ones who suffered the most, as the following quotes from the residents of Mastung illustrate:

> *In these modern times people are abandoning the ancient and traditional irrigation, and trying to maximize cropped area. Ever since the tubewells have arrived, a competitive trend has emerged amongst the people and farmers. The installation of tubewells for modern irrigation succeeded in increasing agricultural productivity, but it also gravely damaged the ancient Karez system. Karezes were a great source of social and communal life for us village folks. People would sit on their sides and discuss their issues and find solutions to their problems. But modern times, new technologies, and tubewells have dried out the karezes and their resurrections is no longer possible, nor is there any future for the existing ones* (Ghaus Bux, Kunghar).

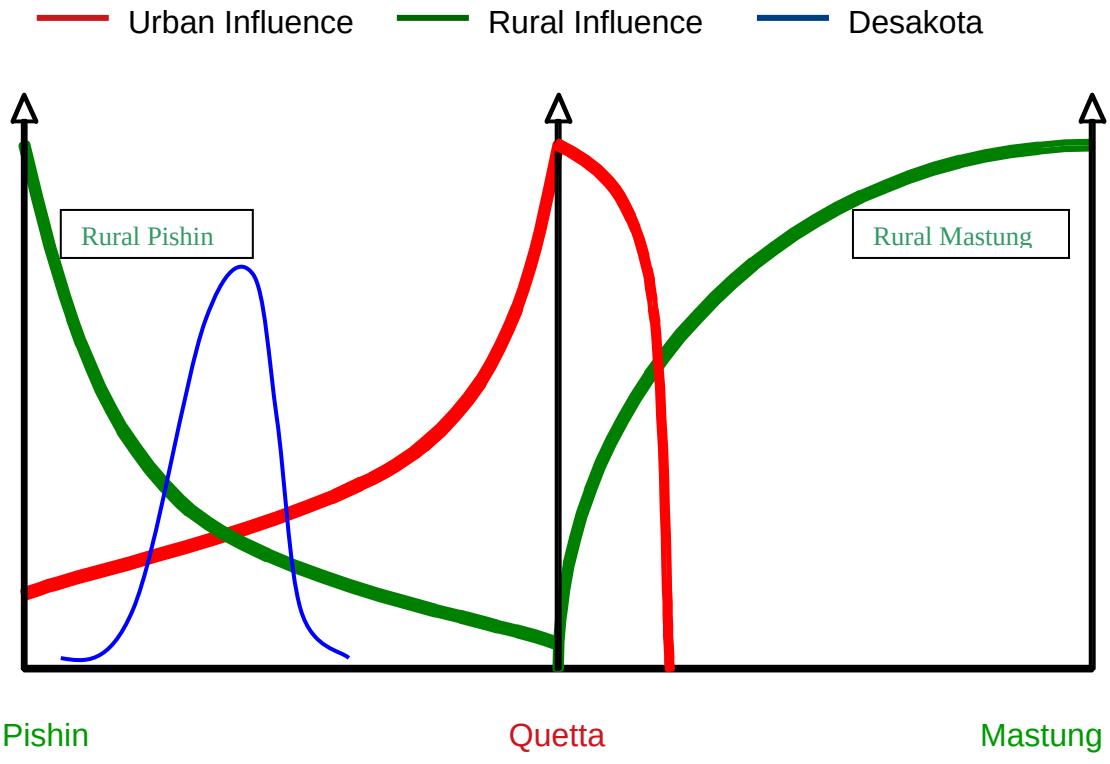
Farmers who have tubewells get high productivity, their economic situation is better. Their children are educated and do not have to work in early childhood. They [tubewell owners] can provide for their children and they own motor vehicles. The karez shareholders have lost out because tubewells have reduced the karez water. Also people with livestock have lost because fodder is much more expensive than in the karez days (Sahib Khatoon, Banghi Karez).

So drastic was the transition from karez to tubewell (and the concomitant drought) that in Mastung district for example of the 365 karezes that were running 20 years ago less than ten are operational at this time. Similar transition was also reported in Pishin and adjoining areas (Mustafa and Qazi 2007).

With the unlimited growth of tubewells, the karezes have gone dry which hurts the smaller shareholders, the bazgars [tenants], and the poor. The larger shareholders have of course benefited, because they could install personal or shared tubewells.(Zangeen Khan, Kunghar).

As might be evident from Table 2 there was varying degree of desakota influence in the two districts, which are almost equidistant from the regional metropolis of Quetta—infact, the small town of Mastung is about 40 minutes drive from Quetta while Pishin town is about a 90 minute drive. Both districts have very good road and communications infrastructure, except that public transport from Pishin is many times a day to Quetta and the rest of the country while in Mastung in some areas there is a once a day wagon that runs between the villages and Quetta or Mastung town.

Below is a graphic illustration of the contrasting Desakota influences in the two areas.
Figure 4: Urban and rural influences in Pishin-Mastung Corridor



Whereas the rural and urban influences in terms of institutions and market penetration decline as we go further from purely rural and urban areas in Pishin, there is very little influence in the Mastung area. Just as we get the a few kilometers outside Quetta, we see that there is hardly a transition zone where desakota could develop. The decline of traditional informal and formal institutions also create a gap in the Mastung area where new forms of social organization based on fundamental interpretation of religion are taking a strong hold and large scale madrassas are being built in this region.

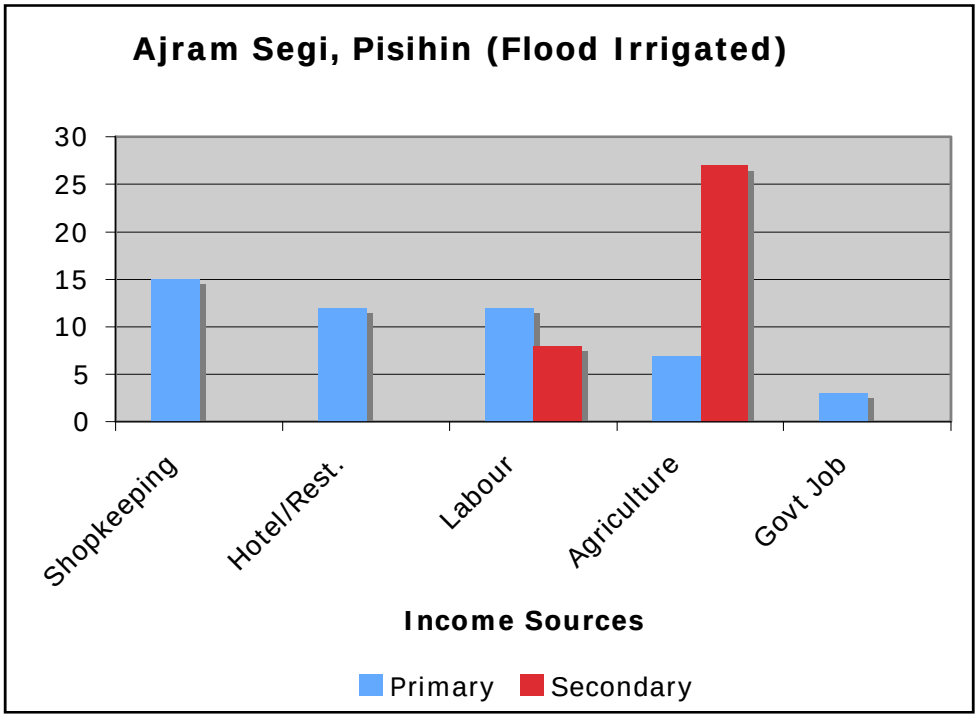
This could partially be explained by the fact that ethnic pathans/pashtuns in Pishin had historically been a sedentary agricultural and partially an agro-pastoralist society, while Mastung district was generally a pastoralist or an agro-pastoralist society. Most people in Mastung had at best switched from pastoralism to agro-pastoralism as a result of the transition from karez to tubewell, whereby they could lease land seasonally from a farmer with a running tubewell and get a crop, or lease out their traditional farming lands to somebody who could drill a tubewell and use the water, while giving a share of the produce--up to 30% to the owner of the land. Most of the poorer residents of Mastung were maintaining their seasonal migration patterns and depending upon either spate/flood irrigation, pastoralism and farm labor in the orchards of more prosperous farmers.

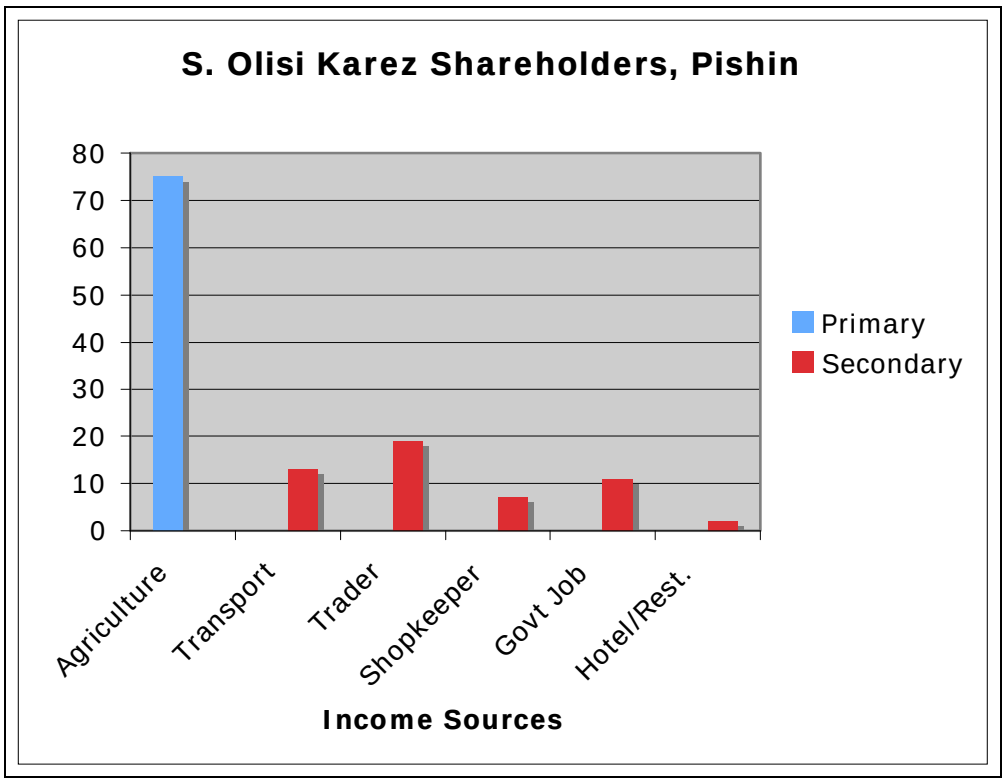
In Pishin, formal government institutional set up was much stronger than in Mastung. Conflict resolution, for example in Pishin was firstly through regular, relatively democratic, tribal councils (jirgas) where every landowner (male) was represented. But failing that people were not averse to formal litigation, and it was in fact quite prevalent. Pishin residents were also much more mobile with every household having at least one member working outside of the village, in nearby Quetta or as far away as Karachi and even the Gulf countries. The social capital developed around karezes was still very much in evidence but it had come under considerable stress because of the drying of the karezes and out migration. The options of the poorer residents were limited in terms of diverse livelihoods. Many of them having been dispossessed of their karez centered social capital were reduced to either day labor or working nearby chromite and coal mines.

One of the unexplored consequences of this stress of the breakdown of traditional karez social capital and the transition from informal to formal institutions for conflict resolution and resource management is the impact on civil conflict. Talibanization is an ongoing phenomenon in Pishin—the wahabi/salafist philosophies of the Taliban being alien to the traditional interpretations of Islam in the region and essentially being cultural import into the region, with the two Afghan wars and wider geopolitical interventions of the great powers serving as a conduit for the diffusion of this philosophy.

While the negative impact of the transition from Karez to tubewells, especially in terms of provision of water for agricultural purposes for the poor is well documented, less well documented are the coping mechanisms of the poor to cope with the effects. The desakota type trends observed between Pishin and Mastung offered a contrast outlined in Table 2.

Furthermore, it was reported that even while the karez were still running and particularly since their drying out in Pishin most households had a diversified basket of livelihoods, while in Mastung despite enquiries at multiple location it emerged that no more than ten percent of the household had non-farm or non-pastoralist livelihoods. For a comparison it is worthwhile seeing how a karez owning community and one dependent on spate irrigation diversifies. Following figures show a how diversification took place in cash earning karez community and the poorer one with less reliable and productive agriculture cope with their predicament.





We can see that agriculture is the predominant economic activity in the karez areas while in other forms of water usage it takes a secondary position. In the karez areas the residents are diversifying into lucrative activities through investment into business development and education while in the poorer villages household manage to invest only into businesses with low capital requirements. Most of the so-called hotels are essentially tea stalls on the roadside and in bazaars and shops are very small grocery stalls. The karez owners have bought trucks and more expensive equipment to support trade.

This choice of diversification also indicates that the karez water owners are looking into other sources of income that would sustain after the water is no longer available. There is an indication that people who have lesser access to water are also more vulnerable to the shocks that the loss of water would bring. The most vulnerable are those who have daily labor as the primary income and hence no secondary income. While the karez water owners could fall back on the secondary income sources the labor will see all opportunities dry up with the orchards.

Once again in the Mastung area the coping strategies are not well known. There has been an increasing pressure on the rangeland which is overgrazed six to seven times its carrying capacity. There seems to be an intensification of pressure on surviving eco-systems from the decline of another. In areas where water has dried out near Quetta, the land has been leased to brick kiln which pollute the air considerably. Also a cement factory has come up in the area which once again has a negative impact on air and provides some emplyment.

Table 2: Comparison of desakota influences between the Pishin and Mastung districts.

Desakota Criteria	Pishin (Strong desakota)	Mastung (Weaker desakota)
1. Greater Connectivity—physical, electronic and cultural.	Very strong. • Good road network • Frequent transport connections to Quetta and to Afghanistan. • Patchy mobile network coverage. • Penetration of agricultural extension services • Talibanization	Strong • Good road network • Infrequent transport connections to Quetta • Patchy mobile network • Penetration of agricultural extension services.
2. Greater penetration of cash economy, with remnants of exchange and reciprocity mechanisms on the decline.	Strong. • Labor terms are mostly cash. • Traditional access of pastoralists to rangelands and water sources still allowed. • Services are strictly cash.	Fair • Labor a mix of cash and reciprocity. • Pastoralist access to fodder and rangelands on traditional basis.
3. Mixed livelihoods drawing upon local as well as non-local service, and manufacturing sector opportunities.	Very Strong • Substantial remittances from migrant workers. • Household members engaged in a variety of non-farm livelihoods.	Weak • Very little migration. • Reportedly very few households have non-farm incomes.
4. Greater diffusion of modern production and resource extractive technologies.	Very Strong • Tube wells • Chemical fertilizers in use. • Tractors ubiquitous.	Very Strong • Tube wells • Tractors • Chemical fertilizers
5. Greater penetration of formal institutions existing in a transformational tension with traditional informal institutions.	Very Strong • Conflict settlement a mix of traditional jirga and formal litigation. • Karez based social capital weakening but still there.	Weak • Karez based system still strong. • Hierarchical sardari system still powerful and a mode of conflict resolution. • Seasonal migration still relevant for the previously pastoralist society.

In Mastung on the other hand the informal institutions were much more hierarchical, with the hierarchy of chieftains (sardars) being the main authority for conflict resolution. Recourse to formal litigation was extremely rare and government's groundwater management laws as well as civil administration were generally ignored. While the formal institutions were weak the informal institutions were quite robust. One could hypothesize that perhaps more hierarchical traditional structures have greater resilience in the face of socio-economic transition, e.g., just ten kilometers out of Quetta towards Mastung, people are still undertaking seasonal migration and not taking advantage of the livelihood opportunities on offer in the metropolis. Furthermore, on the more cultural front, while wahabi Islam is making some inroads into the area, its influence is much more limited in Mastung—there the axes of conflict are more along the lines of secularist Baloch nationalism.

The key issue is that there is a contrast in the manifestations of desakota between the two regions of Pishin and Mastung. While the desakota concept seems to apply reasonably well to the agriculturist society of Pishin it does not quite to pastoralist and agro-pastoralist society of Mastung. This suggests that there is gap in our understanding of how desakota influences interact with, and manifest themselves in predominantly pastoralist and agro-pastoralist societies.

Existing and Emerging Ecosystem Trends

Climate change predictions show a general warming in the region, coupled with changes to the precipitation regime (see section 4.2.2). As the influence of the monsoon is weak in this region, overall rainfall is predicted to decrease. Precipitation will also become more seasonal and decreases in the dry season will increase the risk of drought. Increases in precipitation intensity during the rainy season may increase runoff during January to April, but a decrease in catchment storage will result in water scarcity during the dry season and a possible reduction in groundwater recharge. Increases in temperature will increase potential evapotranspiration rates, which may exacerbate water scarcity during the dry season and increase rates of soil salinisation, reducing the area available for cultivation (Irshad 2007).

Changes to the hydrological cycle from climate change will induce change in the vegetation of the region. Reductions in precipitation will reduce the extent of East Afghan montane conifer forest and possibly the alpine meadows, whilst steppe flora may increase. This may impact the hydrological regime, as water storage and actual evapotranspiration rates may decrease.

Population increases in the region have resulted in significant changes in land use, including an expansion in agricultural production and industrialisation. East Afgan montane conifer forests have seen extensive deforestation from the construction of industrial sites and degradation from overgrazing and woodcutting (Olson et al. 2001; Majeed 2004). This has caused a huge increase in sheet and gully erosion, resulting in large losses of topsoil and natural nutrients (Majeed 2004). This has caused problems of desertification and has reduced the area of land available for cultivation (Olson et al. 2001). Deforestation has also caused heavy surface runoff and floods during the rainy season (Majeed 2004). Xeric shrubland has not currently been overexploited, but future degradation of this habitat may have large hydrological implications, as the

deep root systems of xeric shrublands facilitate deep drainage and groundwater recharge (Seyfield and Schwinning 2005).

Although there are currently no significant groundwater water quality problems (Chaudhry 2000), this may become a concern as anthropogenic activity increases. Majeed (2004) notes a degradation of water quality from the disposal of raw and untreated industrial, domestic and municipal wastes into water courses, which is currently common practice. Increasing use of insecticides, pesticides, herbicides and chemical fertilisers on agricultural lands is also polluting aquifers (Majeed 2004), and this may worsen with an increase in agricultural production. Furthermore, increasing shortages of water for irrigation has forced farmers to irrigate vegetables with city sewage water, which has caused a number of problems including weed infestation, soil infertility (Chaudhry 2000), and possible aquifer pollution.

With the climate change scenario painting a picture of even greater water scarcity coupled with increased groundwater extraction, the prospects are not very good for the region. While on the face of it the entire region may look afflicted with severe poverty to an outsider there are very region specific nuances of poverty. In the pathan dominated Pishin area, a person without land is considered poor, because he (and it is generally a he, since women rarely feature in public economic life) is not included in the tribal council. In Mastung, a person who does not have a water right, no animals and lives on daily wages is considered poor. Most of the poor, who are designated as poor by the local society are typically engaged in day labor and flood irrigation.

While the poor Pathans do tend to engage in a variety of locally available livelihoods like mining or construction work, in the Brahvi region they tend to rely more on local farm labor, norms of reciprocity in their community and *khuskaba* rain harvesting and *sailaba* flood harvesting agriculture (van Streenbergen 1997). With greater uncertainty of the timing of precipitation in the region coupled with less precipitation as predicted by the climate change scenarios, it seems that the labor intensive spate and rain harvesting agriculture is likely to become more precarious for the poorest people who have this technique as a part of their livelihood strategy. While cyclical migrations and abandonment of spate systems has been well documented in other parts of Balochistan, we need to learn more about the livelihood strategies of farmers who for cultural and institutional reasons are not entering non-traditional desakota type markets, as in case of Mastung.

Role of ecosystems services for poor and vulnerable populations in the Pishin-Mastung Desakota

The role of ecosystem services for poor and vulnerable populations under variable desakota conditions is outlined in Table 3. The discussion in this section will be with reference to the matrix.

Table 3: Outline of the impacts of desakota system on the poor and water based ecosystem services.

Desakota Criteria	Pishin		Mastung	
	Poverty	Water ecosystem service	Poverty	Water ecosystem service
1. Greater Connectivity—physical, electronic and cultural.	1. Excellent road transport network being capitalized by the poor to access non-local livelihood opportunities. 2. Cell phones accessible to all 3. Greater consumerism putting the poor under greater stress.	1. Non-local marketing opportunities of water intensive crops like apples leading to a strain on groundwater resources.	1. Good roads but infrequent transport. 2. Minimal daily or medium term migration for livelihoods. 3. Greater sedentarization of previously pastoralist economy.	1. Non-local marketing opportunities of water intensive crops like apples straining groundwater. 2. Rangelands being degraded because of overgrazing and more marketing opportunities for meat.
2. Greater penetration of cash economy, with remnants of exchange and reciprocity mechanisms on the decline.	1. Cash economy excluding poor from participation in resource mngt. e.g. they can't offer labor for access to water as in case of karez in tubewell systems. 2. Poor don't have money for the diesel to run the diesel tubewell to get their water right. 2. Fodder more expensive, and cash for access to resources.	1. Cash based economy encouraging inappropriate, water intensive cash crops. 2. Over extraction of water to maximize cash earnings causing groundwater draw down. 3. People educating children with expressed intent of abandoning farming once the groundwater runs out and the children have cash paying non-farm jobs.	1. Fodder more expensive for animals. 2. Poor cannot afford expensive ag. Inputs. 3. Can't pay for labor, which was previously based on reciprocity to maintain rain harvesting or flood irrigation infrastructure. 4. Can't contribute cash to tubewell operations.	1. Overgrazing of rangelands to maximize cash returns. 2. Water intensive crops more pervasive.
3. Mixed livelihoods drawing upon local as well as non-local service, and manufacturing sector opportunities.	1. Diversity of transport, manufacturing and non-local job opportunities providing greater income for the poor.	1. Diversity of incomes removing people from the immediate consequences of ecosystem services and causing breakdown of moderating/regulating institutional mechanisms for resource management. 2. Diverse incomes financing	1. Diverse incomes although available in theory do not seem to be as pervasive. 2. Nearer to Mastung town there were more diverse incomes. 3. Diversity is more towards agro-pastoralism from pastoralism.	1. Diverse incomes making people less interested in maintaining karez. 2. Diverse incomes financing tubewells.

Desakota Criteria	Pishin		Mastung	
	Poverty	Water ecosystem service	Poverty	Water ecosystem service
		individual tubewells that cause groundwater draw down.		
4. Greater diffusion of modern production and resource extractive technologies.	1. Expansion of farming from tubewells creating some labor jobs for the poor. 2. Poor deprived of their water rights and customary resource access rights in karez systems as they are being eliminated by tubewells. 3. Poor cannot afford the production and resource extractive technologies.	1. Groundwater draw down by tubewells.	1. Expansion of farming from tubewells creating some labor jobs for the poor. 2. Poor deprived of their water rights and customary resource access rights in karez systems as they are being eliminated by tubewells. 3. Poor cannot afford the production and resource extractive technologies.	1. Groundwater draw down by tubewells.
5. Greater penetration of formal institutions existing in a transformational tension with traditional informal institutions.	1. Poor cannot afford to pay cash to gain access to formal court system. 2. The protective cushion of customary rights of access to resources breaking down. 3. Hard to find labor to maintain rain harvesting infrastructure. 4. Greater conflict.	1. Informal institutions were more efficacious in moderating water and rangeland use. 2. Formal institutions not effective in protecting water quality or quantity.	1. Formal institutions although there, have not penetrated as much. 2. Because of the drying of karez, the social capital around it is under severe strain. 3. Poor at a disadvantage.	1. Informal institutions were more efficacious in moderating water and rangeland use. 2. Formal institutions not effective in protecting water quality or quantity.

The key ecosystem services for the poor are access to groundwater, rangeland and ability to capture soil moisture, floods and rain to get a crop in spate/flood irrigation. The desakota phenomena has deeper penetration in the Pishin area and less so in the Mastung area. The desakota phenomena's sharpest material manifestations have been the introduction of tubewells, agricultural extension services promoting apple orchards, migration of labor to the extent that at times there is simply not enough labor to maintain rain and flood harvesting infrastructure for spate irrigation, and the weakening of customary institutions which protected poor's water rights and afforded some protection against environmental variability. Although, intuitively it would seem reasonable that greater connectivity and access to diverse livelihoods will help the poor and the environment. But in this case to varying degrees between Pishin and Mastung, the poor were less able to avail themselves of the livelihood opportunities and, if anything because of the influences that followed greater connectivity their existing livelihoods became more precarious. The precariousness of the livelihoods was mostly because of the technologies that diffused in the area with greater connectivity, namely, tubewells. As tubewells replaced the karez and hence weakened the institutions and social capital based on karez, the poor who relied on those networks and the access to water through the karez based social capital were the first ones to lose out.

Greater connectivity also brought in the wahabi Islam, talibanization and along with it the law and order problems, particularly in Pishin. Talibanization has been particularly insidious for the women, who previously had access to village level labor markets, but are now harassed even at the village level by the talibanized local and Afghan youth.

The penetration and efficacy of the formal institutions is variable, but the informal institutions had a much greater moderating influence on water use, extraction and rangeland management. The previous *harim* rule prohibited digging of wells in a certain specified distance at the headwaters of the Karez and hence regulated the ecosytem service. Consequently the poor's access to those resources albeit their small share was temporally very secure. In the present ongoing transition, the prospects are not very good for the poor, where the informal institutions are under more strain in Pishin than in Mastung, and the formal institutions have not quite come into their own. Balochistan has passed a law that imitates the *harim* rule but the structures and incentives to enforce it are not present to make it effective. Also the resultant sparse institutional landscape is ripe for civil conflict and further marginalization of the already marginalized. However, such a situation can also lend itself to introduction of participatory structures that may be beneficial to the social reality of desakota.

Major Challenges and Knowledge Gaps for Supporting the Role of Ecosystems Services for Poverty Alleviation in the Arid Regions

One of the primary knowledge gaps for supporting the role of ecosystem services for poverty alleviation is the general ignorance of modern scientists, hydrologists and resource managers of the hydrology, engineering, institutional context, social implications of traditional water management technologies like karez or techniques like spate irrigation. National and international attention to restoration and preservation of the *karez* and other similar systems in the world will have to begin with greater research on the engineering, hydrological, economic and social aspects of

karez irrigation with an eye towards building a pool of technical experts on the technique. The research and the technical expertise will of necessity have to dispense with some of the modernist biases about 'newer is better', and instead adopt an attitude of active learning from the *karez* communities and the traditional *karez* constructors (a tribe called *Ghilzis* in the Brahvi and Baloch areas of the province).

Indeed there have been winners as a result of the introduction of tubewells and rural electrification, but the winners, who are primarily large farmers constitute three percent of the total number of farmers in the province are greatly outnumbered by the losers, who are primarily poorer farmers and *karez* shareholders (Ahmed 2005). Many policy makers in Balochistan and the federal level in Pakistan are aware of the ecological consequences of policy distortions that have allowed the ongoing over exploitation of groundwater. The policy makers, however, are relatively in the dark as to the social consequences of the replacement of *karez* with tubewell irrigation or the geography of prosperity and poverty that the transformation has created.

An important knowledge gap is the type of institutional transformation that desakota type influences have on traditional resource management institutions. Could one hypothesize that where traditional institutions were inherently resource optimizing, the formal institutions tend to be more biased towards resource maximization? Or while the transition is ongoing between formal and informal resource management institutions, the resource extraction ethos becomes predatory, to the disadvantage of the poor and sustainability of the ecosystem services? While one could hope that the unsustainable groundwater extraction in the study area is a temporary outcome of the ongoing transition, environmentally fragile arid zones like Balochistan may not be able to recover from even a temporary increase in water extraction.

Little is understood about the linkage between the desakota transition and the concomitant straining of the traditional social capital and institutions, environmental degradation, and civil and resource conflict. Could one hypothesize that the further marginalization of the poor in the ongoing transition, as documented above is manifesting itself in greater talibanization and conflict in Pishin for example? Or ethno-nationalist type conflict in Mastung?

Lastly, since it is the poor who depend the most of water based ecosystem services, and were protected the most by the water management institutions, could it be that we need poor centered interventions which are sensitive to the local nuances of poverty? The rural and peri-urban middle classes being more engaged in diverse livelihoods and more integrated into the desakota type transition no longer have the stakes to mobilize socially and materially to protect and sustain water based ecosystem services. Maybe it is the local poor who are likely to be the most eager participants in participatory water management as they are the ones with the most to gain from them.

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[i] Karez shareholders are invariably male.