Contents lists available at ScienceDirect

Journal of Hydrology: Regional Studies

journal homepage: www.elsevier.com/locate/ejrh

A case of groundwater depletion in Balochistan, Pakistan: Enter into the void☆

Frank van Steenbergen[a,*], Allah Bakhsh Kaisarani[b], Niamat Ullah Khan[c], Mohammed Shamshad Gohar[a]

[a] MetaMeta Research, Paardskerkhofweg 14, s-Hertogenbosch, The Netherlands
[b] Pakistan Spate Irrigation Network in Association with SPO (Strenghening Participatory Organization), H. 9, Street # 32, MPCHS E-11/3, Islamabad, Pakistan
[c] Development Research and Support Services (DRSS), Flat No. 218, Second Floor, Universal Complex, Jinnah Road, Quetta, Balochistan, Pakistan

ARTICLE INFO

Article history:
Received 7 February 2014
Received in revised form 5 September 2014
Accepted 17 November 2014
Available online 23 December 2014

Keywords:
Balochistan
South Asia
Groundwater
Depletion
Agriculture
Adaptation

ABSTRACT

Study region: Kuchlagh, Balochistan Province, Pakistan.
Study focus: The depletion of groundwater is a specter presented for many parts of the world that rely on the unmanaged use of groundwater. This article describes how the alluvial aquifer in Kuchlagh was exhausted after three decades of intensive use from more than three hundred agricultural wells and how the water users gradually adapted to it. Intense and unsustainable resource use is often expected to lead to conflict or cooperation. However, in Kuchlagh overuse did not lead to conflict nor did it trigger a process of cooperation or the use of efficient irrigation methods or the adaptation of local groundwater recharge measures. The situation is best described as a 'socio-institutional void' in which at no point in time action is taken, whereas at the same time the resource is gradually destroyed.
New hydrological insights for the region: In Kuchlagh the loss of opportunities in high value horticulture were cushioned by emerging urban employment, by developing agriculture in other parts of the Province or by simply 'chasing the water table deeper', i.e. investment in pumping from the hard rock layers underneath the alluvial aquifer. This suggests that if groundwater depletion occurs in a single isolated place it may not necessarily lead to human disaster or trigger a turn-around as the loss of resources may be compensated by other intervening opportunities.

☆ This article has been prepared as a background paper for the NWO CoCoon project Groundwater in the Political Domain and with the support of Royal Netherlands Embassy Islamabad as part of the work on the WSTF FODP.

* Corresponding author. Tel.: +31 736238206.
E-mail addresses: fvansteenbergen@metameta.nl (F. van Steenbergen), kaisarani@yahoo.com (A.B. Kaisarani), niamat_kuchlagh@yahoo.com (N.U. Khan), msgohar555@yahoo.com (M.S. Gohar).

http://dx.doi.org/10.1016/j.ejrh.2014.11.003

1. Introduction

Groundwater irrigation has been a major force behind the spectacular increase in food production in South Asia. The reliability and timeliness of groundwater use and the additional water it brought has made it an integral part of the region's green revolution since the 1970s. However, groundwater is also the world's 'most mined resource' (UNESCO, 2003; Mukherjee et al., 2015). Over recent decades, groundwater use has grown exponentially in scale and intensity in many places, leading to aquifer depletion and groundwater pollution (Giordano, 2009; Wada et al., 2010; Kulkarni et al., 2015). The National Academy of Sciences (2012) for instance in its report on glacier melt in the Himalayan asserted that groundwater over use was a bigger problem in the Indo Gangetic Basin than the melt associated with climate change and air pollution. In Pakistan, the decrease in water tables outside the canal areas is a threat to the sustainability of irrigated agriculture.

This article describes the steady decline in groundwater levels over a period of thirty years in Kuchlagh sub-basin in Pishin Lora Basin in Pakistan's arid western Province of Balochistan. It is based on a longitudinal study with research visits to the area in 1993, 1998, 2005 and 2011. Initially in 1970s the groundwater use was very nominal through karezes and open dug wells. Groundwater use however increased steeply around 1980 with economic expansion and in particular the development of transport to large markets like Lahore and Karachi and the influx of Afghan refugees, bringing skilled labor. By the late nineties and early part of 2000s a point was reached whereby the main alluvial aquifer in Kuchlagh was exhausted.

Kuchlagh presents a specter predicted for more semi-arid areas of the world that depend on unmanaged groundwater, particularly where there is little recharge to compensate for the intensive use of groundwater. This article traces how groundwater users responded to the falling and later disappearing water tables and how livelihoods were adjusted over time as the groundwater reserves vanished.

Several theories link more intense resource use and competition over resources to either one of the two opposite outcomes: either there will be more conflict or there will be more cooperation. The main exponent of this first 'pessimist' cluster of theories is the Neo-Malthusian school. Resource scarcity is caused by an increase in demand whereas at the same time resources are in limited supply, and this may even exacerbated by unequal access. The resulting tension weakens institutions. This encourages resource capture and encroachment, which further undermines the resource bases. Instability increases. Another main cluster of resource scarcity theories is 'optimist' in outlook and predicts that resource competition will lead to cooperation. If resource scarcity does occur, technological innovation, efficiency, conservation or other forms of human ingenuity and cooperation are triggered. Boserup is the main inspiration for this school of thought. There is the assumption that humans can respond to scarcity by a variety of mechanisms: regulation, market mechanisms and pricing, technological innovation or more intense development investment.

A third theoretical perspective emerged more recently, particularly in the work in transboundary water management by Zeitoun and Mirumachi (2010). In their so-called TWINS perspective Zeitoun and Mirumachi demonstrate that conflict and cooperation can very well co-exist. Conflict is not necessarily problematic: it helps to raise the issue and come to a redefined and better system of resource management. Also cooperation is not necessarily good, as it can for instance consolidate relations that are asymmetrical and unbalanced. The drivers of cooperation and conflict are not exclusively related to scarcity and competition, but also include power hegemonies, governance arrangements and the dominant political discourses.

This article discusses an example from arid high land South Asia where groundwater depletion ran its full course and scarcity rapidly turned into exhaustion. The first part of this article (Section 2) describes the so-called 'race to the bottom' in Kuchlagh: the accelerated use of groundwater till the point was reached whereby first water tables started to severely drop. The next section (Section 3) discusses the tipping point that was reached in 1998–2004, when the alluvial aquifer was by and large exhausted. Section 4 describes the coping mechanisms of different groups of water users after 2004, the institutional responses in terms of conflict and cooperation and economic options. Section 5 is a summary of findings and Section 6 discusses what the Kuchlagh case suggests for theories on conflict and cooperation over over-used resources.

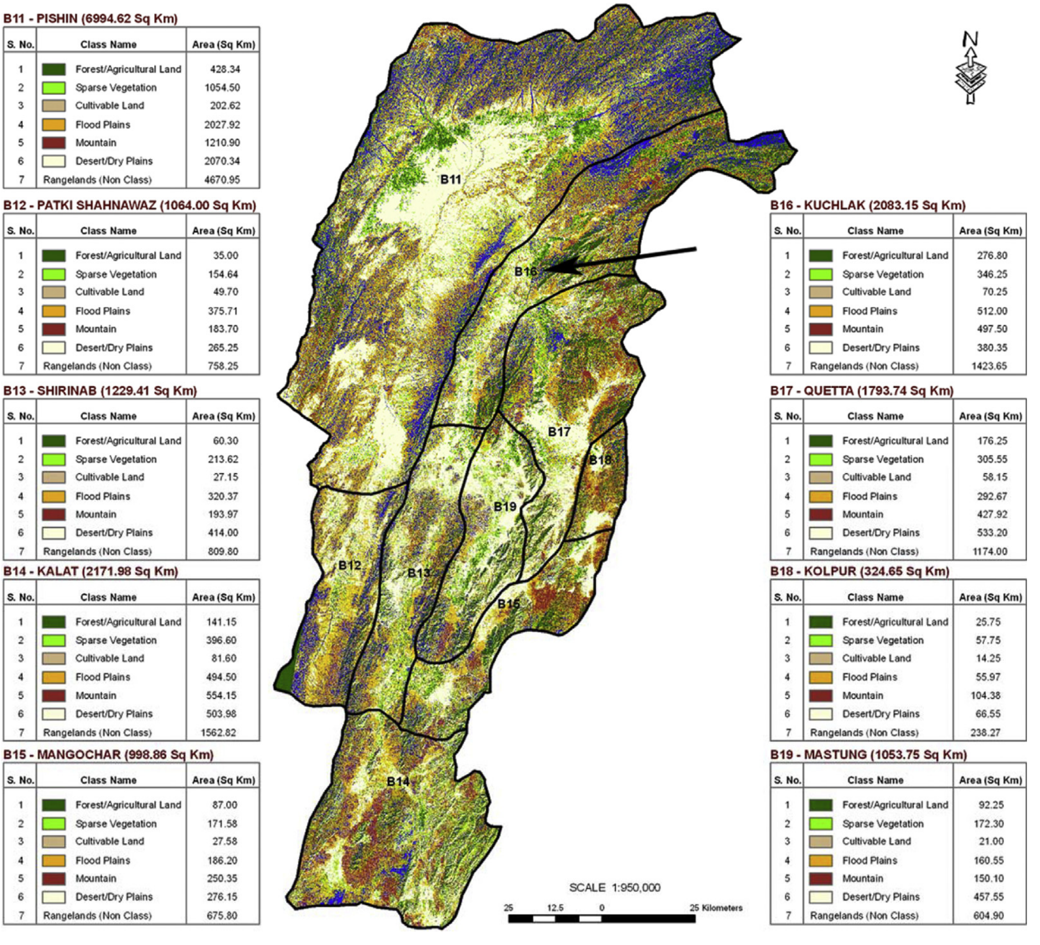

Fig. 1. Land use in sub-basins of Pishin Lora Basin.
Source: Halcrow Pakistan and Cameos (2008a).

2. Race to the bottom in Kuchlagh: 1980–1998

Kuchlagh is situated in the Pishin Lora Basin, just northeast of the center of the basin. The Kuchlagh sub basin is a part of the intermountain valley system of Balochistan formed due to the ingression of Indian Shield under the Arabian Shield. This has resulted in over-folding of rocks with a series of thrust faults trending northeast–southwest, giving rise to a complicated hydrogeology. The sedimentary rocks of the basin range in age from Jurassic to Recent. Over time the synclinal zones were filled with alluvial material – often deposits of gravels and boulders in the form of fanglomerates and poorly sorted sand and clay sediments. These alluvial deposits constitute the most important aquifers in the area (Halcrow Pakistan and Cameos, 2008a). The Kuchlagh sub basin measures 2083 square kilometers. Of this area 340 square kilometers is cultivable. Rainfall measures 217 mm/annually, with a large variability. Annual evaporation is in the order of 1750 mm: the area is classified as arid (Fig. 1).

Agriculture sector uses 97% of the water in Balochistan (Khair et al., 2010) and Kuchlagh is no exception to this. In the entire Pishin district in which Kuchlagh is situated farming still provides the livelihood to 31–49% of the rural population (Halcrow Pakistan and Cameos, 2008a). There were no landless families in Kuchlagh until the early eighties, but there was a difference in access to groundwater from the alluvial aquifer – depending on the share one had in the collective water systems. In Kuchlagh there were originally no people without land, but there were 'waterless' families, who instead depended on run-off farming only.

The original residents of Kuchlagh were Sargarha, Dumer and Essa Khel. These are sub clans of the Kakar and Kasi tribes of the Pashtun ethnic group. Though rules can be very strong and lineage solidarity is paramount, Pashtun tribes do not have a centralized authority. This clearly sets them apart from other ethnic groups in Balochistan Province (Van Steenbergen, 1996). At the census of 1977 the population of Kuchlagh town was 7000 persons. At this time most of the farm land was under cultivation. Annual crops were common: wheat, vegetables and potatoes. Fruit Trees – apples, mulberries and apricots – were cultivated as well but sporadically at this time. The main sources both of irrigation and domestic water were *karezes* and springs. *Karezes* are the marvel of traditional engineering with a "mother well" at the base of the hills and a number of other wells connected through tunnels – with an outlet near the valley floor with culturable lands. These vertical well systems are known as *qanats* in Iran and *aflaj* in Oman. Water rights in the Kuchlagh *karezes* were defined by time shares. These did not necessarily correspond to land holding, but more to the original investment in the development of the *kareze* and the subsequent exchange and trade of water shares.

From the 1970s onwards two developments took place that altered the local economy. The first change was the accelerated population growth, caused by the influx of Afghan refugees. This started in 1982 at the time of the USSR-Afghan war. Over the years the population in Kuchlagh grew very fast – with a second wave of displaced persons arriving after the Allied Forces operations in Afghanistan in 2001. The population of Kuchlagh eventually reached an estimated 120,000 in 2011. The small cross roads town was transformed into a satellite city of the provincial capital, Quetta, thirty kilometers away.

The second change was the emergence of the lucrative apple cultivation. This caused a steep increase in the use of groundwater. In the first stage – in the seventies – dug wells were developed often by 'have not' farmers – i.e. those **without** a share in the jointly owned *kareze* or spring. In due time water tables dropped and went beyond the level where *karezes* and springs could be relied upon. This set in motion a classical groundwater 'race to the bottom'. The faltering *karezes* accelerated the development of more dug wells in the late seventies and eighties by those who could afford it. Ultimately, these dug wells fell victim to the overexploitation of ground water as well. Spring boxes were installed inside the dug wells. However as water tables continued to fall, these failed too and dug wells were replaced from the early eighties onwards by electric powered deep tubewells, using submersible pumps (Van Steenbergen, 1995; Mustafa and Usman Qazi, 2007; Baloch and Tanik, 2008). By 1990 the ground water level was 80 m below the surface. It kept declining and tubewells were drilled ever deeper. Agriculture by that time had transformed – and the Kuchlagh area was dominated by high value commercial horticulture. The high returns from the apple cultivation were fuelling investment in more and deeper tubewells. By this time almost every farmer in Kuchlagh had established a fruit orchard, though not all farmers (5–25%) had a tubewell of their own. They, however, had access to groundwater through 'water tenancies', whereby a tubewell owner provides irrigation services and in return receives one-fourth of the crop. On average a tubewell served 6–8 ha of land. Orchards were mainly cultivated through specialized hired labor, often migrants from Afghanistan. Small land owners relied less on hired labor, using family labor instead.

Change came in the mid nineties. First apple cultivation lost its luster. Production had increased so much throughout Balochistan that a glut was created. In Kuchlagh at this time also some of the older apple orchards were beyond their prime productivity – at an age of fifteen years. The worsened electricity supply further dampened orchard expansion. It also paradoxically encouraged additional tubewell development by those farmers that could afford it. The idea of the additional drilling was that several wells would operate at the same time, when there was no power outage. Farmers in the area were particularly concerned about adequate irrigation water supply in the last stages of fruit development, which determines the quality of the apple.

The major change manifested itself in 1998 when new tubewells for the first time started to hit the bottom of the alluvial aquifer – at approximately 120 m depth. The decline in water table continued with several tubewells going dry or having severely reduced discharge. In several cases a network of pipelines was developed to convey water from the remaining functioning tubewells. What

Table 1
Tubewells in Kuchlagh sub drainage basin.

Type	No. of TWs	Remarks
Domestic water supply	15	Operated by Public Health Engineering Department
Agriculture – illegal connection	20	No payment of electricity charge
Agriculture – legal connection	244	Payment of flat rate of PAR 4000/month (USD 45)
Total	279	

is remarkable is that even though the writing was clearly on the wall, **no** initiative was taken either by farmers or others to reverse the trend – through local regulation or the imposition of more water-efficient farming for instance. Rather the opposite – farmers continued irrigating even winter wheat, whereas the same crop was very cheaply available in the market. No water saving measures were introduced – whereas pilots had shown that higher apple yields would come with less water (the reason being less loss of blossom and better fruit setting).

With tubewells reaching the bottom of the alluvial aquifer, the race to the bottom had reached its logical conclusion. In the period up to this a shake-out had already taken place – small farmers could not stay in the race to the bottom. Only the rich farmers were left on the ground to go for the deep tube wells, but these were eventually falling dry too.

3. Turning point 1998–2004

A new era started in the late 1990s with a substantial decline in the agricultural economy. From 1999 onwards some of the remaining farmers invested more in even deeper tube wells beyond the alluvial aquifer – penetrating the harder limestone formation. These wells were typically drilled at a depth of 250 m The yield of these new deep tubewells was far less – not more than 15% of a production well in the alluvial aquifer in the good years. Other farmers continued to run their well in the alluvial aquifer but again with increasingly marginal results.

Irrigated agriculture reduced to 20% of what it was in the heydays of the early eighties. The extended drought around 2003–2004 accelerated the transformation. At this time apple trees were cut down on a massive scale. Farming was not abandoned but apples were substituted for less water demanding and less water sensitive crops – apricot, grapes and vegetables. The cultivation of winter wheat – irrational from a water economics point of view – continued. Tubewell owners with a legal connection paid a flat rate of as little as PAR 4000 per month (USD 45 per month),[1] so there was no financial incentive not to pump for winter wheat.

The balance sheet is that 400 tube wells connections[2] were issued from 1977 to 2011 to the farmers in the area (sub tehsil Kuchlagh and some adjoining portion of Quetta tehsil). Currently, only 259 'official' tubewells are somehow functional in the area – see Table 1 – but at significantly reduced discharges. In addition there are 20 tubewells that have an illegal connection to the power grid. Table 1 shows the use of tube wells.[3]

Most pumping is for agriculture, as mentioned for apricot, grapes and vegetables and winter wheat. Water sharing between farmers is still practiced. It is not based on payments, but on informal reciprocal exchange.

In addition use of the shallow aquifer continues in a limited decree, mainly fed by seepage water from surface sources and leakage from pumping. As mentioned, the population of Kuchlagh increased

[1] In this period there was a high level debate on the subsidized flat rates for agricultural water use. As part of a loan of the Asian Development Bank the rationalization of tubewell subsidies was agreed by the Government of Balochistan. To affect the first release of the loan the Chief Minister of Balochistan announced the closure of illegal connections and the changes in the electricity tariffs. After this opening gambit the policy stalled. A major opponent was WAPDA – the power company. WAPDA management and employees stand to benefit substantially from the flat rates as it makes it possible to cover electricity losses under the flat rates consumption.

[2] All tubewells are powered by electricity. The main 'regulation' in fact is not the license for to operate a well under the 1978 Groundwater Rights Administration Ordinance but the sanctioning of a power connection for the tubewell.

[3] These tube wells are powered by Sheikh Manda Grid Station and the newly built grid station at Kuchlagh.

tremendously – rising to more than twenty times the population of 1977. There are an estimated 27,000 households and approximately one-third of these – mainly in the south of the city – have excavated a small diameter tubewell or open dug wells in their compounds for domestic use. The water is used for washing clothes and for home gardening – not for drinking water as it brackish. Small quantities are tapped at 20–30 m depth – lifted with buckets or small donkey pumps. The source of this recharged shallow groundwater water is the excess water of surrounding irrigated farms and the run-off trapped in artificial ditches that are excavated for selling of soil used for house construction. In addition, some water replenished from recharge ponds (so called ‘delay action dams’) after rainfall.

4. Adapt or manage: 2004–2011

Farmers and agricultural laborers responded to the collapse of the alluvial aquifer in several ways. Though no steps were taken to undertake groundwater management, by and large a livelihood crisis was avoided. Neither did conflicts occur between obviously competing resource users nor did new forms of cooperation emerge that would have regulated the use of groundwater.

Instead farmers ‘dealt’ with the situation and adopted a number of coping mechanisms: either (1) selling out and seeking non agricultural livelihoods (2) developing new farms elsewhere or (3) continue farming in Kuchlagh but tapping water from greater depth but under a changed cropping pattern.

The earnings from several decades of commercial farming and the parallel urbanization of Kuchlagh meant there were sufficient opportunities in the local economy to cushion the blow from the diminished agriculture that came with the depletion of the alluvial aquifer. Based on field survey, below the coping strategy for three categories of farmers is discussed, i.e. those that sold out, those that continued farming and those that shifted to selling water for domestic use.

4.1. Farmers who sold out

The sale of land became common after the drying up of tube wells. Small farmers in particular sold lands to the outsiders especially Afghan Refugees, several of whom were rich through remittances from the Middle East or from business in Afghanistan and Pakistan. This was a departure from the past when the custom prevailed to preferably sell land to neighbors and not to outsiders. Farmers – especially large farmers – that had lands close to the main road changed their holding into commercial shops and started renting these out on monthly basis. In addition several ex-farmers joined government services and small trades.

The price of land increased with the demand for housing from the town. The number of shops in Kuchlagh for instance increased ten-fold in fifteen years. Agriculture, moreover, became less attractive due to the proximity of the fast growing town: theft of standing crops and related incidents increased. In spite of the sell-out, there was no negative affect on the local economy due to decrease of apple cultivation in the area. Other areas took over Kuchlagh’s earlier premier position in apple cultivation – able to compete in quality of production as well.

A new trade emerged in 2008 when a modicum of regulation of groundwater came into being. At this time the issuing of tubewell connections by WAPDA was tightened and was linked to the groundwater situation in Balochistan. An all-out ban on new agricultural connections was imposed by the Government throughout the Province. This ban, however, triggered an informal market in sanctioned tubewell connections that undid the intended effect of the ban.

If a tubewell ran dry the connection could be officially transferred to another farmer within the district or to the area of the concerned electricity grid. The transfer required an official no objection from the public power company WAPDA. The rates for the transfer were Rs 600,000–700,000 (USD 7–8000). This amount includes cost of reconnection and all related equipments i.e. transformers, control panel board cables and the submersible pumps. Only with transferred sanctioned connection farmers can avail the attractive subsidized flat rate that was issued before imposing the ban.

The farmers who sold out in Kuchlagh did not all quit farming. Many farmers either purchased new agricultural lands elsewhere (generally at a far cheaper rate than in Kuchlagh) or irrigated lands on a lease and tenancy basis. Similarly, sizeable numbers of skilled agriculture labor migrated to other

Table 2
Expenditures and income on agricultural tubewell in Kuchlagh.

No.	Item	Expenditures (Rs)	Income (Rs)	Net income (Rs)
1	Electricity	48,000	0	−48,000
2	O & M cost	20,000	0	−20,000
3	Apricot	170,000	250,000	180,000
4	Vegetables	60,000	300,000	240,000
5	Alfalfa	150,00	200,000	185,000
6	Wheat	25,000	150,000	125,000
7	Wheat straw	0	40,000	40,000
Net				702,000

NB: Average farm size per TW is 6–8 ha (15–20 acres).

areas like nearby Qilla Saifullah or more remote locations – that were close to the Karachi market – in Lasbela and Uthal Districts.

4.2. Farmers who continued

Drilling of new tube wells for agriculture did not stop but decreased drastically mainly due to non availability of new connections and the transformation and urbanization of the area. The high investment of a new tubewell, penetrating into the deep limestone aquifer – at USD 13,000 – with lesser yields discouraged the development of new wells.

After 1995 ground water further declined to the depth of 120 m and more farmers in Kuchlagh started cutting apple trees due to scarcity of water and competition in market price. Some farmers tried to sink new deep borewells to save their drying trees but usually failed to get the desired quantity of irrigation water. The new borewells in the limestone aquifer moreover had short life spans – typically 5–7 years before they fell dry, the reason being that they were exploiting small crevices. Fluctuation in electricity and long load shedding (16 out of 24 h in 2011) further added to the frustration. At this time the majority of the farmers changed over to low water consuming crops, such as apricot, vegetable and wheat. Apple orchards were abandoned – either cut down or left to whither.

At this time also the use of conveyance pipes became more common. They had not been used earlier. From 1995 onwards farmers made use of galvanized iron pipes to prevent seepage losses from the diminishing flows and to reach the outer corners of the command area. In some cases the pipelines were also used to overcome level differences. Reinforced concrete pipes were also used to save water saving. Currently, about fifteen tube well owners in Kuchlagh have also provided underground connections to their personal houses, small hotels and sometimes car washing centers as well.

Table 2 shows the incomes and operation cost of the tube well. With the substitution of the very lucrative apple cultivation for less rewarding crops profit margins of a tubewell farm are in the order of Rs 700,000 or USD 8000. If electricity would be charged on market rates instead of subsidized flat rates this profit margin would be halved. The profit margin may also be compared to the cost of water in the nearby provincial capital of Quetta. To counter the overuse of groundwater and secure water supply to the city the construction of a drinking water reservoir is contemplated at a cost of USD 100 Million. The water from the reservoir would take care of 30% of demand in Quetta. The interest on the investment costs equals USD 6 Million. For this amount one could ‘buy out’ 750 tubewells – which is three times the number of agricultural tubewells in the Quetta sub-basin that are seen as the major threat to the sustainable water supply to the city. These could be partly converted to drinking water resources and the others could be rested.

4.3. Farmers who sell to water tankers

Of the running tubewells a small group of tubewell owners (5) sell water for domestic consumption. In fact these farmers had acquired agricultural connections and pay the subsidized rate to WAPDA, although they are primarily selling water to urban water trucks. As a minor side activity they also

Table 3
Expenditures and income on drinking water tubewell in Kuchlagh.

Sr. no.	Crops	Input/ expenditures (Rs)	Income (Rs)	Net income (Rs)
1	Electricity	48,000	0	−48,000
2	O & M cost	30,000	0	−30,000
3	Wheat	25,000	150,000	125,000
4	Water sale (Rs 5600/day) in summer months	0	1,008,800	1,008,000
5	Water sale (Rs 2800/days) day in winter months	0	504,000	504,000
Net annual income				1,549,000

grow wheat and vegetables on small scale to justify their connection being used for irrigation, yet their income is primarily from water sales. The sales record of one of these five farmers shows benefits being more than double of the income that could be generated with farming that would require a far larger effort (Table 3).

Water is sold to private tractor and truck owners who fill their tankers from the tube well. The tankers owners pay PAR 80–150 (USD 1–1.8) for the filling of a 1500 L tanker – which is subsequently delivered to the houses in different areas in Kuchlagh town. Depending on the distance, tanker owners sell at the rate of PAR 500–700 for home delivery: transport in fact is the major cost. During electricity load shedding the cost for pumping go up as generators are used. This additional cost is born by the tankers owners. The demand by water tankers varies – in the summer months it is double of what it is in the winter months as the tanker water is also used for small home gardens and household livestock. A tube well owner sells 70–80 tankers per day in the summer month and in winter months it reduces to 35–40 tankers. The returns for a tubewell owner more than equals the payment for the subsidized flat rate for the 'agricultural' connection in an entire month.

5. Some lessons

At this stage in the semi-arid Province of Balochistan groundwater use exceeds recharge with 22% – see Table 4 (Halcrow, 2007). In 10 out of 19 sub-basins groundwater use is overused. The Pishin Lora – of which Kuchlagh is part – accounts for the largest imbalance with consumption a factor 4 higher than recharge. Almost all use is for agriculture. What happened in Kuchlagh may be representative for other areas in Balochistan in the future as well as for other semi-arid areas dependent on groundwater for agriculture. The aquifer was depleted. What it means was not that groundwater pumpage stopped. It continued from the hard rock aquifer – and even to some extent on 'a hand to mouth' basis from the alluvial aquifer. The buffer in the alluvial aquifer however was gone – and pumping was less secure and far less reliable.

There are several lessons to draw from the Kuchlagh aquifer depletion case – in terms of impact and response and in terms of lessons for the future.

First is that the response to the aquifer collapse in Kuchlagh was very much individual and consisted of adapting to the declining groundwater tables rather than trying to reverse the trend. Adaptation was first done by drilling deeper by those who could afford and accessing water through tenancy arrangements by those who were losing the 'race to the bottom'. In the later stage, when the buffer capacity of the alluvial aquifer was largely exhausted adaptation consisted of searching alternative livelihoods or in a more limited number of cases pursuing the earlier coping strategy of drilling ever deeper. The fast urbanization of Kuchlagh provided the opportunities for: (1) selling out land and starting agri-business elsewhere; and/or (2) finding non-agricultural employment in the area – including renting out commercial property.

A second point is that all along there had been little interest in groundwater recharge. The main intervention had been the publicly funded development of recharge reservoirs, the so-called 'delay actions dams'. These delays action dams have been constructed in Balochistan since the 1970s and now exceed 300. Their aim is to intercept flood run-off and retain it for recharge (Nippon Giken Inc

Table 4
Annual water balance for Balochistan and sub-basins in 2007 (billion m^3) – Halcrow (2007).

Province	Water source	Recharge/flow	Total use	Balance	Usages portioned			
					Agriculture	Nature	People	Livestock
Balochistan	Groundwater (% of total)	2.210 (17)	2.659 (54)	−0.459	2.474 (70)	n/a (n/a)	0.091 (71)	0.094 (68)
	Surface water	10.793	2.221	8.572	1.059	1.079	0.038	0.045
Sub-basins								
Dasht River Basin	Groundwater (% of total)	0.100 (13)	0.094 (53)	0.006	0.069 (90)	(n/a)	0.013 (81)	0.012 (67)
	Surface water	0.66	0.083	0.577	0.008	0.066	0.003	0.006
Gaj River Basin	Groundwater (% of total)	0.070 (23)	0.072 (74)	−0.002	0.070 (100)	(n/a)	0.001 (100)	0.001 (33)
	Surface water	0.233	0.025	0.208	0.000	0.023	0.000	0.002
Gawadar – Ormara	Groundwater (% of total)	0.040 (7)	0.025 (28)	0.015	0.017 (68)	(n/a)	0.004 (80)	0.003 (75)
	Surface water	0.546	0.064	0.482	0.008	0.055	0.001	0.001
Hamun-e-Lora	Groundwater (% of total)	0.040 (17)	0.141 (83)	−0.101	0.139 (95)	(n/a)	0.001 (100)	0.001 (50)
	Surface water	0.189	0.028	0.161	0.008	0.019	0.000	0.001
Hamun-e-Mashkel	Groundwater (% of total)	0.300 (13)	0.027 (8)	0.273	0.012 (11)	(n/a)	0.008 (80)	0.007 (70)
	Surface water	2.078	0.312	1.766	0.099	0.208	0.002	0.003
Hingol River Basin	Groundwater (% of total)	0.200 (18)	0.168 (55)	0.032	0.156 (83)	(n/a)	0.005 (50)	0.007 (70)
	Surface water	0.942	0.136	0.806	0.033	0.094	0.005	0.003
Hub River Basin	Groundwater (% of total)	0.080 (17)	0.088 (52)	−0.008	0.086 (68)	(n/a)	0.001 (50)	0.001 (50)
	Surface water	0.38	0.08	0.300	0.041	0.038	0.001	0.001
Kachi Plain	Groundwater (% of total)	0.180 (9)	0.169 (21)	0.011	0.140 (25)	(n/a)	0.017 (61)	0.012 (67)
	Surface water	1.902	0.634	1.268	0.428	0.190	0.011	0.006
Kadanai River Basin	Groundwater (% of total)	0.030 (28)	0.115 (92)	−0.085	0.110 (100)	(n/a)	0.000 (n/a)	0.005 (71)
	Surface water	0.077	0.01	0.067	0.000	0.008	0.000	0.002
Kaha Basin	Groundwater (% of total)	0.190 (27)	0.319 (76)	−0.129	0.315 (87)	(n/a)	0.000 (n/a)	0.004 (67)
	Surface water	0.515	0.103	0.412	0.049	0.052	0.000	0.002
Kand River Basin	Groundwater (% of total)	0.010 (36)	0.019 (90)	−0.009	0.018 (100)	(n/a)	0.000 (n/a)	0.000 (n/a)
	Surface water	0.018	0.002	0.016	0.000	0.002	0.000	0.000
Kunder River basin	Groundwater (% of total)	0.050 (33)	0.048 (64)	0.002	0.048 (75)	(n/a)	0.000 (n/a)	0.000 (n/a)
	Surface water	0.103	0.027	0.076	0.016	0.010	0.000	0.000
Mula River basin	Groundwater (% of total)	0.120 (26)	0.129 (75)	−0.009	0.126 (94)	(n/a)	0.002 (100)	0.001 (50)
	Surface water	0.338	0.043	0.295	0.008	0.034	0.000	0.001
Nari River Basin	Groundwater (% of total)	0.270 (25)	0.180 (59)	0.090	0.171 (81)	(n/a)	0.006 (86)	0.004 (67)
	Surface water	0.817	0.126	0.691	0.041	0.082	0.001	0.002
Pishin River Basin	Groundwater (% of total)	0.170 (36)	0.566 (77)	−0.396	0.513 (82)	(n/a)	0.024 (71)	0.029 (67)
	Surface water	0.302	0.169	0.133	0.115	0.030	0.010	0.014
Porali River basin	Groundwater (% of total)	0.140 (11)	0.146 (38)	−0.006	0.142 (54)	(n/a)	0.002 (50)	0.003 (75)
	Surface water	1.106	0.237	0.869	0.123	0.111	0.002	0.001
Rakhshan River basin	Groundwater (% of total)	0.050 (14)	0.081 (70)	−0.031	0.075 (100)	(n/a)	0.003 (67)	0.003 (75)
	Surface water	0.320	0.034	0.286	0.000	0.032	0.001	0.001
Zhob River Basin	Groundwater (% of total)	0.160 (37)	0.270 (71)	−0.110	0.267 (77)	(n/a)	0.002 (100)	0.001 (50)
	Surface water	0.267	0.110	0.157	0.082	0.027	0.000	0.001

and Sanyy Consultants, 1997). Delay action dams typically have a storage capacity close to 1 million m^3 – but the there is wide variation (Halcrow Pakistan and Cameos, 2008b). While the first generation delay action dams in Balochistan was not successful the new generation fared much better – because of better location and because the impounded water was recharged through the downstream riverbed by means of water released out of the storage reservoir. Where they were constructed – downstream water levels typically went up (with 1.4 m).

Based on a study of thirty delay action dams their economic internal rate of return was calculated to be 19% on average (Halcrow Pakistan and Cameos, 2008b). Delay action dams are public investments and expenditure is relatively high. There was no match in the private or community domain and there was never farmer investment in local recharge although by default the trenches made in Kuchlagh town for sourcing construction material served to retain some of the surface run-off and recharge the shallow aquifer. There is in fact a broader repertoire of recharge measures that could have been applied – catchment protection, sink pits, flood water spreading, cascade dams and spate irrigation (Van Steenbergen et al., 2011), but these options were not used. There was in fact as good as no individual or collective investment in recharge – that could have triggered larger concern for and 'ownership' of the resource.

User cooperation, in particular participatory groundwater management has been recommended as a promising strategy for Balochistan – for instance in Techno-consult et al. (2011). Its taking shape either spontaneous as in parts of Yemen or guided and supported as in parts of South India. It has not spread in Balochistan beyond a limited few examples (Van Steenbergen, 1995). There are several possible explanations why no spontaneously self-regulation happened in Kuchlagh. One is that the number of wells in the Kuchlagh area is too large for a spontaneous process. The examples from Yemen show that were local management took off spontaneously the number of wells were in the tens or less (Taher et al., 2012). This reduces the number of players and agreement can be reached without external facilitation. The second reason for the lack of action in Kuchlagh is that the well owners after the influx of the Afghan refugees were not closely knit but diverse. Coupled with the absence of dominating leadership in the Pashtun ethnic group it was difficult to see who would assume a leadership role in addressing the issue. Cooperation did not come off the ground, because no one – internally or externally – ever took the initiative in the area. In Kuchlagh even studies that were undertaken to chart the groundwater resource were never shared with the community of users themselves.

On a different level the course of events in Kuchlagh is strongly reminiscent of the 'desakota' phenomena, where in an urbanizing context rural-urban relations are redefined on several fronts: economically, ecologically and institutionally (Desakota Study Team, 2008). In case of the Kuchlagh 'desakota' the increased connections to outside markets triggered the unprecedented use of groundwater, resulting in its eclipse in a period of 15–20 years. The influx of outsiders weakened traditional social relations and made a community response less likely. On the other hand the growing urban economy provided alternative livelihood opportunities and made it possible to cushion the blow of natural resource depletion. Land was converted into shop fronts and some well-owners turned toward selling water to urban consumers. The growing city provided job opportunities and skilled farm labor moved out and found employment in commercial horticulture in other parts of the Province. All in all the impact of the aquifer collapse on the livelihood of people was not overly dramatic. The decline was gradual and largely unseen (as no one ever discussed the groundwater situation). People adapted to the new reality and the diminishing opportunities related to groundwater use did not result in conflicts or in cooperation. Even the rules on regulating groundwater use through electricity connections were circumvented and there was no protest or commotion whatsoever.

Though the possible shock of disappearing groundwater resource base was largely absorbed by new income opportunities in and around Kuchlagh Town what is lost the capacity of the agricultural sector to provide secure jobs. What is gone also is the capacity to tidy over a dry spell in Kuchlagh with local groundwater resources. This has left the area – including the town – more exposed to variability and climate change. In addition as the groundwater reservoir was depleted the option of high value and low cost horticulture disappeared in spite of a nearby market to be substituted by a less rewarding farm production system.

6. Conclusion: conflict, cooperation or socio-institutional void

In contrast to what Neo-Malthusian or Boserup-inspired theories predict, at no stage did conflict arise or was co-operation triggered. No local rules on groundwater allocation were initiated, nor did anybody take steps to reduce on water consumption, by using efficient field irrigation or phasing out crops with a high water footprint or low returns per water consumed. Zeitoun and Mirumachi (2010) describe that conflicts and cooperation may co-exist at the same time and that cooperation may be repressive whereas conflicts may be liberating in that they may break an impasse. However in Kuchlagh also this more diverse pattern did not emerge.

There were several factors explaining this collective '*sitting duck*' attitude. First, understanding of the imminent disaster was for a long time hidden as farmers were least aware of the nature of the aquifer system[4] and were under the impression that the deepening of wells could continue forever – and so there was no urgency to act. Second, the group of tubewell owners was large and because of the influx of Afghan immigrants no longer homogenous. Several farmers expected the local leader of the area to take the initiative but nothing happened. Local rules or restrictions on individual groundwater use – would these have been formulated – in principle could get a formal legal cover. The Balochistan Groundwater Rights Ordinance first announced in 1978 and then amended in 2001, in principle would provide the basis for such local groundwater management. The objective of the Groundwater Rights Administration Ordinance was "*to regulate the use of groundwater and to administer the rights of the various persons therein*". Under the Ordinance existing groundwater extraction points were to be registered and location-specific rules to be developed and agreed by the main local stakeholders. Against such local rules the district civil administration would then issue permits for the development of new *karezes*, dugwells and tubewells. The relevant authority would be the District Water Committee, composed of government officials as well as two appointed local 'notables'. As such, the Balochistan Ordinance was one of the first 'enabling' groundwater laws, but unfortunately it was not put in effect as such. With a few exceptions no one made the effort to come to the formulation of such local rules (Van Steenbergen, 1995). In Kuchlagh no one took the initiative – least of all the local traditional leadership. The Government of Balochistan similarly did not intervene. In the end rather than earlier envisaged location-specific locally agreed rules, a standard minimum distance rule was adopted in an amendment of the Ordinance, which also carried little meaning.

Nor did conflicts arise at any stage, in fact the gradual depletion was a collective problem, something all well owners faced – without this being attributed to the pumping behavior of any individual or group of individuals. There was an undividedness in the resource use. When some wells in fact fell dry they were connected by pipelines to the remaining wells that were still operational. The closest the Kuchlagh farmers came to cooperation and the cooperation was to share the burden, not to address the overuse.

So there was no conflict and no cooperation – just adaptation to a new reality facilitated by the urbanization taking place. In fact one could argue it might have been better if there had been conflict: it could have triggered some collective action and effort to better manage the limited groundwater resource and use it more productively and strategically. Conflict is often seen as the opposite of cooperation: more conflict means less cooperation and vice versa. Conflict is associated with resource destruction, but it could be the opposite – it may well be the opening toward preservation of a resource under stress.

Focusing on conflict and cooperation one may overlook the situations where neither conflict nor cooperation occurs. These maybe called 'socio-institutional voids'. Even though pressure mounts on a resource, no action is triggered. Forests may be depleted, rivers polluted, fish stocks depleted, erosion increased – but nothing happens: no conflict between the users but also no corrective action or cooperation that turns the depletion around. In case of groundwater 'the race to the bottom' runs to the very end and no stage any one intervenes. We would like argue that it is useful to better understand and address such socio-institutional voids than studying conflicts or cooperation that have already

[4] Groundwater studies had been done for instance by WAPDA Hydrogeology yet these were never shared let alone communicated.

occurred. It suggests also a different handling perspective: not to mitigate conflicts, but to address the socio-economic voids by awareness raising and facilitating local discussion and action.

Conflict of interest

None declared.

Acknowledgements

The comments of two anonymous reviewers is gratefully acknowledges, as is the support of Marta Agujetas in finalizing this document. This longitudinal study was undertaken as part of the NWO-supported CoCoon research project 'Groundwater in the Political Domain'.

References

Baloch, M.A., Tanik, A., 2008. Development of an integrated watershed management strategy for resource conservation in Balochistan Province of Pakistan. Desalination 226 (1–3), 38–46.

Desakota Study Team, 2008. Re-imagining the Rural–Urban Continuum: Understanding the role Ecosystem Services Play in the Livelihoods of the Poor in Diskette Regions Undergoing Rapid Change. ISET, Nepal.

Giordano, M., 2009. Global groundwater? Issues and solutions. Annu. Rev. Environ. Resour. 34, 153–178.

Halcrow, 2007. Supporting Public Resource Management in Balochistan. Basin-wide Water Resources Availability and Use. Asian Development Bank: Supporting Public Resource Management in Balochistan.

Halcrow Pakistan and Cameos, 2008a. Pishin Lora Basin Management Plan. Asian Development Bank: Supporting Public Resource Management in Balochistan.

Halcrow Pakistan and Cameos, 2008b. Effectiveness of the Delay Action/storage Dams in Balochistan. Quetta: Supporting Public Resource Management in Balochistan.

Khair, S.M., Culas, R.J., Hafeez, M., 2010. The causes of groundwater decline in upland Balochistan region of Pakistan: implication for water management policies. In: Paper presented at the 39th Australian Conference of Economists (ACE 2010), Sydney, Australia 27–29 September 2010.

Kulkarni, H., Shah, M., Shankar, V., 2015. Shaping the contours of groundwater governance in India. J. Hydrol.: Reg. Stud. 4, 172–192.

Mukherjee, A., Saha, D., Harvey, C.F., Taylor, R.G., Ahmed, K.M., 2015. Groundwater systems of the Indian sub-continent. J. Hydrol.: Reg. Stud. 4, 1–14.

Mustafa, D., Usman Qazi, M., 2007. Transition from Karez to tubewell irrigation: development, modernization, and social capital in Balochistan, Pakistan. World Dev. 35, 1796–1813.

Nippon Giken Inc, Sanyy Consultants, 1997. Feasibility Study on the Irrigation Water Resources Development with Delay Action Dams Project in Balochistan in the Islamic Republic of Pakistan. Irrigation and Power Department, Government of Balochistan/Japan International Cooperation Agency.

National Academy of Sciences, 2012. Himalayan Glaciers: Climate Change, Water Resources, and Water Security. The National Academies Press, Washington, DC.

Taher, T., Bruns, B., Bamaga, O., Al-Weshali, A., van Steenbergen, F., 2012. Local groundwater governance in Yemen: building on traditions and enabling communities to craft new rules. Hydrogeol. J. 20 (6), 1177–1188, http://dx.doi.org/10.1007/s10040-012-0863-1.

Techno-consult, ACE, Cameos, 2011. Groundwater Management Action Plan for Pishin Lora Basin and Implementation of Pilot Program in Quetta Sub-basin. Quetta: Balochistan Small Scale Irrigation Project.

Van Steenbergen, Frank, 1995. The frontier problem in incipient groundwater management regimes in Balochistan (Pakistan). Hum. Ecol. 23, 1.

Van Steenbergen, F., 1996. Land, water and ethnicity: social organization and resource management in irrigated communities in Balochistan. In: Titus, P. (Ed.), Marginality and Modernity: Ethnicity and Change in Post-colonial Balochistan. Oxford University Press, Karachi.

Van Steenbergen, F., Tuinhof, A., Knoop, L., 2011. Transforming Landscapes, Transforming Lives: The Business of Sustainable Water Buffer Management. IFAD, Rome.

UNESCO World Water Assessment Programme, 2003. Water for People, Water for Life. A Joint Report by the Twenty-three UN Agencies Concerned with Freshwater. UNESCO, Paris, pp. 576.

Wada, Y., van Beek, L.P.H., van Kempen, C.M., Reckman, J.W.T.M., Vasak, S., Bierkens, M.F.P., 2010. Global depletion of groundwater resources. Geophys. Res. Lett. 37, 1–5.

Zeitoun, M., Mirumachi, N., 2010. Transboundary water interaction: reconsidering conflict and cooperation. In: Wegerich, K, Warner, J (Eds.), The Politics of Water: A Survey. Routledge, London.