To centralize or not to centralize:
Planning appropriate sanitation infrastructure in Leh Town, Ladakh, India

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ABSTRACT: Safe drinking water access is already a very serious issue for large populations in fast-growing economies such as India, which is being exacerbated by climate change. Leh Town, the capital of Ladakh, India is at the centre of a fast expanding and globalising tourism-based economy. Located in an ecologically vulnerable semi-arid region of the Himalayas, Leh has expanded exponentially in the past decades. Significant lifestyle changes for the local population are augmenting already very serious environmental issues caused by lack of water and sanitation infrastructure, and consumption patterns of limited water resources. Thus, an integrated urban planning strategy linking wastewater management and water resources conservation is a pressing task. Field survey was conducted between July 2012 and February 2013, including Geographic Information Systems (GIS) mapping of guesthouses, hotels and point sources of water pollution, and a questionnaire survey of 200 households and 70 hotels and guesthouses. It is found that guesthouses and hotels have increased predominantly on agricultural land and point sources of water pollution tend to cluster in rapidly transforming parts of Leh, potentially impacting groundwater quality. This study advocates a decentralized sanitation system for groundwater resources conservation in Leh.
Keywords: Urban water resources management, health, India.

NTRODUCTION

Rapid urbanization in developing economies such as ndia is inducing water-related environmental challenges 1] as urban infrastructure planning is often unable to eep up with the pace of development. The resulting ack of access to safe water and sanitation is increasing ater-related health risks [2], which are further being xacerbated by climate change induced water scarcity 3]. Especially in regions where water is already scarce, ntegrated urban planning taking health issues into onsideration is needed.

Health issues do not directly drive urban design, but ney did provide the original impetus for the urban lanning profession: the discovery in 19th century ondon that cholera is a water-borne disease, for xample, and that it was spreading from one particular ontaminated water pump had huge implications. Thus, rban design is considered a powerful tool for ddressing new public health concerns [4,5] and new rameworks linking public health and urban planning are eeded [6] in order to address contemporary challenges. tudies on the relation between the built environment nd health are often confined to certain academic fields nd their theoretical frameworks and terminologies, aking results difficult to share [7]. Further, most such tudies focus on developed country contexts rather than eveloping countries like India. Hence increase in cross-isciplinary collaboration to strengthen the associations research cooperation [9] enabling cross-country learnin experiences are needed.

Although one of the earliest examples of publi sewerage was found in the ancient Indus Valley, Indi today is facing a sanitation crisis in part due to coloni heritage [10]: only 16 percent of the urban populatio have access to adequate sanitation resulting in large scale open defecation and thus ground and surface wate pollution [11]. Water and health studies tend to focus o large cities while there is a dearth of information abou small and medium-sized cities. Historically, although i industrializing Europe sewerage or centralized sanitatio systems proved very effective in curbing the spread o disease related to water and poor sanitation in urba areas, they are very water-intensive to operate: thus, i regions facing water shortages, alternative sanitatio systems are increasingly being recognized as a way t help protect and conserve water resources [12 Alternatives include various types of decentralize sanitation systems such as Ecosan [13]. Although thes alternative systems have various advantages such a water conservation, nutrient recovery, low maintenanc cost, etc. [14], they have relatively rarely bee implemented successfully. Instead, the flush toilet an centralized sanitation / sewage system, which has bee termed “ecologically mindless”, remains a preferre option [15] as a symbol of “modernity”. Whil decentralization in the water sector in India has helpe

f issues surrounding health in urban India, new pproaches are needed [17].

ı small town in a water-scarce region is taken as a case tudy. Leh Town, the capital of Ladakh Region of ammu & Kashmir State, is considered one of the astest-expanding small towns in India [18]. Located in remote ecologically sensitive semi-arid region in the Himalayas at an altitude of 3,500 metres above sea level, eh is a green oasis of agricultural fields between barren ıountains and fringing a historic town centre (Figure 1). he Ladakh Autonomous Hill Development Council LAHDC) has been governing Leh since 1995. ıccording to the 2011 Census, Leh Town has a opulation of 17,553. In addition, there are 40,000 army ersonnel [19] and several thousand migrant workers ome to Leh every summer.

ground- and spring water are the main water resources f Leh as rainwater is negligible and glacial melt water s decreasing [20] possibly due to climate change, and is nly sufficient for irrigation. The green oasis of Leh is ıus not a natural occurrence, but the result of hundreds f years of careful management of limited water esources and cultivation of a fertile desert. Since 1974 hen Ladakh was opened to tourism, the number of isitors has increased exponentially, and in 2012, 79,000 tourists visited Leh. Most tourists visit between ıpril and October, but in the harsh winters only the ocal population remains.

igure 1: Cultural landscape of Leh Town

o cater to the huge increase in visitors, hundreds of uesthouses and hotels have been constructed in Leh. adakhi dry toilets are an example of a traditional ecentralized sanitation system with nutrient recovery or agriculture and do not require any water. However, ith changing lifestyles and the majority of tourists referring to use flush toilets [21], water demand has

Public Health Engineering Department (PHE) supplie about 80 percent of Leh Town's water demand throug groundwater extraction in the summer months [22], bu this only suffices to provide running water for a fe hours per day, which is insufficient for the operation flush toilets and showers. Thus, guesthouses and hote are increasingly constructing private bore wells t procure additional water. Environmental pollutio through lack of adequate sanitation and rubbis dumping is already severe and it is thus assumed th groundwater pollution due to seepage is occurrin Increase in water-borne diseases such as hepatitis an diarrhoea were already recorded in Leh over a decad ago [23] and incidences of diarrhoea have risen sinc which is not expected with economic growth and may b linked to groundwater pollution [24].

The aim of this study is to characterize the wat management situation and to highlight opportunities an challenges for implementing a decentralized sanitatio system in Leh.

METHODOLOGY

Field survey was conducted between July 2012 an February 2013 in collaboration with the Ladak Ecological Development Group (LEDeG), a local no governmental organization. Global positioning syste (GPS) was used to map new hotels, guesthouses an restaurants, and 270 point sources of water pollution. WorldView-2 very high-resolution satellite imag (ground resolution 50 cm) from November 2011 serve as a base map. Geographic information systems (GI data on rivers, roads, hotels and guesthouses mapped b Akhtar [21] were used. Further, questionnaire survey 200 households and 70 hotels and guesthouses wa conducted, as well as semi-structured interviews with range of stakeholders.

RESULTS

There has been a dramatic increase in the number hotels and guesthouses in Leh Town in the past decade in the 1980's there were only 24 hotels and guesthouse in Leh, but by 1990 there were 62, by 2000 there we 117, by 2010 there were 282, and just from 2010 t 2012, the number had increased to ca. 360 guesthouse and hotels in business, with another ca. 60 not yet i business or under construction (Figure 2). Of 21 ward in Leh Town, 10 have agricultural land, whilst the othe are predominantly desert-like. The study found that 9 percent of hotels and guesthouses in Leh are located i wards with agricultural land area (Figure 2).

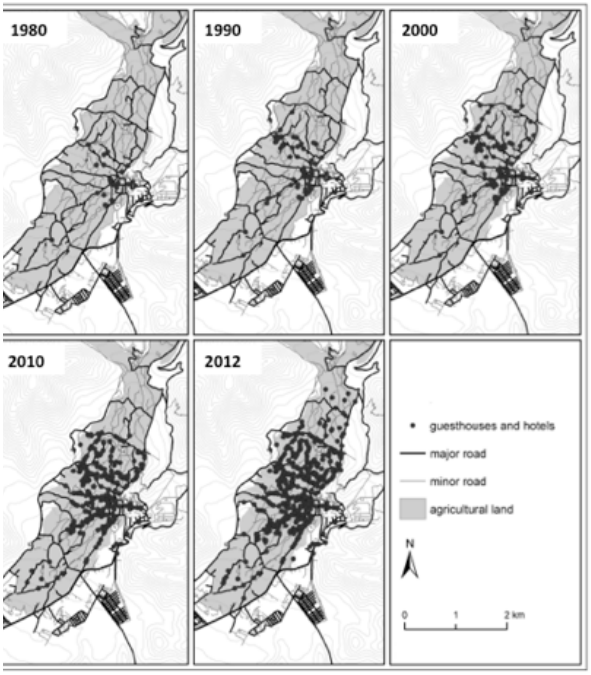

Figure 2: Increase in hotels and guesthouses since 1974

The huge increase in tourists in Leh signifies a huge increase in water demand. Hotels and guesthouses strive to provide flush toilets and showers to increase their rating and, thus, their overnight prices, according to the interview surveys. Thus, on top of the official extraction of groundwater by PHE, the questionnaire survey revealed that 52 percent of hotels and guesthouses have private bore wells, and are each extracting several thousand litres daily from the groundwater in the tourist season. For example, one hotel owner interviewed of a hotel with 18 en-suite rooms reported extracting up to 5,000 litres per day during the tourist season.

Focusing on water pollution factors in the 10 wards of Leh Town with predominantly agricultural land, the study found that as there is currently no overall or systematic wastewater management existing in Leh, hotels and guesthouses use septic tanks or soak pits to collect black- and grey wastewater. Many guesthouses were found to have only soak pits, potentially representing a significant source of effluents and thus groundwater pollution threat. In addition, 270 point sources of water pollution were mapped in the wards with predominantly agricultural land, which can be divided into three categories (total numbers of each are in brackets):

1. Black water pollution sites including black water inlets (from toilets) (8), public toilets without septic tanks and foul-smelling empty
2. Grey water pollution sites including grey wate inlets (other bathroom and kitchen wastewate (216), clothes (12) and car washing points (1);
3. Garbage dumps (18).

Of all point sources of water pollution, 80 percent ar grey water inlets, which is of concern because with gre water increasing amounts of chemicals are bein released into the water system in Leh from detergen used for cleaning and washing purposes. Further, 4 restaurants were mapped in wards with predominantl agricultural land (Table 1). The field survey revealed that many restaurants in the agricultural land wards o Leh Town are garden restaurants without sanitar infrastructure and only dug pit toilets, so that effluen from restaurants along rivers and streams signify bot surface and groundwater pollution threats.

The wards with predominantly agricultural land in Le Town can be divided into 5 inner and 5 outer ward inner wards being those directly adjoining the ancien town centre. 96 percent of hotels, guesthouses an restaurants are located in the inner wards. Consideratio of the distribution of point sources of water pollution i terms of proximity to rivers and streams in these 1 wards showed the following: hardly any point sources o water pollution were found in the outer wards. Th percentage of the total number of point sources of wate pollution located within 100 metres of a river or strear was more than twice as high in the inner than in the ou outer ward where point sources of water pollution wer found. Further, the relation of the number of hotel guesthouses and restaurants to the percentage of poi sources of water pollution within 100 metres of a rive or stream was clearly the highest in the two ward Tukcha and Karzoo, which have the largest number o hotels, guesthouses and restaurants. Thus, increase i water pollution may be directly linked to the tourisr industry. Overall, 62 percent of point sources of wate pollution in the wards with predominantly agricultura land in Leh Town are within 100 metres of rivers an streams (Table 1).

Table 1: Distribution of point sources of water pollutio in 2012

Ward ID	Ward Name	Ward Type	No. of Hotels (*H*) or Guesthouses (*GH*)	No. of Restaurants (*R*)	No. of Pollution Points (*PP*)	No. of *PP* within 100 Metres of a River/ Stream	% of total *PP* within 100 Metres of a River/ Stream	Relation of No. of *GH*/*H*+*R* to % of *PP* within 100 Metres of a River/ Stream
1	Sanker	Inner	57	0	26	19	73	1
2	Sheynam I	Inner	17	0	32	28	88	0
3	Sheynam II	Inner	22	4	55	24	44	1
4	Tukcha	Inner	103	18	97	66	68	2
5	Karzoo	Inner	110	17	36	24	67	2
6	Skara I	Outer	6	2	22	5	23	0
7	Gonpa I	Outer	1	0	0	0	-	-
8	Gonpa II	Outer	4	0	0	0	-	-
9	Gangles	Outer	0	0	0	0	-	-

n terms of the local populations perception of water ssues, the questionnaire survey revealed that although 8 percent of households thought that drinking water uality is safe in Leh, 49 percent of households thought rinking water quality today is worse than 10 years ago. 5 percent of households reported having problems with neir drinking water in terms of smell, taste or colour. ack of adequate sanitation system, i.e. septic tanks, or oak pits, were thought by 31 percent of households to e the main source for groundwater pollution. Increased se of chemical fertilizer in agriculture was also erceived as a water quality threat. 40 percent of ouseholds thought drinking water pollution is related to iarrhoea. Thus, this study finds drinking water ollution to be a serious concern of the local population.

ISCUSSION

roundwater extraction is not regulated in Leh, and the otal number of bore wells, rates of extraction and roundwater aquifer levels are currently not known. An ncreasing percentage of hotels and guesthouses are nstalling showers and flush toilets although, according o the interview survey, inhabitants think that some prings in Leh seem to have dried up because of high ates of groundwater extraction. There is so far no trategy tackling water issues in Leh from the demand ide. Negligible rainfall, decrease in surface water and in rrigated agricultural land due to hotel and guesthouse onstruction, added to the sum of PHE and private xtraction by hotels and guesthouses, may mean that roundwater is being depleted faster than the rate of echarge in Leh. Further spatial investigation of istribution of water resources and water demand may elp to estimate Leh's carrying capacity in terms of vater resources, which currently is not known. Overall, ne type and distribution of water pollution in Leh ndicates further environmental planning is needed.

Currently, PHE supplies following daily estimates uring summer months from these sources [25]:

1. 1-2 million litres extracted via four tube wells from the Indus River aquifer;
2. 1,3 million litres extracted from various tube and bore wells distributed in Leh Town;
3. 0,8 million litres channelled from various springs near the top of Leh Town.

Thus, most of Leh Town's water demand is being rovided through groundwater extraction via bore and ube wells. Water from the Indus River aquifer is being fted several hundred meters up to reservoirs distributed n Leh Town, which is very energy intensive. From the and private water taps. An additional several thousan litres daily are distributed to the local population witho access to any taps by water tankers. Variou stakeholders according to the interview survey a voicing concern that groundwater resources in Leh a being over-depleted. However, the main concern PHE, also according to the interview survey, is how t procure ever more water from groundwater and riv water sources.

Although LAHDC aims to promote Ladakh as an ec tourism destination and even an "ideal society", an conserve and protect water resources, in practice this difficult to implement as the environment is commonl degraded due to lack of awareness or for short-sighte monetary gains [26]. Due to decrease in the prima farming sector as a multitude of other job opportuniti have opened up, Ladakh currently already has an impo dependency ratio of 60 percent for food [27]: thu LAHDC plans to use groundwater for irrigation in ord to boost food production and to introduce legislatio completely banning construction on agricultural lan [26]. Energy provision is also already a challenge i Leh, with the town facing regular daily electricity cuts.

A decentralized sanitation system in Leh may hel address these challenges as well as to conserve an protect groundwater resources by enabling:

1. Conservation of water resources by using les water for flushing;
2. Nutrient recovery and continuation traditional practices and use of natural fertiliz as opposed to chemical fertilizer in a sti actively agricultural society;
3. Wastewater can be used in agriculture locall instead of needing to procure additional wat for irrigation;
4. Less environmental pollution of soil and wat resources and loss of water due to less seepag due to shorter pipes;
5. Lower energy consumption due to less wat having to be lifted from groundwater resourc and pumped up-hill;
6. Renewable energy production (biogas);
7. Lower costs of installation and maintenance.

In addition, wastewater could be treated and channelle back to replenish the aquifer proportionally to i demand locally. Despite these advantages, to implemen a decentralized sanitation system effectively will requi significant increase in awareness of inhabitants an tourists to initiate change in water consumptio behaviour. One hotel in Leh is currently alread implementing its own decentralized wastewat

n order to deal with increasing amounts of wastewater, AHDC plans to implement a centralized sanitation ystem by 2040 through a private company which is lanned to comprise about 20 kilometres of piping to be id at a depth of 2 metres below the surface to avoid eezing in winter and with a central water treatment lant close to the Indus River aquifer, again several undred metres below Leh Town [28]. However, such a entralized sanitation system may require increased ater resources in order to flush long pipes, which will n turn require more energy for extraction, and may ntail high maintenance costs due to the harsh climate nd rugged topography.

espite these seemingly natural constraints to the nplementation of a centralized sanitation system, onetheless, such a system represents a large-scale nfrastructure investment opportunity for the local overnment. Further, the centralized system may ymbolize the "modernity" that a society facing the urdens of rapid transition and as recently still ompletely traditional as Ladakh wishes to strive for. ith its apparent record of success, the centralized anitation system still stands for "business as usual".

owever, until quite recently, this same traditional ociety was using only a decentralized sanitation system, ne Ladakhi dry toilet, which was very well adapted to ne local conditions. The Ladakhi dry toilet is an levated slab, sometimes as part of a house or as a eparate out-house, where faecal matter falls into a hamber beneath the slab and is covered after each visit y a shovel full of earth – hence "dry" as no water is sed. The faecal matter is stored and used as dry gricultural fertilizer by adding it to irrigation water. hilst many of the local population continue to utilize ne Ladakhi dry toilet, also because fertilizer remains aluable in agriculture, the vast majority of tourists to eh prefer to use the flush toilet because it is considered nore convenient and hygienic. As a result, hotels and uesthouses strive to provide flush toilets en-suite to all ooms.

ue to administrative decentralization, ratification of the ndian Groundwater Act is still pending in Ladakh. At ne same time, the increasingly autonomous government s short of funds, leaving it prey to investors keen to sell xpensive infrastructure. Despite evident need for anitation infrastructure, the government may shy away rom addressing the issue in more detail as poverty nked to the caste system and sanitation most directly, ontinues to be a highly political and sensitive issue in ndia.

In-depth understanding of stakeholder decision-makin power distribution is needed to approach water-relate health risks through alternative urban developmer scenarios effectively. There may be a range of optior potentially better suited to the water scarcity situation i Leh that could even present innovative opportunities fc eco-tourism. Perhaps a decentralized system can b implement like a centralized one and thus also preser investment opportunity, or there may be hybrid option In any case, this study advocates a study of Leh carrying capacity in terms of water resources, and a independent evaluation of both a centralized and decentralized sanitation system in terms of which more beneficial for water resources conservation. Wit an appropriate vision, Leh has the full potential t become an international lighthouse example of an "ide eco-society".

CONCLUSION

As long as short-term economic goals prevai developing enough awareness of water issues in Leh t change water consumption patterns will be difficult. fixed idea of "modernity" predominantly throug technological solutions and a "earn money first, clea later" approach, has also not served the Western worl at all well in all instances. Decentralized sanitatio technology may be "old hat" *per se*, but implementatio of innovative approaches in the development as well a in the developed contexts is still a far cry from a routir process. One of the most difficult challenges we face i our time is to open our mindsets to allow alternative an perhaps more appropriate visions of "modernity" int existence so that we can systematically evaluate them.

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REFERENCES

1. Marcotullio, P.J. (2007). Urban water-relate environmental transitions in Southeast Asia. Sustainabili Science, 2, 27–54.
2. Galea, S. & D. Vlahov (2005). Urban Health: Evidenc Challenges and Directions. Annual Review of Publ Health, 26, 341-65.
3. Vörösmarty, C.J., Green, P., and Lammers, R.P (2000 Global Water Resources: Vulnerability from Clima

. Jackson, L.E. (2003). The relationship of urban design to human health and condition. Landscape and Urban Planning 64, 191–200.
5. Jackson, R.J. (2003). The Impact of Built Environment on Health: An Emerging Field. American Journal of Public Health, 93(9), 1382-4.
6. Naess, P. (2006). Urban Structure Matters. Routlegde, Abingdon, England, pp. 328.
7. Dannenberg, A.L., Jackson, R.J., Frumkin, H., Schieber, R.A., Pratt, M., Kochtitzky, C. and Tilson, H.H. (2003). The Impact of Community Design and Land-Use Choices on Public Health: A Scientific Research Agenda. American Journal of Public Health, 93(9), 1500-8.
8. Jackson, L.E. (2003). The relationship of urban design to human health and condition. Landscape and Urban Planning 64, 191–200.
9. Bork, T., Butsch, C. Kraas, F. and Kroll, M. (2009). Megastaedte: Neue Risiken fuer die Gesundheit. Deutsches Aerzteblatt, 39, 1609 (in German).
10. Jha, N. (2010). Access of the poor to water supply and sanitation in India: salient concepts, issues and cases. International Policy Centre for Inclusive Growth Working paper No. 62.
11. World Health Organisation (WHO) and United Nations Children's Fund (UNICEF) (2006). Meeting the MDG Drinking Water and Sanitation Target: The Urban and Rural Challenge of the Decade. Geneva, WHO Press.
12. Lüthi, C., Panesar, A., Schütze, T., Norström, A., McConville, J., Parkinson, J., Saywell, D., Ingle, R. (2011). Sustainable Sanitation in Cities - A Framework for Action. Sustainable Sanitation Alliance (SuSanA) & International Forum on Urbanism (IFoU), Papiroz Publishing House, The Netherlands.
13. Haller, J.A. (2010). Ecological Sanitation Literature Review. Ladakh Ecological Development Group (LEDeG) Working Paper, 10th June 2010.
14. Tilley, E., C. Lüthi, A. Morel, C. Zurbrügg and R. Schertenleib (2008). Compendium of Sanitation Systems and Technologies. Swiss Federal Institute of Aquatic Science and Technology (Eawag). Dübendorf, Switzerland.
15. Narain, S. (2002). The flush toilet is ecologically mindless. Down to Earth, Vol 10, No. 19.
16. Saravanan, V.S. (2009). Decentralisation and Water Resources Management in the Indian Himalayas: The Contribution of New Institutional Theories. Conservation and Society 7(3): 183-199.
17. Butsch, C., P. Sakdapolrak and V.S. Saravanan (2012). Urban health in India. Internationales Asienforum, Vol. 43 (2012), No. 1–2, pp. 13–32.
18. Rieger-Jandl, A. (2005). Living culture in the Himalayas. Anthropological Guidelines for Building in Developing Countries. Facultas, Wien, pp.263.
19. Skeldon, R. (1985). Population pressure, mobility, and socioeconomic change in mountainous environments: Regions of Refuge in comparative perspective. Mountain Research and Development 5,

Stadtquartiers im indischen Trans-Himalaya. Mast Thesis in Geography, Ruprecht-Karls-Universit Heidelberg, Sept. 2009, pp.117.
21. Akhtar, A. (2010). Tourism and Water Resources in Le Town (NW-India): Analysis from a Political Ecolog Perspective. Master Thesis in Geography, Ruprecht-Karl Universität Heidelberg, January 2010, pp.116.
22. LEDeG (2010). Water in Leh: A drop in the dese Ladakh Ecological Development Group brochure, Le Ladakh, India.
23. Bhasin, V. (1999). Leh – an endangered city Anthropologist, 1(1): 1-17.
24. Gondhalekar, D., A. Akhtar, P. Keilmann, J. Kebschull, S Nussbaum, S. Dawa, P. Namgyal, L. Tsultim, T. Phuntso S. Dorje and T. Mutup (forthcoming). Drops and h stones: towards integrated urban planning in terms water scarcity and health issues in Leh Town, Ladak India. In Gislason, M.K. (ed.). Ecological Health: Societ Ecology and Health. Volume 15 of the Advances Medical Sociology Series.
25. Public Health Engineering Department (PHE) Leh Ladak http://leh.nic.in/dept.htm [14 May 2013].
26. LAHDC (Ladakh Autonomous Hill Development Counci (2005). Ladakh 2025 Vision Document. LAHDC, Le Ladakh, India, pp. 75.
27. Pellicardi, V. (2010). Sustainability Perspectives Development in Leh District (Ladakh, Indian Tran Himalaya): an Assessment. Doctoral Thesis submitted CIRPS (Interuniversity Research Centre for Sustainab Development) University of Rome "Sapienza", pp. 174.
28. Tetra Tech (2009). Plan for implementation of centralize sewage system in Leh Town, Ladakh. Public presentatio 17th December 2009, Leh, Ladakh, India.