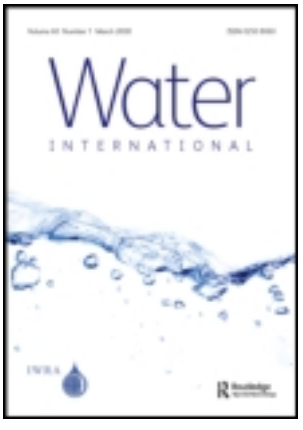

Water International
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/rwin20

Including cultural water requirements in environmental flow assessment: an example from the upper Ganga River, India

Chicu Lokgariwar[a], Ravi Chopra[a], Vladimir Smakhtin[b], Luna Bharati[c] & Jay O'Keeffe[d]

[a] Peoples' Science Institute, Dehradun, India

[b] International Water Management Institute, Colombo, Sri Lanka

[c] International Water Management Institute, Kathmandu, Nepal

[d] Rhodes University, Grahamstown, South Africa

Published online: 07 Dec 2013.

To cite this article: Chicu Lokgariwar, Ravi Chopra, Vladimir Smakhtin, Luna Bharati & Jay O'Keeffe (2014) Including cultural water requirements in environmental flow assessment: an example from the upper Ganga River, India, Water International, 39:1, 81-96, DOI: 10.1080/02508060.2013.863684

To link to this article: http://dx.doi.org/10.1080/02508060.2013.863684

Water International, 2014
Vol. 39, No. 1, 81–96, http://dx.doi.org/10.1080/02508060.2013.863684

Routledge
Taylor & Francis Group

Including cultural water requirements in environmental flow assessment: an example from the upper Ganga River, India

Chicu Lokgariwar[a]*, Ravi Chopra[a], Vladimir Smakhtin[b], Luna Bharati[c] and Jay O'Keeffe[d]

[a]*Peoples' Science Institute, Dehradun, India;* [b]*International Water Management Institute, Colombo, Sri Lanka;* [c]*International Water Management Institute, Kathmandu, Nepal;* [d]*Rhodes University, Grahamstown, South Africa*

(*Received 22 June 2012; accepted 5 November 2013*)

The rituals of riparian communities are frequently linked to the flow regimes of their river. These dependencies need to be identified, quantified and communicated to policy makers who manage river flows. This paper describes the first attempt to explicitly evaluate the flows required to maintain the cultural and spiritual activities in the upper Ganga River basin. Riparian dwellers and visitors were interviewed and the responses analyzed to obtain an overview of the needs and motivations for cultural flows. The approach enhances the overall concept of environmental flow assessment, especially in river basins where spiritual values ascribed to rivers are high.

Keywords: environmental flows; cultural flow component; riparian communities; Ganga

Introduction

Maintaining or restoring elements of the natural flow regime in rapidly developing river basins is essential to maintaining rivers' health and functions (Poff et al., 1997). Assessment of a modified flow regime that would maintain a river in some agreed state or restore it to that state is known as environmental flow assessment (EFA). A recent review of the many methods used to estimate environmental flows (EF) can be found in Acreman and Dunbar (2004). With a few exceptions, these methods focus primarily on estimating flows important for river ecology. Yet, besides river ecology per se, the in-stream flow requirements of riparian communities are equally important for the sustainable and socially responsible management of rivers.

Human beings study the world around them, and use this knowledge to develop practices that sustain life. This knowledge of their environment is recorded and handed down through beliefs, myths and rituals (Croll & Parkin, 1992). Ecological and community water needs are inherently linked, with rivers supporting many livelihoods (such as fishing and floodplain farming) that are directly dependent on in-stream flows. The water quantity required for small-scale irrigation, depth for ferrying, periodic floods for supplying silt, etc., comprise the flow requirements for livelihoods. In addition, rivers support the quality and "way of life" not only of the riparian communities but also of people and communities who live outside the hydrological basin. This is especially true for the many rivers in the South Asian subcontinent that are worshipped as deities.

*Corresponding author. Email: chicu.l@gmail.com

Deified rivers can be said to have a "cultural basin", populated by devotees of the deity. This may have undefined boundaries extending beyond the hydrological basin, depending on where the worshippers live.

Over millennia, riparian communities and devotees have developed customs, rituals and philosophies that are synchronic with and reflective of the natural rhythms of the river. Their ability to practise such rituals (e.g. ceremonial bathing) depends on the availability of certain flows at different times of the year. As will be seen in this paper, spiritual values and folklore are also attached to varying levels of flow; thus the appearance of culturally important and iconic rivers should match their descriptions in folklore and mythology. These are referred to here as the "cultural flow requirements" for a river.

Quantifying such belief- or opinion-based requirements, which rely partially on intangible benefits to all dwellers of a "cultural basin", poses obvious difficulties. However, quantification of cultural flows is important if policy makers are serious about the socially responsible management of rivers. Not considering these water requirements threatens the cultural identities of communities, causes the loss of traditional knowledge, and alienates a large section of stakeholders (Verschuuren, 2006). The close affinity between water management and conflict management necessitates that both the quantifiable and the transcendent be acknowledged and applied to water negotiations (Wolf, 2012).

While the "cultural perspectives of indigenous communities on water" have been acknowledged, for example, in the Australian National Water Initiative of 2004, assessment of such water requirements has neither been carried out separately nor explicitly included in EFA before (Jackson, 2008; Verschuuren, 2006). This paper aims to fill that gap. It describes an approach to the explicit determination of cultural flow requirements using the upper stretch of the Ganga river in India as an example.

The aims of the Upper Ganga EFA were to capture the requirements of people, biodiversity, water quality, and important river channel and floodplain processes which could be maintained or improved by flow manipulation. It is important to realize that there can only be one flow at any particular time in each reach of the river. This flow may be advantageous for some components and processes but detrimental to others. For example, floods are essential for sediment redistribution, floodplain replenishment and fish breeding, but may pose dangers and limitations for human use. It is also important to realize that, although many components and processes are flow-dependent, many, including cultural and spiritual issues, and either unaffected or only marginally affected by flow. Therefore, environmental flows should not be seen as a panacea for all the problems in a river; they will always be a compromise whose goal is to optimize conditions with respect to those priorities identified by the stakeholders.

Study area

The river Ganga originates at the Gangotri Glacier in India's Uttarakhand State and flows for 2525 km into the Bay of Bengal. It drains an area of 981,371 km^2 in India, Nepal, China (Tibet) and Bangladesh (Sharma, Amarshinghe, & Sikka, 2008). The Ganga's hydrological basin is home to an estimated 445 million people in India alone. Eck (2003) has stated that it is "the archetype", "the quintessence" and "the source" of sacred waters in Hindu mythology and revered by millions of Hindus all over the world.

According to Hindu mythology as mentioned in the *Ramayana*, the *Mahabharata* and several Puranas, the Ganga is a goddess reincarnated on Earth to wash away the sins of humanity (Eck, 2003). The Ganga's water is credited with the power to ensure salvation

for those who imbibe it or wash in it. The Skanda Purana (Kumar, 1983) describes the Ganga as turbulent, sportive, moving, swift, leaping and booming. This movement is a crucial aspect of the river, which derives its name from the Sanskrit verb *gam* (to go), especially because it is running water that has the capacity to absorb and carry away pollution (Eck, 2003).

The present study focuses on the Upper Ganga Basin (UGB), the main upstream branch of the river (Figure 1). The total area of the UGB is 87,787 km^2. Elevation in the UGB ranges from 7500 m in the upper mountain region to 100 m in the lower plains. The average annual rainfall is in the range of 550–2500 mm. The major part of the rains is due to the south-western monsoon (from June to October). Some mountain peaks in the headwater reaches are permanently covered with snow, and glacial melt contributes to summer flows.

The main river channel and some tributaries are highly regulated with dams, barrages and corresponding canal systems (Figure 1). The three main canal systems (the Upper, Madhya and Lower Ganga canals) irrigate 2.7 million hectares between them. All these dams and barrages are located in the study area. This infrastructure development affects the river flow regime, which in turn impacts water quality, riverine ecosystems, community life and cultural activities.

Assessment of cultural flow requirements formed a part of a comprehensive EFA of the UGB (WWF-India, 2012), which in turn was a component of WWF-India's Living Ganga Programme. The main objective of this programme is to develop and promote approaches for sustainable water resources management, including EF which conserve biodiversity and support livelihoods under current and changing climate scenarios (WWF India, 2011). In conducting the EFA, the UGB from Gangotri to Kanpur was further subdivided into several zones. Three of these zones and their corresponding EF sites (EF 1, Rishikesh; EF 2, Kachla Ghat; and EF 4, Bithur, in Figure 1) were used in this study.

Rishikesh, in Zone 1, is a pilgrimage centre with a population of around 60,000 (Census of India, 2001) located just as the Ganga enters the plains. Kachla Ghat, in Zone 2, is a revered cremation site just downstream of the Kachla Bridge railway station and about 2.5 km from Kachla Village. Bithoor, in Zone 3, is a riverside town with a population of around 10,000 (Census of India, 2001). All three sites have a long history of being linked to the Ganga. In addition to the resident population, they attract a large number of pilgrims.

Methods and data

The place of cultural flow assessment in EFA

The overall EFA was carried out using the building block methodology (BBM) (King, Tharme, & Villiers, 2000). "Building blocks" (BBs) are EF which jointly comprise the ecologically and socially acceptable modified flow regimes. The major BBs are low flows, small increases in flow ("freshes") and larger high flows, which are required for floodplain flooding and for river channel maintenance. BBs differ between "normal years" and "drought years". The set of BBs, therefore, includes maintenance low flows, maintenance high flows, drought low flows and drought high flows.

The BBM recognizes that very few rivers are in the natural state today. BBs are therefore defined so as to maintain a river in some predetermined state or environmental management class (ranging from "near natural" to "highly modified"). The

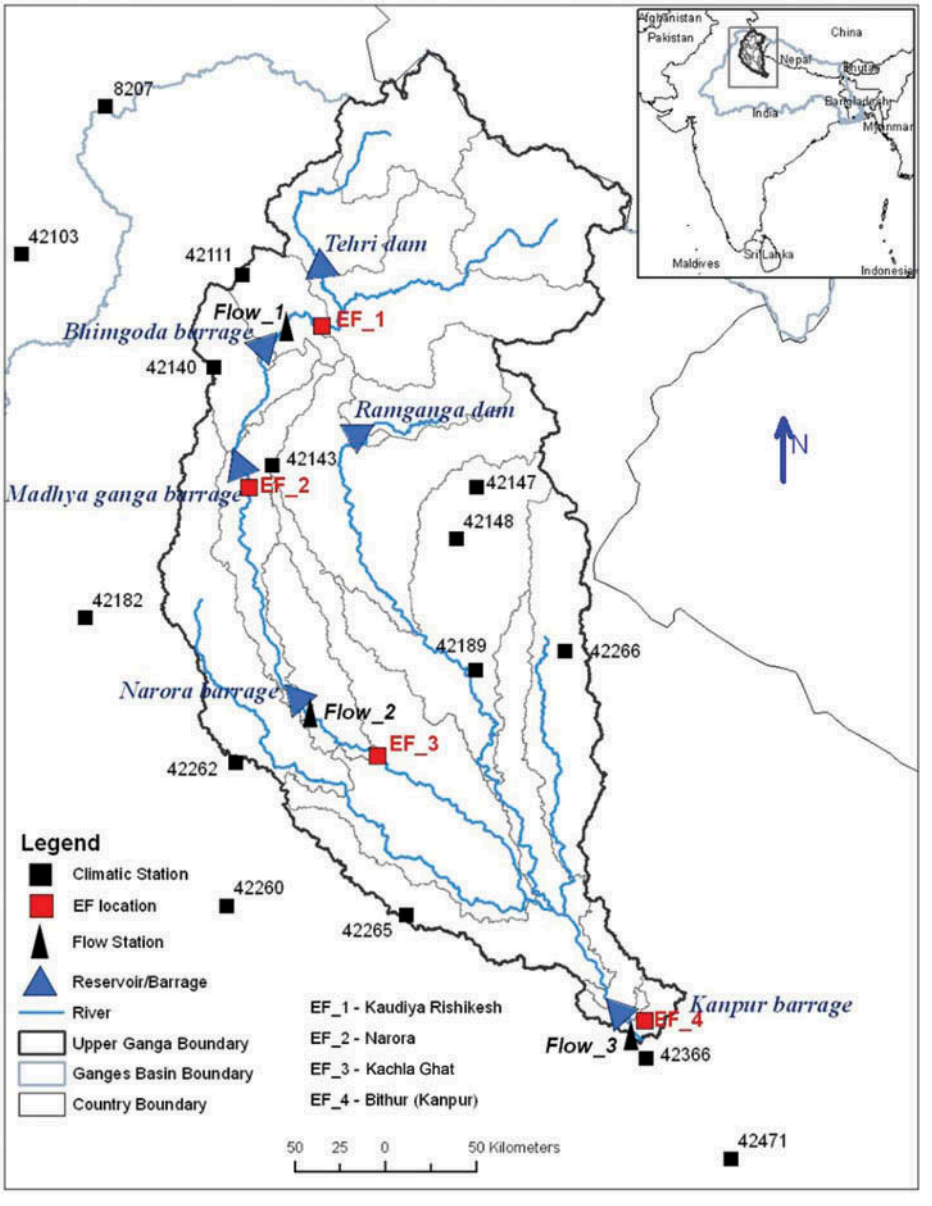

Figure 1. Map of the upper Ganga River basin showing location of barrages, reservoirs, sites used in environmental flow assessment (EF), and observed data points used in the study.

Source: Bharati et al. (2011).

BBM is typically a multidisciplinary process, where individual BBs are defined not only depending on the class or month but also by different specialists for maintaining various ecosystem functions in a predetermined state. All flow requirements are described by each specialist group using various parameters such as water level, width, velocity, depth and wetted perimeter, and justified by formulating specific

motivations for each recommended flow and the implications of not providing these flows. The BBM typically includes the recommendations of specialist groups comprising hydraulics, hydrology, fluvial geomorphology, water quality, riparian vegetation, fish, macro-invertebrates and livelihoods. The cultural (spiritual) flow assessment formed an explicit component and correspondingly an additional specialist group in the UGB EFA process.

Data collection

The assessment of cultural flows demands that the researcher understand the river – its contexts and relationships – from the riparian dwellers' and devotees' point of view. Participatory surveys that unpack these relationships formed the backbone of data acquisition and included participant observation, semi-structured interviews and group interviews. As visitors who were physically present at the sites but did not actually participate in worship, the survey team took on the role of passive participant-observers (Spradley, 1980). Focus group discussions among respondents known to each other allowed collective memory rather than individual memory to be tapped into and enabled information to be gathered about historical flows. One of the most important questions regarded the present and desired flows of the river. For this it was necessary to have the respondents present in front of the river to provide auditory and visual indicators. All work therefore was carried out on the river banks.

The study required the interpretation of opinions and beliefs into precise information regarding the quantity, timing and justification for various flows (BBs) in addition to a historical flow regime. A conversation guide was developed for the use of the survey team. This set of questions (Table 1) gave direction to the interview and provided the survey team with access to a list of desired goals. In addition, the presence of such a guide acts as an interview prop and reassures respondents of the scientific

Table 1. Summary of the conversation guide used during interviews.

Background information	Place of residence
	Whether first time or regular visitor
Cultural and spiritual relevance	Reason for visiting the river
	Significance of the present section
Description of present and desired flow regime	*First-time visitors:*
	What were your expectations of the Ganga?
	Does the current state match those expectations (especially with reference to flows)?
	Regular visitors:
	Please describe the Ganga as you first saw it (especially with reference to flows).
	What are the flow-related changes you have witnessed, and how have they affected your ability to worship or carry out rituals?
	All respondents:
	Are you satisfied with the present state of the river? Why?
	What, according to you, should be the nature of water in the river (quantity of water)?
Reference conditions	*Visitors*: Please share any historical description of the river you may have heard.
	Residents: Please describe the river as you remember it from your childhood.

(and so, non-threatening) nature of the interview while discussing sensitive or politically charged topics (Rubin & Rubin, 1995).

Care was taken that the questions asked during the interviews did not stipulate the parameters used to describe the river but left these to the respondents. This procedure was followed so as not to intimidate respondents by demanding quantities and also to invite statements beyond simple numerical data. In most cases, respondents used landmarks to point out various levels of flow and added stories describing what these flows meant to them.

To obtain information about the present and desired flow regimes, respondents were asked to describe the extent of their satisfaction with the appearance of the river at the time of the interview. Some respondents replied in qualitative terms; others, with specific depths or water levels.

In addition to the desired levels of flow, the conversation guide attempted to define reference conditions for the river from the point of view of the people who depend on it, using their mythologies, histories and expectations. The reference state was thought of as that in which major modifications of the river, whether through the construction of barrages, pollution, or the extraction of large quantities of water, had not yet begun. If they were visitors, respondents were asked to describe the Ganga as they had expected it to look on the basis of descriptions they had heard in folklore or stories, and to describe how closely the reality met these expectations. Residents were asked to describe the Ganga as they had seen it in the past.

The goddess Ganga being all-powerful, there is a belief that her power of conferring salvation will not vary with a decrease in flow. In the words of one respondent, "Even if the river is reduced to the thickness of my little finger, Ganga will still be powerful." To avoid the erroneous conclusion that near-natural flows are not required, respondents were asked to describe the river Ganga as they would like to see it. This exercise allowed the survey team to separate the respondents' need to assert the invulnerable nature of Ganga the goddess from the very real needs of Ganga the river.

A clear distinction cannot always be made between livelihoods and "way of life". For instance, livelihood activities like ferrying and sand-bank farming form an integral part of community life as well as of the landscape. Interviewee responses frequently referred to these and similar practices while describing historical and required flows. The flows required for these traditional activities were recorded and considered in the analysis.

The total number of respondents was 265 (60 in Rishikesh, 105 in Kachla Ghat and 100 in Bithoor). The interviews aimed to capture the diversity of opinions – the views of various stakeholders – rather than what was said most frequently. For example, it was only the boatmen at Bithoor who spoke of the need for a higher velocity to wash away sand deposits in the channel; their responses were recorded. It is important to recognize that while the process of eliciting the opinions, wishes and beliefs of the respondents may be rigorous and to some extent objective, the responses are by their nature subjective. The aim of the analysis was to capture the diversity of the community's beliefs, needs and hopes for the river. In this sense, an EFA is always guided by societal judgements of the desired state of the river; these can be in terms of biodiversity, water quality or channel form, as well as livelihoods, recreational opportunities and cultural or spiritual beliefs. There is therefore no one "right" answer to environmental flows: it depends on the desired balance between the use of the water as a resource and the protection of the river from undesirable degradation.

Purposive sampling was used to select people – farmers, pilgrims, residents and boatmen, among others. An effort was made to maintain a gender balance among respondents. However, because most of the respondents were a part of visiting family

groups, they were isolated, with the male members of the families doing much of the interaction with "outsiders". Even when the women in the team attempted to interview women pilgrims, the male members of the family insisted on speaking "for" the female members. As a result, 80% of our total respondents were male and 20% were female. The difficulty in achieving gender balance could be redressed by the survey team residing at the sections for an extended period of time. This would enable the women in the team to gain admission to social networks where they could interview other women.

The residents and the shopkeepers, people who lived at or close to the site for a significant part of their lives, had observed the river over several years. Accordingly, they had first-hand knowledge of past flows and were able to supply crucial information regarding both historical flow regimes and the impact of various flow levels. The visitors were at the site for a short and planned duration; 44% were at the river for reasons directly connected with the cultural or religious services provided by the river (bathing and religious rituals), while 19% were there for recreational reasons. In many cases they were seeing the river for the first time, but had come to the site with some preconceived notions of how it would be. The visitors' responses provided insights into the desirability of flows and the link between flow levels and satisfaction. The respondent set was nearly equally balanced between residents (46%) and visitors (54%).

All the responses were analyzed and the parameters used most often to describe required flows were tabulated with reasons. Table 2 illustrates this tabulation. The "concern" row refers to the point below which flows were considered unacceptable by the interviewees.

After this compilation, the parameters were marked on the cross-sections for which discharges had previously been determined for various depths of flow. As the levels of the existing landmarks were known, marking the levels of desired flows vis-à-vis these landmarks was a simple task and allowed responses to be converted into flow discharges. The methods for converting depths and water levels to discharges are explained in detail in WWF-India (2012).

Hydrology and hydraulics

Discharge data under natural (or, at the very least, naturalized, non-regulated) conditions are a prerequisite for calculating EF. The Ganga being a transboundary river, discharge data is classified and not made available to organizations or individuals outside the specific government department (Ministry of Water Resources, 2013). For this reason, a

Table 2. Flow-related parameters at low-flow conditions: a summary from the interviews.

Parameter	Rishikesh	Kachla Ghat	Bithoor
Width	Touching the bottom steps	50 m wider than current winter width	n/a
Depth	Approximately 0.5 m at the bottom step of the *ghat*s	Approximately 0.5–1 m at the existing banks	Not less than 0.5 m on the river bed, next to the *ghat*s
Velocity	Current velocity is adequate	Perceivable flow (to carry away flowers, etc.)	Sufficient to carry away flowers, trash, etc.
Concern	Visibility of boulders in the channel (0.5 m above current flow levels)	Water at the existing banks, which is much lower than the acceptable level	No water at the bottom step of the *ghat*s

semi-distributed hydrological model was set up for the UGB in SWAT (Soil and Water Assessment Tool) to simulate the required hydrological time series. SWAT is a process-based continuous model that predicts the impact of land management practices on water, sediment and agricultural chemical yields in complex basins with varying soils, land use and management conditions (Arnold et al., 1998; Srinivasan et al., 1998).

The model used the observed climatic data from 15 meteorological stations scattered unevenly throughout the UGB and was calibrated against the limited daily or monthly observed flow data at three barrages. The calibrated model was then used to simulate "naturalized" flow time series – with all water infrastructure such as dams, barrages and reservoirs "removed" from the UGB – and a flow time series representing the present-day flow regime for each EF site. A detailed description of the modelling process is given in Bharati et al. (2011). The simulated daily flow data for each site were then analyzed to illustrate the EF-relevant elements of the flow regime (Figure 2).

At the EF-setting workshop, various specialists justified their low and high requirements for the driest (January) and wettest (August) months of the year for both normal (maintenance) and drought years. These requirements, formulated in terms of flow-related variables such as depth and width, were converted to discharge values using hydraulic relationships established by the hydraulics group for each EF section. The EF values for intermediate months were then estimated by means of interpolation. That allowed the annual volume of EF as well as annual volumes for maintenance and high flows to be estimated and expressed as a percentage of the simulated reference naturalized flow time series at each EF site.

Results and discussion

Results of the interviews suggest that flows for cultural and spiritual needs are not exclusively based on functional demand. While the amount of water essential to carry out worship, ritual bathing and cremation rites is minimal, dwellers in the hydrological and cultural basin require a healthy river with a reasonable flow regime to satisfy their livelihood requirements and spiritual aspirations. As one respondent emphasized, "The water should be enough to cover a cow's hooves – even this will do. But ideally, it should be up to the waist."

At all three sites, the built environment served as an accurate record-keeper of historical flows. At Rishikesh, the banks are lined with broad steps with intermittent landings, called *ghat*s. The landings of these *ghat*s corresponded to the original winter and monsoon flows. At Bithoor, two temples (Brahmakhunti and Hanuman) marked the high points of the winter and monsoon flows. According to the villagers, the inundation of the idols by the Ganga signified their annual purification.

Agriculturists and ferrymen provided information about the velocity of flow. The information obtained therefore consisted of required flow quantities in terms of depth and width of the river and the nature of flow (velocity and pollution levels). The respondents' definitions of desired flows are summarized in Table 3.

The justification for these demands in many cases is inherently linked to the description of flow. For example, the requirement of a certain depth at the bottom steps of the banks enables ritual bathing. The inundation of certain villages (Parihar, Kachla Gaon) during monsoonal floods was narrated as the Ganga "visiting" these villages. The absence of these floods therefore is seen as abandonment of the villages by the river goddess. Villagers conceded that floods led to a redistribution of land, where some villagers' fields were washed away and others experienced an increase in the land available to them. This

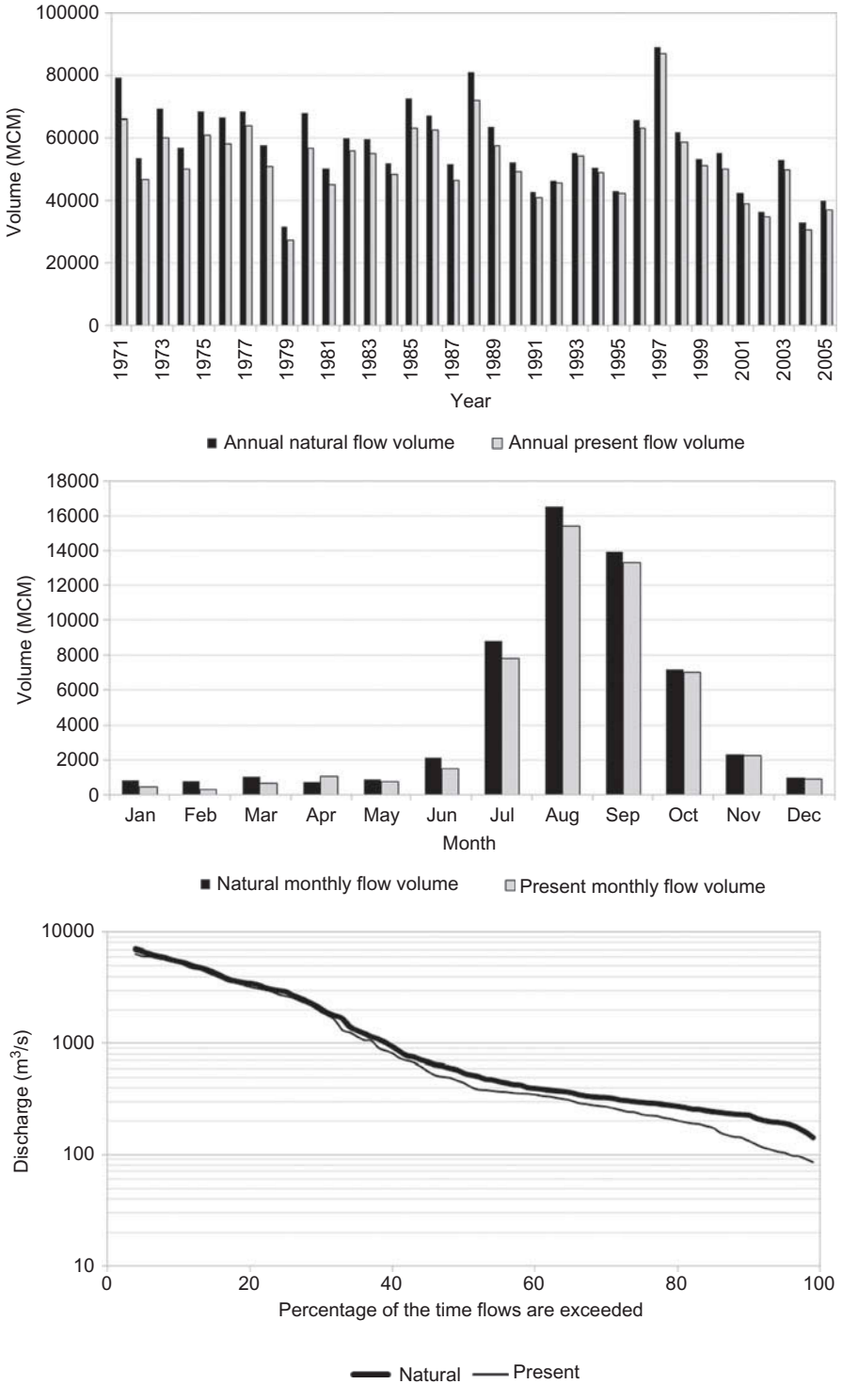

Figure 2. Examples of annual flow totals (top), average monthly flow distribution (middle) and flow duration curves (bottom). 'Natural' flows are those that would have been available in the absence of all river modification (infrastructure, withdrawals).

Table 3. Perception of desired flows with justification.

	Rishikesh	Kachla Ghat	Bithoor
Banks: *quantification*	At least waist-deep at the steps of the banks	At least waist-deep 4 to 5 feet from the water's edge	At least waist-deep at the steps of the banks
Banks: *justification*	At all the sites, this depth allows worshippers to bathe as per the stipulated procedure, which is to submerge oneself completely in the water three times.		
River channel: *quantification*	Boulders should not be visible	As deep as oars are long (15 feet)	At least deep enough to ply a boat (10 feet)
River channel: *justification*	If the boulders are visible, it reduces the satisfaction that visitors get when they look at the river. Satisfying the condition at the banks automatically satisfies this condition as well.	This is the historical depth, according to the boatmen.	This enables the boatmen to ply their boats with ease.
Flow velocity: *description*	Currently adequate	Enough for land-forming and carrying away sand	Enough for land-forming and carrying away sand
Flow velocity: *justification*	This velocity is sufficient to carry away the flowers, etc., used during worship.	The velocity of the water should be sufficient to carry away sand particles. Currently, sediment is accumulated on the steps (impeding access to the river) and in the channels (making the river impossible to navigate).	
Water pollution: *description*	No sewage or solid waste in the water	Transparent, odourless water	Transparent, non-stagnant water
Water pollution: *justification*	*Aachman*, the ceremonial imbibing of Ganga water, is a crucial part of worship. Water should be of a quality that allows the pilgrim to bathe in it without revulsion.		
Biodiversity: *description*	Habitable for fish	Turtles to return	Habitable for fish
Biodiversity: *justification*	This site is home to a captive population of golden trout. Feeding them is an important part of a visit to the area, and locals take considerable pride and pleasure in this population.	Turtles are scavengers, and useful for eating partially decomposed corpses. Without the turtles they are difficult to dispose of and the remains cause distress and revulsion to pilgrims.	The site originally supported several types of fish. These were not only culturally important but also a component of the residents' diet. Their disappearance led to decreased nourishment. Locals also miss the experience of feeding the fish.
Seasonal floods: *description*	Currently low, but not a source of concern	Floods up to the Ganga temple	Floods up to Parihar Village
Seasonal floods: *justification*	Floods scour the steps on the banks of any accumulated sediment.	While the respondents acknowledged the importance of floods for clearing the channel and the banks of accumulated sediment, it is equally important that the floodwaters reach the areas mentioned above. This is seen as an annual blessing of the temple and the village. Failure to do so is seen as abandonment.	

caused them to renegotiate the sharing of land, which often favoured the farmers with greater influence thanks to their wealth or caste. Despite this, the floods were still considered a welcome event, and all inconveniences were squarely attributed to villagers, not to the river.

EF 1 for the cultural surveys was located at Rishikesh, a major site of pilgrimage. The desired flow levels as obtained from the respondents are illustrated in Figure 3.

EF levels for high and low flows in maintenance and drought years for Kachla Ghat (EF 2) and Bithoor (EF 3) are illustrated in Figures 4 and 5, respectively. In addition, the flow levels for one year (maintenance or drought) are also illustrated in a view of the river banks.

These levels for all three sites were pointed out by the people interviewed. Because the choice of parameters for describing flows (discharges, flow levels and so on) was left to the interviewees, they often used the riverbanks to point out flow levels.

Table 4 summarizes the flow requirements of the respondents and the corresponding discharge values. The respondents' requirements are reported in terms of depth and width. The discharge and velocities are calculated using the hydraulic relationships established for each cross-section, as described in the section "Hydrology and hydraulics". The cultural flow requirements for different sites for maintenance years vary between 35% and 65% of the natural flows in the monsoon (August), and between 18% and 77% of natural flows in winter (January) (Figure 6).

This work was done despite the lack of measured flow data. Although this reduces the confidence of the discharge estimates, the cultural flow requirements, articulated in terms of river widths and depths, are valid. The resulting discharges may be reviewed as hydrological data becomes available.

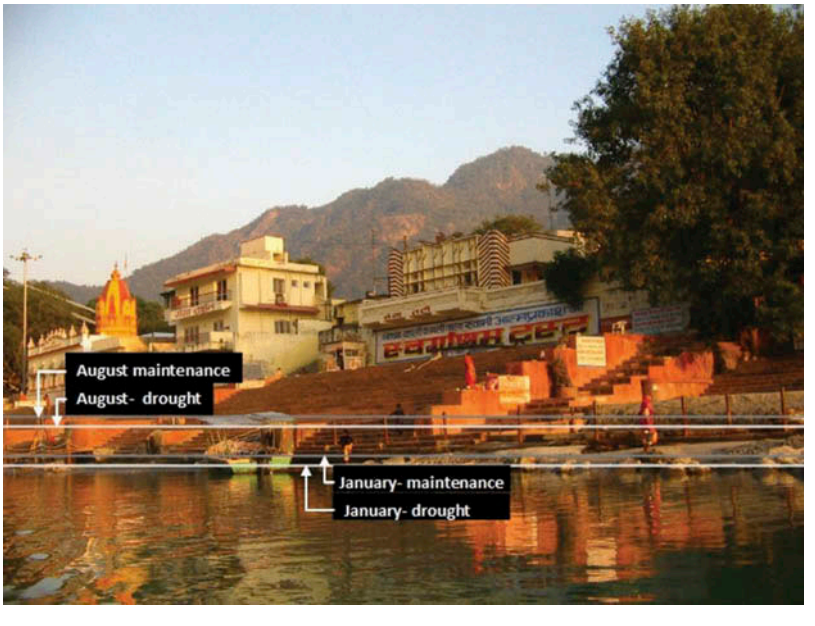

Figure 3. Culturally desired flows at Rishikesh (EF 1) for maintenance and drought years, located on a photo of the site showing the right bank.

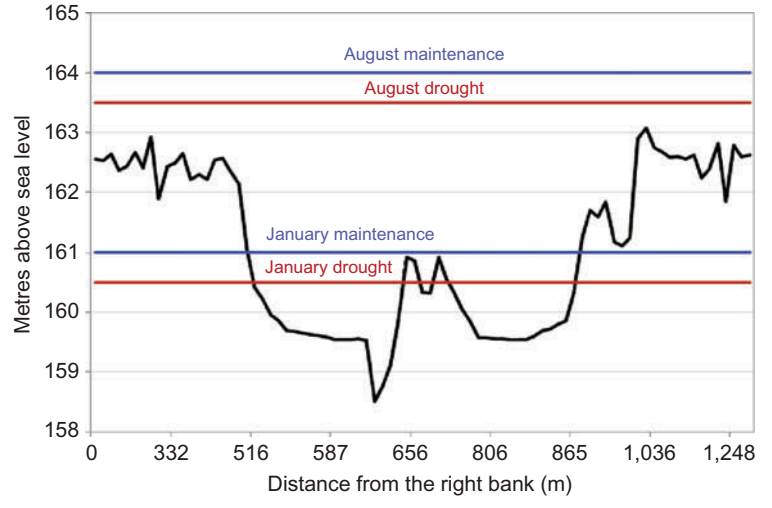

Figure 4. Culturally desired flows at Kachla Ghat (EF 2). The graph shows levels for maintenance and drought years at the cross-section. The plate shows levels for maintenance years with respect to the left bank.

During the environmental flow assessment, two different teams assessed the flow requirements of the riparian communities, with one team studying requirements for livelihoods and the other studying requirements for culture. This paper presents the findings of the "culture" team. However, it was repeatedly illustrated that the two cannot always be separated; cultural rituals are woven into livelihood patterns. An excellent example of this interweaving of "religious" rituals with livelihoods is the "water temples" of Bali. Here, the temples provide the structure for region-wide management of agriculture; the festivals organized there govern planting dates, irrigation, conflict resolution and pest control (Lansing, 1987). While the temples along the banks of the Ganga do not directly manage the regional planting calendar, they serve as "markers" for flow records. Festivals such as Kumbh Mela where devotees indulge in a ceremonial bath focus attention on flows in the river. Given that culture does not imply only religion but the whole bouquet of activities and beliefs that define a community, it is important that livelihoods are considered as part of the cultural identity.

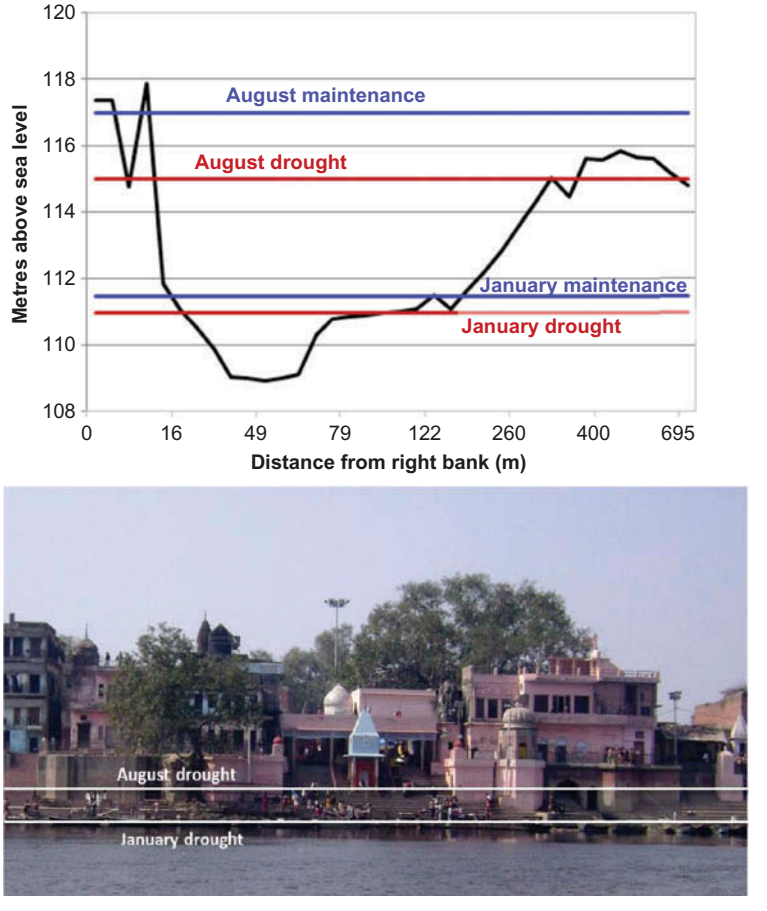

Figure 5. Culturally desired flows at Bithoor (EF 3). The graph shows levels for maintenance and drought years at the cross-section. The plate shows levels for drought years with respect to the right bank.

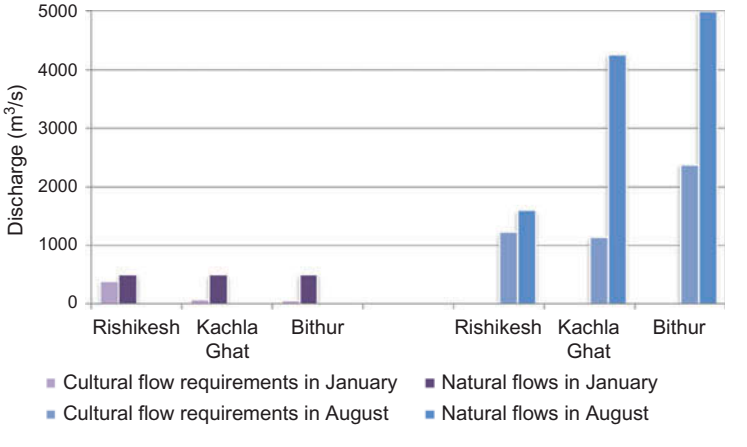

Figure 6. Cultural flow requirements vs. naturalized flows at EF sites for maintenance years.

Table 4. Summary of cultural flow requirements obtained by correlating respondents' requirements for depth and width to the corresponding calculated discharge and velocity for each section.

	Monsoon flows				Winter flows			
	Depth	Width	Velocity (m/s)	Discharge (m^3/s)	Depth	Width (m)	Velocity (m/s)	Discharge (m^3/s)
Maintenance year								
Rishikesh	3–3.5 m above bottom step of *ghat*s	~197 m	~1.6	1355	0.5 m at bottom steps of *ghat*s	~188	~1.5	386
Kachla Ghat	6 m above deepest part of channel (162 m asl)	~1000 m	~0.30	1740	1 m above level at time of survey (161 m asl)	~150	0.25–0.3	90.73
Bithoor	To the village of Parihar (117 m asl)	To the village of Parihar (~4 km away)	~1.2	3303	1 m at bottom steps of *ghat*s (111.5 m asl)	n/a	~0.70	98.78
Drought year								
Rishikesh	2–2.5 m above bottom step of *ghat*s	~195 m	~1.5	1055	Barely touching bottom steps of *ghat*s	~186	<1.5	~350
Kachla Ghat	5.5 m above deepest part of channel (161.5 m asl)	~800 m	~0.30	551	0.5 m above level at time of survey (160.5 m asl)	120–130	~0.22–0.25	39.62
Bithoor	To the level of the Brahmakhunti Temple (115 m asl)	n/a	~1.5	1469	0.5 m at bottom steps of *ghat*s (111 m asl)	n/a	~0.65	15–18

Note: At Bithoor, the reach at the *ghat*s is the prime criterion. The width varies considerably with sedimentation and land use.

Conclusions

So far, cultural requirements have not been explicitly considered in environmental flow assessment, though attempts have been made to acknowledge indigenous recommendations, especially in Australia and Central America, where aboriginal beliefs have been considered while planning for management of landscapes (Maffi, 2007). This paper documents the first attempt to quantify cultural flow requirements as part of a multidisciplinary EFA.

This cultural study was part of a much broader assessment of flow requirements with respect to restoring the natural riverine biota and riparian and floodplain vegetation, maintaining the channel morphology of the river and improving water quality. One of the very interesting outcomes was that the flows favoured by the participants in the cultural survey generally matched very closely those required for the maintenance of the biota and natural processes. For example, the dry-season depth range in which the endemic Ganga river dolphins are found in the river upstream of Narora Barrage (where healthy flows are maintained) was between 1.4 to 3.7 m, and the dry-season flows desired by bathers at Kachla Ghat (where present dry-season flows provide maximum depths often less than 0.5 metres) implied a maximum depth of 2.6 metres in that river reach (WWF-India, 2012). This concurrence of ecological and cultural requirements provides excellent support for the flows recommended by the specialist teams in that they will achieve multiple use objectives for the river.

This first attempt to quantify modified flows in the Ganga that will provide conditions desired by many of the river's users asks as many questions as it answers. How important is flow to the religious perceptions of the Ganga? How diverse are the perceptions of the different communities of users, and of occasional visitors compared to riparian dwellers? How would the implementation of cultural, spiritual and ecological flow requirements impact on economic requirements, e.g. with respect to irrigation water, and how will society judge their relative importance? This study, aimed at a pragmatic conversion of cultural and spiritual beliefs and opinions into a required water volume, has uncovered a cross-section of views. A more comprehensive study would be required regarding water in its physical/material form, symbolic meanings, cultural practices and rituals, as well as its economic value, to answer the above questions. However, when presented the findings of WWF-India (2012), the government of Uttar Pradesh did agree to allocate an additional 200–300 m^3/s for the two-month duration of the Kumbh religious festival from January to March 2013. In the event, unseasonal rainfall provided most of this additional flow naturally.

The Ganga, along with several other rivers in the subcontinent, is under threat. Peoples' movements to save "their" river, as well as governmental development plans, are frequently stuck in an impasse of positional bargaining. The disconnect between policy makers and riparian dwellers is intensified by the lack of an adequate tool to fairly and objectively determine water requirements. The process of quantifying community requirements for in-stream flows demonstrated in this paper may provide these two groups with a common language and a starting-point for further negotiations.

Acknowledgement

The financial support for this study came from WWF-India under its Living Ganga Programme (sponsored by HSBC). Ms Mabel Gergan, Dr Anil Gautam and Mr Akshay Das, colleagues from the People's Science Institute, assisted in the survey. Ms Gergan, now a Ph.D. student at the University of North Carolina, Chapel Hill, carried out the quantitative analysis of the surveys in this study. The rated cross-sections were provided by Integrated Natural Resource Management Consultants Pvt. Ltd, New Delhi, India. Many thanks to the anonymous reviewer for a careful analysis of the original manuscript and for many useful suggestions and information.

References

Acreman, M. C., & And Dunbar, M. J. (2004). Defining environmental flow requirements – A review. *Hydrology and Earth System Sciences, 5*, 861–876.

Arnold, J. G., Srinivasan, P., Muttiah, R. S., & Williams, J. R. (1998). Large area hydrologic modelling and assessment. Part I. Model development. *Journal of the American Water Resources Association, 34*, 73–89.

Bharati, L., Lacombe, G., Gurung, P., Jayakody, P., Hoanh, C. T., & Smakhtin, V. (2011). *The impacts of water infrastructure and climate change on the hydrology of the Upper Ganges River Basin, IWMI Research Report 142* (44 pp.). Colombo, Sri Lanka: International Water Management Institute.

Census Of India. (2001). Government of India. Retrieved from http://censusindia.gov.in/2011-common/censusdataonline.html

Croll, E., & Parkin, D. (1992). Anthropology, the environment and development. In E. Croll & D. Parkin (Eds.), *Bush base: Forest farm* (pp. 3–10). London: Routledge.

Eck, D. (2003). The goddess Ganges in Hindu sacred geography. In A. Bavishkar (Ed.), *Waterlines* (pp. 28–49). New Delhi: Penguin Books.

Jackson, S. (2008). Recognition of indigenous interests in Australian water management, with particular reference to environmental flow assessment. *Geography Compass, 2/3*, 874–898.

King, J., Tharme, R., & Villiers, D. E. (2000). *Environmental flow assessments for rivers: Manual for the building block methodology*. Water Research Commission Report No.TT131/00.

Kumar, S. V. (1983). *The Paurāṇic lore of holy water-places: With special reference to SkandaPurāṇa*. New Delhi: Munshiram Manoharlal.

Lansing, S. J. (1987). Balinese "water temples" and the management of irrigation. *American Anthropologist New Series, 89*(2), 326–341.

Maffi, L. (2007). Bio-cultural diversity for endogenous development: Lessons from research, policy and on-the-ground experiences. Paper presented at *Conference on Endogenous development and bio-cultural diversity: The interplay of worldviews, globalization, and locality,* Geneva, October 2006, 56–66.

Ministry of Water Resources. (2013). *Draft Hydro-meteorological data dissemination policy*. Government of India.

Poff, N. L., Allan, J. D., Bain, M. B., Karr, J. R., Presetegaard, K. L., Richter, B. D., Sparks, R. E., & Stromberg, J. C. (1997). The natural flow regime: A paradigm for river conservation and restoration. *BioScience*, *47*(11), 769–784.

Rubin, H. J., & Rubin, I. S. (1995). *Qualitative interviewing: The art of hearing data*. London: Sage.

Sharma, B. R., Amarshinghe, U. A., & Sikka, A. (2008). *Indo Gangetic river basins: Summary situation analysis.* Delhi, India: International Water Management Institute.

Spradley, J. P. (1980). *Participant Observation*. Fort Worth, Philadelphia: Harcourt Brace College Publishers.

Srinivasan, R., Ramanarayanan, T. S., Arnold, J. G., & Bednarz, S. T. (1998). Large area hydrological modeling and assessment. Part II: Model application. *Journal of the American Water Resources Association*, *34*(1), 91–101.

Verschuuren, B. (2006). *An overview of cultural and spiritual values in ecosystem management and conservation strategies*. The Netherlands: Foundation for Sustainable Development.

Wolf, A. T. (2012). Spiritual understandings of conflict and transformation and their contribution to water dialogue. *Water Policy, 14*(S1), 73–88. doi:10.2166/wp.2012.010

WWF-India. (2011). For a living Ganga - Working with people and aquatic species. WWF India. Retrieved November 28, 2013 from http://www.wwfindia.org/?6582/FOR-A-LIVING-GANGA–Working-with-people-and-aquatic-species

WWF-India. (2012). Assessment of environmental flows for the Upper Ganga Basin. Report published by WWF-India. (161 pp.).