Leonardo lecture

Is hydrology a natural science?

Pieter van der Zaag

Dept. of Integrated Water Systems and Governance, UNESCO-IHE, Delft, Netherlands
Water Resources section, Delft University of Technology, Delft, The Netherlands

Is hydrology a natural science?

Introduction

1. Socio-hydrology
2. Hydrology serving and shaping society
3. Coupled human-water systems – Africa
4. Towards a new (reflexive?) hydrology
Is hydrology a natural science?

Defining hydrology

“tracing and explaining the processes and phenomena of the hydrologic cycle, or the course of natural circulation of water in, on and over the Earth's surface”

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1 Socio-hydrology

HYDROLOGICAL PROCESSES

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Socio-hydrology: A new science of people and water

Murugesu Sivapalan,¹, ²* Hubert H. G. Savenije³ and Günter Blöschl⁴

¹ Department of Civil and Environmental Engineering, Department of Geography, University of Illinois at Urbana-Champaign, Urbana, IL 61801, USA
² Department of Civil and Environmental Engineering, University of Technology Sydney, Broadway, NSW 2007, Australia
³ Department of Water Management, Faculty of Civil Engineering and

Humans have changed the way the world works. Now they have to change the way they think about it, too. The Economist, May 26, 2011

THE COUPLED HUMAN-WATER SYSTEM

Dateline November 2010, Murrumbidgee River Basin, Australia: Irrigators are up in arms over proposed government plans to cut their water allocations and return flows back to the basin’s rivers to support the environment and restore lost biodiversity. The Australian of November 04, 2010 reported on the community backlash, including the resort to ‘book burning’ to highlight their plight. Community backlash and ‘book burning’ notwithstanding, the reality is that this conflict had been brewing for decades. Now, wind back the clock 100 years to the early 20th century. Up
1 Socio-hydrology

aims at "understanding the dynamics and co-evolution of coupled human-water systems”

"socio-hydrology treats people as endogenous of the water cycle"

(Sivapalan et al., 2012)

• I find the above propositions interesting but also problematic
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1 Socio-hydrology

aims at “understanding the dynamics and co-evolution of coupled human-water systems”

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• I find the above propositions interesting but also problematic
• Seems to imply that hydrology has not been integral part of society
• Socio-hydrology should make explicit the role of hydrological knowledge and hydrological consciousness in society.
• Socio-hydrology vs. “Hydro-sociology” – how to bring these together
• My own interest: I now see a possibility to contribute to hydrology, as I have studied coupled human-water systems
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2 Hydrology serving and shaping society

Nilometer (3000? BC - 1000 AD)
Hero of Alexandria ("the first engineer“) (c. 10–70 AD)
Antoine Chézy (1718-1798)
Gaspard Darcy (1803-1858)
S.B. Hooghoudt (1901-1953)
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Nilometer (3000? BC - 1000 AD)

These first river gauges were used to plan the start of the irrigation season, and to tax the irrigators.

These Nilometers thus served the status quo.
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Hero of Alexandria ("the first engineer")
(c. 10–70 AD)

measured the discharge of a spring correctly for the first time

this information was important for the design of water works and the supply of water to the city of Alexandria

he also wrote about the discharge of syphons used for irrigating lands bordering the desert

(Biswa, 1970: 87-88)
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Antoine Chézy (1718-1798) needed to design a new canal to bring additional water to Paris, and developed a formula to calculate discharge

(Biswas 1970, p. 262-267)
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Gaspard Darcy (1803-1858)

in his 1856 report on the water supply system of Dyon described in quantitative terms the purification of water by filtration through sand and developed an equation that is considered the theoretical foundation of groundwater hydrology

(Biswas 1970, p. 308)
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The Netherlands

In 1857 the General Royal Agricultural Association in The Netherlands called for a competition whereby a reward would be given to the person who could design a sub-surface drainage system for agricultural lands based on scientific rules in the most effective manner.

The absence of an adequate groundwater flow theory that could model Dutch circumstances was considered problematic.

Apparently no satisfactory solution was submitted

(De Vries, 1982: 18-19)
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S.B. Hooghoudt (1901-1953)

published in 1940 a formula to calculate the spacing of and size of underground drainage pipes for a two-layered soil profile with different permeability.

Fig. 32. Dwarsdoorsnede door drains bij een twee-lagen situatie (volgens Hoogh 1940).

\[ NL^2 = 8 k_2 d (h_1 - h_0) + 4 k_1 (h_1^2 - h_0^2). \]

(De Vries, 1982, p. 92 & 86)
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S.B. Hooghoudt (1901-1953)
Conclusion: hydrology has been instrumental in shaping society. This knowledge helped to transform the landscape – and thus also the very hydrology it had helped to describe and analyse.

The history of hydrological research describes "how the human "art" calls upon "nature", which it has violated, for assistance to mitigate the consequences” (R. Hooykaas in De Vries, 1982, p.ii)

This in fact describes an active process of co-evolution between society and hydrology.
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3 Coupled human-water systems - Africa

Coupled human-water systems have fundamentally changed the hydrology, even in Africa!

- Zambezi: a modified flow regime
- Incomati: what is the natural hydrology
- Lake Victoria: controversy over declining lake levels
- Makanya, Tanzania: hydrograph reveals institutions
- Basse Casamance, Senegal: ricepolders
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Zambezi
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Zambezi

A completely modified flow regime

Monthly average discharge at Tete, Mozambique (Source: Ronco et al., 2010)
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Incomati
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Incomati

**Discharge (Mm³/month)**

- Oct 1952 - Sep 1979 (average 2,297 Mm³/a)
- Oct 1979 - Sep 1999 (average 950 Mm³/a)

**Discharge (M³³/month)**

- 2 yrs return period (1957-1980)
- 2 yrs return period (1980-2001)
- 5 yrs return period (1957-1980)
- 5 yrs return period (1980-2001)
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Saraiva-Okello et al., 2012

Incomati

What is the natural hydrology?
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Lake Victoria
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Lake Victoria

Lake Victoria annual, 1900-1999

Source: Conway, 2005
Lake Victoria

Owen Falls (Nalubaale) Dam (1954; 200 MW)

Kiira Dam (2000; 180 MW)

The “Agreed Curve”

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(Source: Sutcliffe and Petersen, 2007)

Modifications to the “Agreed Curve”

(LVBCS, 2012)
Lake Victoria

Water balance 1950-2000 (km$^3$/yr)

- Surface area: 67,000 km$^2$
- Volume: 2,750 km$^3$

Source: adapted from LVEMP I Hydrology and Meteorology Report (2005)
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Lake Victoria

Water balance 1950-2000 (km³/yr)

Uncertainties create room for different explanations and transboundary tensions.
Irrigation canals in the Pangani basin, Tanzania

Source: PWBO/IUCN, 2008

Enfors & Gordon, 2008

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Makanya

Enfors & Gordon, 2008
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Evidence of the presence of a river institution

Komakech et al., 2012

Mul et al., 2010
Rice polders in Basse Casamance
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A sophisticated coupled system!
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4 Towards a new (reflexive?) hydrology (i)

Everywhere and throughout history we have with limited knowledge intervened in the water cycle. As a consequence societies could develop. But nature always “talks back”, requiring us to refine our water knowledge and adjust our interventions.

Water management is dialectic, “in which each successful response gives rise to new challenges” (Briscoe, 2010)

This dynamic may be a kind of "double hermeneutics": “The ‘findings’ of the ... sciences (may) ... enter constitutively into the world they describe” (Giddens, 1987: 20).

Active feedbacks and increasing levels of self-consciousness are thus an essential feature of the anthropocene.
4 Towards a new (reflexive?) hydrology (ii)

A new hydrology:
- coupled systems co-evolve
- describes and analyses how water knowledge is created and used by humans
- how it informs policies but also the behaviour of individuals
- feedbacks to the water system and the hydrology

Optimality: in coupled human-water systems optimality may be a normative concept, difficult to “universalise”, and raising ethical issues

Co-evolution: in coupled human-water systems co-evolution leads to increased awareness among humans of their interdependence;
- co-evolution implies learning
- an enhanced understanding of risk (cf. risk society, Ulrich Beck)
4 Towards a new (reflexive?) hydrology (iii)

We need social science concepts to enrich this new hydrology, and we need hydrological concepts to enrich sociology and human geography.

Possible starting points to overcome the rift between the natural and social sciences:

- to attribute (or allow) agency not only to humans but also to non-humans, i.e. the concept of symmetry (Latour)
- to accept that coupled human-water systems consist of tangible and intangible elements that interact
- to postulate a political/normative objective, e.g. to strive for sustainable and socially acceptable water systems
- to embrace an empirical approach and “action research”
4 Towards a new (reflexive?) hydrology (iv)

Priority research agenda for the new hydrology:

- Densely populated floodplains
- Peri-urban / slum areas
- Spatial epidemiology of waterborne pathogens (A. Rinaldo)
- ..
- ..
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So is hydrology a natural science?

Yes, just as natural as we humans are!
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"Remember when you speak about water to show first the experience and then the interpretation"

Leonardo Da Vinci

(ca. 1500, Codex Paris H, cited in Pfister et al., 2009, p.17)