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The Israeli-Palestinian Water Distribution Revisited: Can Hydro-Entropy be a Useful Tool to Understand The Complexity of Hydropolitics?

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Against the background of a failed Kerry peace initiative, severe militarization of the Gaza conflict in the summer of 2014 and an overall rise of tensions in the region and between superpowers, the question is posed if and how existing and new tools can help in fostering future water negotiations between Palestine and Israel. We reflect on the narrative using a number of concepts. The Transboundary Waters Interaction NexuS (TWINS) which combines factors of cooperation and conflict and hydro-politics is applied to describe the interdependency of the political context, water governance and discourse in the case. In addition, we introduce the concept of *hydro-entropy* and illustrate it for the Israel-Palestine case as part of the theories of water governance and management. Hydro-entropy can be regarded as an information tool to indicate the level of chaos and order of a water governance system and its natural counterpart, the water system. Hydro-entropy is described in four domains: physical-chemical, information systems, social sciences and philosophy. By using insights from *hydro-entropy, hydrolectics, hydro-psychology* and *socio-hydrology*, an approach such as TWINS can become even more illustrative and useful for the parties involved in water negotiations. This positive effect is explained by the fact that these concepts and the TWINS-approach all draw on speech act theory.

Keywords: Palestine – Israel water case, chaos and order, hydro-entropy, hydrolectics, hydropolitics, water governance, water management.

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1. Introductory reflection on anarchy, chaos and water governance

Water as a natural phenomenon creates chaos and order, anarchy and efficient governance processes.[1] The same river and sea that bring prosperity on a long term average have devastating effects almost instantaneously once natural forces of floods outweigh human capacities. At the other extreme end of the spectrum, prolonged droughts destabilize societies. The positive offspring of such calamities is that at least they tend to rapidly put issues high on the political agenda. Examples are numerous: the Dutch Delta works, a multi-billion project consisting of innovative and large dams, were constructed after a storm surge in 1953 which resulted in almost 2000 casualties and great economic damage; a flood forecasting system was installed along the Indian Ocean after the 2004 Indonesia tsunami that caused almost 200,000 casualties. The drought of 2012 in the USA caused former Secretary of State Hillary Clinton to talk about the relation between politics, economics and water management in times of uncertainty. She did not only politicize water but also 'securitized' the resource (Buzan, Waever, & Wilde de, 1998) and called special attention to natural buffers in the form of non-renewable groundwater reservoirs (see Box 1).

Water has become more and more of a political issue since the 1980s and '90s, not only at the national levels but also on the international agendas. The Dublin Principles of 1992 were the result of the work of experts but they caused intensive political debates continuing to date on the question if water can be considered an economic good or if water is a resource to which everyone has a basic right of access. The latter principle was approved by the United Nations in 2010. To harmonize water management internationally a number of international conventions have been developed, such as the UN Non-navigational

Box 1. The politicization and securitization of water

(quote from http://www.csmonitor.com/USA/2012/0719/US-drought-how-it-could-impact-food-water-needs-around-the-world/(page)/2)

The United States needs to come to terms with the changing terrain of water, "and fast," says Christiana Peppard, assistant professor of theology and science at Fordham University in New York. Not just because, as Secretary of State Hillary Rodham Clinton remarked on World Water Day 2012, "water is integral for well-being and can even pose a national security threat", she notes via email, but because facing drought as "the new normal" means that the nation will have to rethink the way it conducts – and incentivizes – its agriculture. It's not just the corn crops that might fail this year, she points out. The Ogallala Aquifer, which undergirds much of the corn belt of the United States and extends from Nebraska into Texas, has long been a primary source of water for large-scale agriculture. "We've fed many, and offloaded many petrochemicals downstream. And where has that water for agriculture come from? It has often come from the Ogallala Aquifer, a source of groundwater that is non-renewable on any humanly meaningful time scale," she notes.

[1] Chaos stems from the Greek word Khaos, meaning a natural 'gaping void'. The term anarchy or anarchism derives from the Greek word anarchos, meaning "without rule(rs)".

Use of Watercourses Convention of 1997 and in Europe the Water Framework Directive (2000/60/EC).

The formulation of these conventions and directives, their implementation and non-implementation and adaptation by existing and new institutions is a lengthy water governance process. The central question in water governance research is how the chain of institutions and rules from macro to micro level affects the daily flow of water and its use by all stakeholders involved: are institutions and rules contributing to optimization of water use, or are they creating non-optimal solutions that stimulate anarchy and new institutions? Or is the reality of water management best considered to be a combination of non-optimal and optimal solutions governed by complicated feedback mechanisms as between the river and its bed? A second even more fundamental question in water governance research, maybe equally or even more important, is how water and the image that water governance practitioners and scientists have of water influences this process. We argue that these two types of interdependencies are influenced to an important degree by small or large chaotic unexpected events caused by complexity and uncertainty, either calamities or positive surprises, in other words: both chaotic and ordered processes need to be taken seriously in water governance studies.

In this contribution, we aim at a deeper understanding of the principles of chaotic and ordered processes in water governance by analyzing the practical case of water resources shared by Israel and Palestine and exploring the added value of introducing the concept of hydro-entropy.[2] This added value can be a new frame which enables the search of negotiating parties for new windows of opportunities to reach agreement on the use of shared water resources. The need for new framing mechanism originates from at least four actual discourses relevant for the Israeli – Palestinian water case:

1. The notion that modern water governance is anarchy by other means like diplomacy is war by other means (Wegerich, Warner, & Tortajada, 2014);
2. Critical reflections on the concept of hydro-hegemony and the functioning of the scientific community studying the concept (Farnum, 2014; Zeitoun et al., 2014);
3. The integrative hydrological research framework Panta Rhei which focuses on the concept of change in hydrology and water management from a combined natural and social sciences perspective (Montanari et al., 2013). Models that combine human agency as actor-networks and hydrological conditions can reasonably well explain and simulate past developments in irrigation systems. However for the application of such models in modern water governance better scientific strategies and software is needed (Ertsen, Murphy, Purdue, & Zhu, 2014).
4. Diplomatic negotiations between states will only be successful if distrust is compensated by an international framework of rules. The process and the structure of negotiations relate to each other as the river and its bed in a multi-faceted manner that needs situational understanding and can never rely on models only. Nevertheless,

[2] Hydro-entropy is here used as a measure for the level of chaos and order of a water governance system and its natural counterpart, the water system.

diplomatic negotiation can be taken as a ceaseless series of attempt to bring order to the international system (Meerts, 2014).

The common background of these discourses is the acknowledgment that acting frameworks for (water) negotiations and scientific models are not sufficiently capable in describing chaotic processes governing day to day reality because they overestimate the importance of order. Including disorder or anarchy in the discourse itself without creating a Gordian knot is a challenging method to be tested.

We will use an inductive and narrating method. First, we will briefly describe the water resources at stake between Palestine and Israel and the history of its use. Due to the regional context of politicization and securitization this brings us inevitably to the concept of hydropolitics and its underlying speech act theory.[3] We will link speech act theory to hydrolectical thinking[4] and the ideas of hydro-psychology and socio-hydrology[5] and search for practical merits of these combinations for the practical case.

We aim at integrating different concepts and argue that non-linear and intuitive trajectories of thought and paradoxical interventions might be as productive as other members of the family of expressions; the article contains components of order and chaos representing daily water practices and resembles a real-life brainstorm in the form of an essay, rather than a scholarly exposé, and can best be regarded as an attempt to address issues and produce knowledge to set agendas for further research. This research can be part of the cooperation between the Israeli and Palestinian parties. We deliberately zoom out to a wide spectrum of scientific developments which are instrumental for zooming in at the applicability of the entropy concept in the Palestine - Israel water conflict. The article aims at contributing to the desecuritization of the water issue making use and contributing to windows of change presented by the overall socio-economic and political context without forgetting the major limitations posed by the same context. We suggest the need for restructuring and rethinking the Israeli-Palestinian water 'cooperation and conflict' language and deeds from a hydro-entropic and socio-hydrological point of view, and the need for further research on relations of information domination and sharing, and on its practical translation into creative cooperation and conflict which interacts with the (inter) national politics of water. By doing so, we suggest the widening of the scope of discussions and research and go beyond the reality of the functioning of the Palestinian-Israeli Joint Water Committee as recently presented by Selby (Selby, 2013). Selby concludes his

[3] Speech act theory describes the interrelationship between language and deeds (Austin, 1962).

[4] Hydrolectics is an approach under development that aims to describe the dialectic relation between the physical water cycle and its linguistic and social meaning: the perception of the water cycle is as important as the water cycle itself (Linton, 2010).

[5] Hydro-psychology is described as the study of interactions between human behaviour and water-related activities in a two-directional manner (Sivakumar, 2011; Sivakumar, 2014)). Socio-hydrology is defined as a use-inspired scientific discipline with a focus on the understanding, interpretation, and scenario development of the flows and stocks in the human-modified water cycle at multiple scales, with explicit inclusion of the two-way feedbacks between human and water systems (Sivapalan, Savenije, & Blöschl, 2012; Sivapalan et al., 2014).

paper by suggesting "the need for both the complete restructuring of Israeli-Palestinian water 'cooperation', and for further research on relations of domination, and the ideology of cooperation, within international (water) politics". Plans for restructuring the actual mode of cooperation on water between Palestine and Israel are being developed (http://www.geneva-accord.org; Brooks & Trottier, 2014) often with the basic notion in mind tha water management should be part of confidence building measures (CBM) (Bzostek & Rogers, 2014). We propose to develop new frameworks for such research using information and knowledge concepts like our discourse on hydro-(neg)entropy.[6]

2. The history of the Israel-Palestine water issues

2.1. Physical and social driving forces in the Israel-Palestine water case

The natural water system in Israel and Palestine is dominated by the following sources of energy and water:

1. A large height difference (1,000 – 2,000 m) between the mountainous areas north of the two states and the Dead Sea causes a relatively fast north-south flowing surface water system dominated by the Jordan River. The groundwater systems underlying these areas show very low flow rates but not to be neglected flow volumes and provides the base flow of the rivers in the area including the Jordan River.
2. The hilly to mountainous area between the coastal plain of the Mediterranean Sea and the Jordan Valley causes two rapid surface water flow systems, one mainly flowing to the west and northwest, towards the Mediterranean Sea, the other to the east to the Dead Sea. The height difference to the west varies from 400 to 900 m, to the east from 800 to 1,300 m. The groundwater systems underlying these areas show moderate to low flow rates and contain mostly rainwater younger than 100-200 years. At depths greater than 1,000 m, fossil or non-renewable groundwater water exists that infiltrated some thousands to tens of thousands years ago during more humid periods in the region.
3. Rainfall varies from less than 150 mm per year in the Negev desert in the south to almost 1,000 mm per year in the mountains in the north. Climate change models mostly predict a further decrease of average rainfall in this region up till 20%-30% by the year 2050 compared to the averages of the last hundred years.

A number of human interventions in the water system can be distinguished:

1. Wells have been constructed since the earliest human settlements to use the groundwater reservoirs and small scale systems of water harvesting and storage were part of households and agricultural practices. Water conveyance systems have been constructed

[6] Knowledge is our map of the world, while information is captured data or knowledge. In the wide context of this article the two concepts can often be exchanged. In the paragraph on speech act theory the importance of further clarifications on the interaction between conflict and cooperation, language, information and knowledge is discussed.

at least since four to five thousand years BP. Water rights systems have been gradually developing over the last three to two thousand years. Plans for distribution of the Jordan River Basin water between riparian states were developed in the twentieth century.

2. In Israel, a Water Carrier system was constructed in the sixties and seventies of the last century that transports water from the Jordan River system to the coastal zone along the Mediterranean Sea, hundreds of wells have been drilled to use the groundwater in the same area, an intensive water reuse system has been realized, water harvesting is practiced at tree to water basin scale, and deep wells have been drilled to explore and exploit the deeper aquifer systems. Drinking water is pumped uphill into Palestine, from west to east, and is being sold to Israeli settlements and the Palestinian Water Authority at different rates. In Palestine, basic water supply systems are being developed, a few hundred wells have been rehabilitated or newly drilled, waste water treatment systems are being developed and water harvesting is being introduced. The development of modern water resources management in Israel started some fifty years ago while the building of appropriate water management systems in Palestine was only given a boost after the Oslo agreements of 1995.
3. Since 20 years, water from the Mediterranean Sea has been desalinated and brought into the Israeli water management system adding to the west–to-east human-induced water flow. Desalinization is planned to deliver 25–50% of the Israeli national water needs. In Gaza, a pilot desalinization plant exists and a large plant is scheduled to be implemented in the coming years if a stable situation returns. Desalinization of brackish groundwater in the Jordan Valley is also planned.
4. The Red Sea Dead Sea Project would introduce water flow from South to North in the Jordan Valley. Part of the water is planned to be desalinated. Realization of a pilot plant is agreed upon by Israel, Jordan and Palestine when stakeholder consultations show that environmental and hydro-political concerns can be met.

These forces act within the complex hydro-political and political reality of the Israel-Palestine conflict, the Arab-Israel conflict and even the disputed power distribution in the Arab world. Since 2011 two power shifts and new presidents have taken place in Egypt, a civil war in Syria is going on and millions of people are taking refuge in Jordan, Lebanon and Turkey. Dominance of forces favoring anarchy in the region is not serving the interests of the USA and its allies, who therefore launched a new regional peace initiative in the beginning of 2013, branded as the Kerry-initiative. The initiative ended on the 29th of April 2014 without concrete results with respect to a final peace agreement between the two parties.[7] To the contrary, it seems to have widened the gap between the parties as Israel continues to allow the construction of new settlements in the West Bank and hardened its position on cooperation between Israelis and Palestinians and Palestine is seeking further recognition at the UN and the two political rivals Fatah and Hamas have agreed to cooperate again, all culminating in the military actions from Hamas and Israel in July 2014

[7] "The talks reached their expiration date with each side blaming the other (and the United States) for the impasse and saying that neither saw a true partner for peace in the other" (Washington Post 30th of April 2014).

surpassing the scale of the previous crisis in 2012 and the 2008 war activities with a severe and unpredictable impact on all peace negotiations between Israel and Palestine.

2.2. *Analysis of the Israel-Palestine water case using the TWINS model*

Figure 1 presents a bird's eye view on the history of the water relations between Israel and Palestine according to the Transboundary Water Interaction NexuS (TWINS) model which is discussed in more detail in the next chapter. The approach is based on the idea and facts that conflict and cooperation occur simultaneously in transboundary water management and that the development in time of the position in the matrix gives insights to the nature of the conflict (Mirumachi & Allan, 2007). The model has been applied successfully for many transboundary water situations. The time frames and the exact locations in the present case can be disputed; however, the main message of the figure in this article is that the processes in water conflict and cooperation in the area show a tendency of a self-repeating loop (B zone). The left curled arrow (from B to C zone) is showing a path reaching toward a common desire to destroy the other and accepting self-destruction as a price for that goal. The right curled arrow (from B to A) depicts a process towards a stage of risk-taking at reasonable politicization levels to non-politicized water management in which individual and mutual interests are defended. The Kerry initiative in 2013-2014 has brought the Israeli and Palestinian parties back to the negotiation table, showing that a sense of urgency was growing to make a *political* quantum leap toward the A zone by starting final negotiations as soon as possible.

From the water availability point of view, such negotiations do have enough new agenda issues to be different from the successful 1993 and 1995 Oslo discussions and accords[8] and subsequent second track negotiations like the Geneva Initiative that resulted in major agreements in 2003 with updates in 2009.[9]

The recent increase of desalinization capacity of Israel, two wet hydrological years (2011/12 and 2012/13) and one with normal recharge of the aquifer (2013/14) creates a slot of almost water abundance. As the largest surface water reservoir in the area, the Sea of Galilee, is full, the overall public opinion in Israel is also confirming the official statistics or vice versa. It has been argued that this temporarily slot is a favorable condition

[8] The **Oslo Accords** are a set of agreements between the government of Israel and the Palestine Liberation Organization (PLO): the Oslo I Accord, signed in Oslo in 1993[1] and the Oslo II Accord, signed in Taba in 1995.[2] The Oslo Accords marked the start of the **Oslo process**, a peace process that aimed for the conclusion of a peace-treaty based on the United Nations Security Council Resolution 242 and 338, and to fulfil the "right of the Palestinian people to self-determination". The Oslo process started after secret negotiations in Oslo, resulting in the recognition by the PLO of the State of Israel and the recognition by Israel of the PLO as the representative of the Palestinian people and as partner in negotiations. (http://en.wikipedia.org/wiki/Oslo_Accords, retrieved 28-04-2014).

[9] The **Geneva Initiative**, also known as the **Geneva Accord**, is a draft *Permanent Status Agreement* to end the Israeli-Palestinian conflict, based on previous official negotiations, international resolutions, the Quartet Roadmap, the Clinton Parameters, and the Arab Peace Initiative. The document was finished on 12 October 2003. . . . In September 2009, a detailed expanded version of the plan was released (http://en.wikipedia.org/wiki/Geneva_Initiative_(2003), retrieved 28-04-2014).

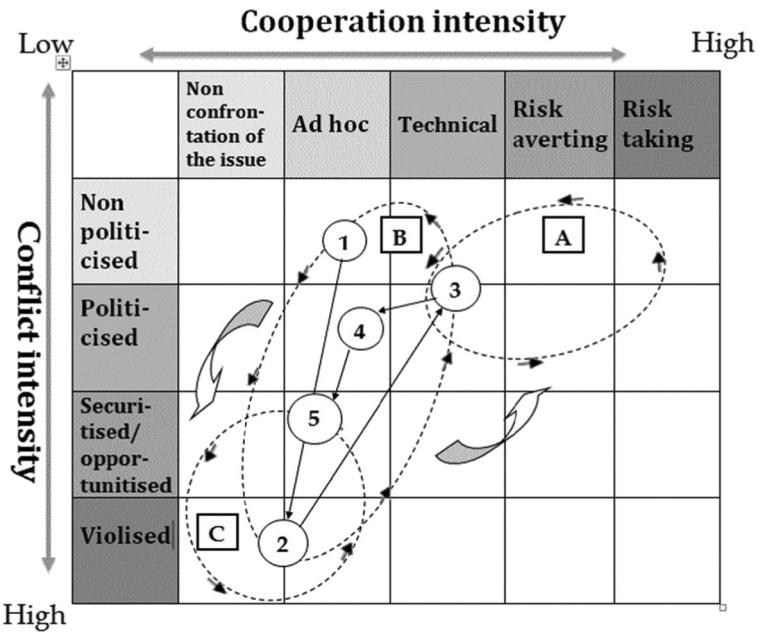

Figure 1. Application of the TWINS matrix to the water relations between Israel and Palestine. Five periods are distinguished: (1) 1920–1948 British rule over Palestine, (2) 1948–1993 Jordanian and Israeli rule over Palestine, (3) 1993–2000 Oslo Accords and following period of optimism with respect to a final two state solution, (4) 2000–2008 Second Intifada, Wall construction, increase of settlements, Israeli withdrawal from Gaza, (5) 2008 – July 2014 Three Gaza crises/wars, UN diplomatic initiative of the Palestinian Authority, Arab countries political unrest. In July 2014 the situation is shifting rapidly from (5) to (2), demonstrating the movement indicated by the left curled arrow (from B to C zone), showing a path reaching toward a common desire to destroy the other and accepting self-destruction as a price for that goal. The right curled arrow (from B to A) is a process towards a stage of risk taking at reasonable politicization levels to non-politicized water management in which mutual interests are defended.

for starting new negotiations on water distribution (Smidt, van der Molen, Boerboom, & ter Horst, 2013). In these negotiations, the role of newly available water resources can be addressed, new possibilities of transport and storage and above all the integrated economics of different options for the integration of the existing and new water systems. Such negotiations can be imposed by a wider peace process as happened during the Oslo negotiations between 1993 and 1995. The overall political goals will have priority during such a process and will set boundaries in priorities, resources and time. Timely preparation of such talks by second-track approaches seems appropriate - that is, outside the official talks by governmental delegations (Kaye, 2007).

2.3. Rethinking the Palestine – Israel water case

Rethinking the above mentioned narrative results in the observation that water cannot be discussed separately from the overall political context of the region. The second observation is that by introducing desalinated sea water on a large scale to the water system, the existing north-south flow directions in operational and new water transport systems

Table 1
Ordering transboundary water issues for the Israel – Palestine case and reference to the contents of Part 3 of this article

Key elements for future water management in the Israel - Palestine case	Transboundary water importance	Relation to existing/ relevant theories	Relevancy of entropy as an ordering principle
Natural water system: how to deal with normal annual variations and climate change expectations?	Almost all surface water bodies and most groundwater bodies are transboundary	Physical models and perceptions	Classical physical concept of entropy (energy not available for work) (section 3.1)
Manmade water system: extension of water conveyance and storage systems, reuse of waste water, access to deep groundwater and access to seawater for desalination, other forms of water transport created by water markets	Untreated transboundary waste water flows Optimization of conveyance and storage systems in an open transboundary status creates new options	Economic theories Practical applications of available models (as MYWAS) Hydro-economics	Economic aspects of entropy (measure for order) (section 3.1and 3.2)
Overall **water shortage** due to growing population	Fair and equal distribution of water and water rights is a transboundary issue	Mixture of physical and economic theories and hydro-politics	Mixture of physical and economic aspects of entropy (section 3.1 and 3.2)
Competition over water: conflict and cooperation – how to stimulate institutionalized cooperation	Present Joint Water Committee regulating water issues needs reforms to address all transboundary water issues	Hydro-politics, Hydro-sociology/ socio-hydrology, hydro-psychology	Patterns of chaos and order, to be translated into notes on (hydro-) entropy and related concepts
External dominant factors of socio-economic and political facts (unequal states, occupation of the West Bank and isolation of Gaza)	Parallel tracks of official diplomacy and second track diplomacy creates (new) transboundary mechanisms	Hydro-politics and other social sciences, theories that bridge scientific disciplines as mechanism design theory that bridges economy and sociology and aims at coping with or reducing uncertainties.	Will something originate as a grounded theory out of old and new narratives, models and the theoretical considerations? Hydro-entropic thinking? (section 3.1, 3.2 and 4)
Feedback between reality, narrative, models and other concepts	Scientific cooperation needed	Speech act theory – TWINS, hydrolectics – hydro-psychology and socio-hydrology Pattern recognition-fractals theory	
Complexity of the system leads to information disputes	Transboundary challenges	Systems approach, complexity and information theories	

can be reversed. This opportunity creates new options for economic and hydrological optimization of water resource allocations. The political acceptance of such allocations is constantly at stake. As parties in the water sector have known their mutual positions since twenty years, the development of new language frameworks like this article is aiming at can assist the review of the existing water distribution systems and the evaluation of new ones. Second-track talks especially do have the opportunity to test new frameworks which might emerge from these talks and are not set beforehand. In Table 1, a listing of topics is provided that emerge from the case description. In the last column we pose the question on the relevancy of entropy as an ordering principle which is the quest of this article.

3. From practice to conceptualization

In this part, a seemingly zigzagging route is taken from natural to social sciences and philosophy. The route is a balance between chaos and order. The reader who experiences too much chaos is advised to jump to the practical conclusions in 3.3, 4 and 5 and then eventually return to this section. The central messages of this section are (i) information plays a vital role in water conflicts and cooperation, (ii) the concept of hydro-entropy helps to understand the direction and patterns in information as expressed in the last message (iii) water and conflicts over this resource determine the speed of reaching sustainability or a lasting equilibrium between changing natural and social conditions.

3.1. Entropy and hydro-entropy

3.1.1. Entropy and negentropy in physics and information Entropy is a classical physical entity that expresses the amount of thermal energy per degree which is not available anymore for performing work in a closed system. It was introduced in physics in the 19th century. The engine in our cars produces the energy to move a few hundreds of kilograms but also a lot of heat that warms the air a little bit. All these small entropy-increasing units which facilitate our civilization cause an increase in global air temperature without there being much potential to use this energy.

In statistical physics, which describes the behavior of molecules, entropy is related to the probability of the occurrence of different ordered states within a closed system. In the simple example of a melting ice cube in a glass of water the highest probability (of one) exists for the state where there is only water with the same temperature as its environment. This equalizing natural tendency has been associated with lack of order and increase of disorder or chaos.

The first scientist to extensively link order or organization with the opposite of entropy, negentropy, was the famous physicist Erwin Schrödinger in his book "What is Life?" published in 1944.[10] When in 1948 Claude Shannon, the founder of the modern

[10] Schrödinger uses the term to identify the remarkable ability of the living system, not only to avoid the effects of entropy production - as dictated by the second law of thermodynamics - but to do just the opposite, to increase organization, which intuitively, seems like the converse of entropy.

science of information, introduced entropy in information theory as a measure of the amount of *uncertainty* associated with the value of a certain parameter, like a piece of information, the association of entropy with chaos and negentropy with order was given a further stimulus (Shannon, 1948). In chaos theory, chaos is more related to developments in time while entropy expresses the state order, which of course also changes in time. It is tempting to translate these notions into anarchy, conflict and cooperation besides using the entropy metaphor on non-useful or wasted energy into other domains than the original physical world. In doing so, we may understand the fact that some situations of conflict appear to be succesful in creating new order(s) while some forms of cooperation appear to actually contribute to lack of energy in social systems.[11] In understanding these situations complexity theory can be of further assistance with its emphasis on far-from-equilibrium systems which requires the rethinking of the entropy concepts and coherent collective self-organized activities called dissipative structures as an addition to the rather dichotomic entropy-negentropy concept (Prigogine & Stengers, 1985; Stengers, 2004).

The process of intelligence development or ordering of information can unfold in fulfilling the law of increase in entropy. Organizations like the Club of Rome continuously warn about mankind becoming a unique evolutionary hegemon that will not become extinct by an extreme natural event but, instead by its own capacity of energy dissipation and entropy increase. Such Neo-Malthusian or entropic ideas are disputed by scientific schools which are more in favor of taking into account negentropic forces of information and intelligence in evolution and the way mankind increases knowledge and learning capacity from errors in the past. As an ultimate consequence of such thinking, the incompleteness of the law of increase of entropy under certain conditions cannot be excluded. Such a condition might for example be an unknown energy field that created the Big Bang and is reminiscent at present and feeds our system in a way we still have to discover. Less theoretical considerations but factual state of the art presentations from modern physics are discussing the end of space and time as the only and determining dimensions of physics (Dijkgraaf, 3rd of April 2012).[12] Pointing at the important role of information in understanding the very basics of the driving forces at micro and macro level in nature, Dijkgraaf in fact invites all disciplines in science to help in understanding the dialectical relation between knowledge and reality. His statement can be related to the concept of the father of western philosophy Thales of Milete: the basic element of reality is not water nor other elements found essential since Thales, but information. We try to answer that invitation by (i) considering information as the basics for understanding water conflicts and understanding and possibly treat it as a dimension like space and time, (ii) determining the relation between information and our language and acts and (iii) investigate if information in the small field of conflict and cooperation over water resources acts in an entropic or a negentropic direction.

[11] The translation of the concept of entropy into social sciences is disputed, see http://en.wikipedia.org/wiki/Social_entropy and http://www.preposterousuniverse.com/blog/2013/01/29/social-entropy/

[12] In the discourse of Dijkgraaf, entropy plays an important role as well. Gravitation is described as an emergent entropic thermodynamic force instead of a basic physical phenomenon. The video link is listed in the reference and the entropic force and equations are defined at time index 42:00–46.00.

3.1.2. The water cycle and water and energy storage: entropy in the physical world The water cycle can be regarded as a subsystem of nature which helps the general process of increase of entropy in nature by dissipation of energy.[13] This physical view does not exclude a more ecological or evolutionary view on the water cycle as part of a complex self-organising system which has the ability to evolve due to incoming solar energy.

The sources of energy at work are solar and the heat of the earth. The heat dissipation from the core of the earth creates the "floating" of parts of the crust and collisions and separations forming highs and lows in the topography of the earth. The dynamics of the hydrological cycle promotes the erosion of the heights and the transport of mass and solvents to the oceans. By doing so it helps to accelerate the dissipation of energy from the core of the earth.[14] Large water reservoirs such as the oceans, icecaps and groundwater reservoirs all have a dual function in this process: mass and energy storage at the points of local maximum entropy (at lowest topography and balancing temperature differences). These processes are described fairly well by our present state of knowledge like the law of conservation of mass and the increase of entropy and the equivalence of mass and energy.

3.1.3. Information, entropy and hydrology Entropy as a measure for the importance of information on unknown or not well understood phenomena has been used over the last 20 years in the important validation of hydrological models. For laymen it is extremely difficult to understand the details, but for specialists it has become a value which helps to use physical and even intuitive knowledge just like distances and time are helpful parameters to not lose orientation.[15]

The role of information in societal life has shown dramatically rapid changes by inventions such as writing, printing and computers and by gradual and spontaneous development of new knowledge fields and their practical applications. The way information either contributes to new creativity or to scattered data without creative power is described as *negentropy and (pos)entropy*, respectively. Hydrogeologist and philosopher Arie Issar has expanded these ideas in a theory of the role of the dimension of information in the progressive development of knowledge (Issar & Sorek, 2010; Issar, 2012; Issar, Ginat, & Zohar, 2012). The quest here is how new thinking on the concepts of entropy can help us to improve our management and governance of water flows and natural buffers like groundwater reservoirs.

Another relevant question to our water domain is if physical and informatics neg- and posentropy can be quantified over the lifetime of the earth? Might local tipping points exist

[13] Which is basically fractal as the process depends on itself.

[14] The incoming solar energy outweighs by far the geothermal energy reaching the surface of the earth (173 petawatts (99.97% of the radiation balance) versus 44–47 terawatts (0.025%) (see http://en.wikipedia.org/wiki/Earth's_energy_budget).

[15] A recent example is: "In this paper we aim to introduce and practically demonstrate a data compression oriented information theoretical framework for learning from data, well-known in theoretical computer science, to the field of hydrology or more generally to the geosciences. . . . The framework may increase intuitive understanding about why and when one approach works better than the other, and how prior knowledge and data can be optimally combined across scales . . ." and a figure title: Overhead above the entropy limit of the best benchmark algorithm" (Weijs, Giesen, & Parlange, 2013).

that separate domains of dominance of one over the other? If information is a dimension as space and time, as uttered in the previous sections with reference to the work of Dijkgraaf (2012) and Issar et al. (2010, 2012), then the equivalence of mass and energy would need an extension into that dimension. Would that enable us to find new clues as how to optimize the role of information in bringing "more efficient" balances between chaos and order in favor of order and harmony with an acceptable and required disharmony instead of chaos with minimum order and maximum conflicts and disharmony? Here the aspect of (monetary) costs and values enters inevitably in the discussion. We have eased the valuation of nature and human artifacts by the creation of money. Money also flows and is stored in reservoirs. Contrary to water, new money is constantly created. Apart from studying the economic aspects of water movements - which is very instrumental for the case at stake - one can also ask a question on the information level: Can we learn from comparing the flow of water in our natural system and the flow of money in the human system? What are the driving forces, how is energy used and (neg)entropy produced and what is the role of reservoirs in both these systems? Hydro-economics and other fields of science that describe the flows and storage of money in all its forms will be needed to answer this question.

3.1.4. The role of water in reaching sustainability More specifically the question is how the balance between posentropy and negentropy functions in the present non-sustainable society and how it can function in a fully sustainable society and most interestingly in the present transition phase of progressive development towards sustainability. If the question is plausible, it should be possible to apply it for example on the role of groundwater storage of desalinated water produced by solar energy in times of excess production. New locations and techniques for such an already existing instrument will emerge from the analysis. This is of particular interest for the case of Palestine and Israel and most of the Arab and Middle East countries that suffer water shortages. Can such measures be made economically feasible in new concepts of monetizing natural resources, products, services and information? Might such thinking (partly) assist to overcome the present economic crisis as it creates new fields of economy as the CO_2 agreements did or can do (Rousse, 2008)?

3.1.5. Hydro-entropy Vital for the success of progressive development towards sustainability is the balance between posentropic and negentropic forces and functions in nature and society. As water and energy are essential ingredients for this process and energy is included in the concepts of entropy and water is not, it appears useful to introduce the term *hydro-entropy*. The natural water system tends to increase entropy, water governance aims at increasing negentropy, although in practice institutions and people ignore complexity (and chaos) and actions will increase entropy as well in practice. Hence hydro-entropy describes the relation between the two forces as described in the practical case of water shared by Israel and Palestine.

If a conceptual qualitative model of hydro-entropy is useful, quantitative relations might be found as well. As economics links the values given by society to different entropic forces, it seems appropriate to investigate these quantitative relations of hydro-entropy

in economic terms. The type of economics to be used needs to include societal benefits and costs over the time spans indicated in Figure 1 and therefore needs innovative concepts that allow taking into consideration high uncertainties when dealing with these time spans.

3.2./ Embedding hydro-entropy in other concepts

3.2.1. Water governance We follow the definition and description of water governance as an art used by the Netherlands Water Governance Centre (Teisman & Veld 't van, 2013), with an addition of practical skills and a reference to familiar and unexpected water circumstances: Water governance is the art of coordinating administrative actions and decision making between and among different actors which success depends on a number of capacities of these actors to apply a wide variety of social and technical *skills and* sciences *in dealing with familiar and unexpected water circumstances.* The decision making might or even has to involve also political levels. In the Netherlands this is evident as the boards of the regional water authorities are elected as a fourth dimension of the Dutch democratic system, the others being national, provincial and municipal.

In addition, water governance is linked worldwide to three issues high on political agendas: food security, climate change and energy provision. The interrelations between these issues are tackled in the water-food-energy nexus. Five main capacities are distinguished in the WGC approach: institutional, economic and financial, management, communication and participation of actors and legal and regulatory capacities (see Figure 2) (WGC-Smidt & Satijn, 2013). The approach can be classified as not politicised or as assuming an indirect role of politics in all types of capacities. By setting different scientific disciplines to the centre of the governance issue – also visually- and by focusing on capacities

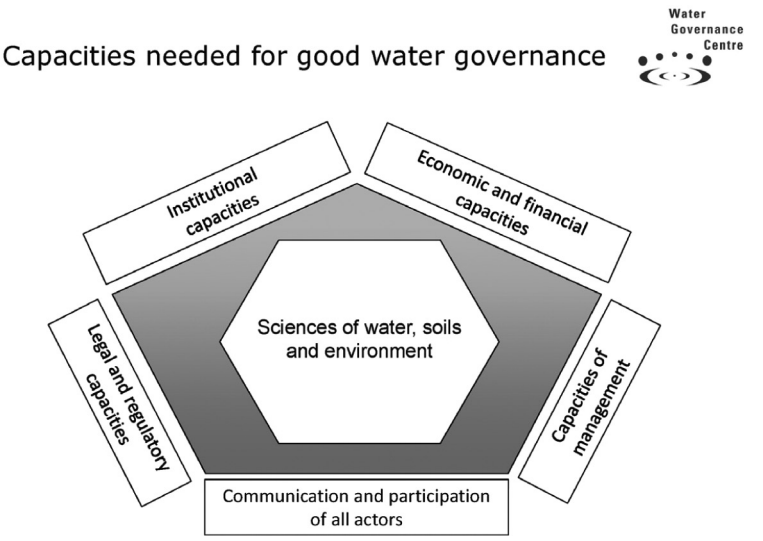

Figure 2. Water Governance Framework used by the Netherlands Water Governance Centre

the approach is a clear exponent of an intended ordering nature of water governance where even political differences are solved in lengthy multi-stakeholder negotiations.

The governance system determining the water management in the Palestine Israel case shows an uneven power distribution and a dependency on larger political issues. The Joint Water Committee which was supposed to function temporarily after the Oslo agreement until the final negotiations would have brought a political solution has become an institutionalized mirror of this uneven power distribution and hence heavily criticized (Selby, 2013).

3.2.2. Hydro-politics Hydro-politics is defined in the classical sense of politics by Turton (Turton, 2002) as 'the authoritative allocation of values in society with respect to water' and further linked to power by Cascão and Zeitoun (2010) incorporation of the role that power plays as an essential feature of water conflict and cooperation in practice'. Power differences can exist in terms of *geography* with the upstream countries normally having most natural advantages, *material power* including economic and military means, *bargaining power* referring to possibilities of determining the rules of the game as agenda setting and *ideational power* as the control over concepts, knowledge and narratives. The latter two are referred to as soft powers while the first are the hard powers. Mapping the strengths of the different powers of the different stakeholders gives good indications and can help in visualizing differences of opinion and arguments (Zeitoun & Warner, 2006; Mirumachi & Warner, 2008). Power differences matter in processes increasing anarchy or order and even more in the impact of anarchy on the creation of new orders.

3.2.3. TWINS model and its base in the speech act theory A model that helps to understand hydro-politics or the position of water discourses in the overall politics is the TWINS model or matrix, the acronym for Transboundary Water Interaction NexuS (Mirumachi & Allan, 2007). Boundaries are often considered national boundaries, but the model can be applied to any type and scale of boundaries. It is based on the assumption that conflict and cooperation over water are seldom totally excluding each other. Conflict and cooperation can be considered even twins in a certain way. Cooperation levels and conflict levels are scaled in four respectively five classes from low to high intensity (see also Figure 1). The conflict levels are based on a crucial notion that the level of politicization changes the very nature of relations in the arena (Warner & Zeitoun, 2008). The four classes of conflict, *non-politicized, politicized, securitized and violized*, are related to the speech act theory as one of the underlying directions of thought (Neumann, 1998; Warner, 2004; Warner & Buuren van, 2009). Speech act theory is instrumental in describing the interrelationship between language and deeds (Austin, 1962) or in a modern version between information and acts. In a non-politicized conflict, information – like scientific data and predictions- can still be considered as "neutral" meaning that (almost) no feedback mechanisms exist between the nature of the conflict and the information. In politicized conflicts, the language and the information itself becomes part of the discourses of the conflict. At the level of securitization, the water issue becomes a matter of (national) security and language and other information serves to develop and test the support for this stage. Uncertainty often

intensifies the securitization spiral (Herzl security dilemma). Once the conflict is violized, language and information has become a full instrument in the conflict.

At the cooperation scale, speech act theory seems to be underdeveloped (Warner & Buuren van, 2009). The five cooperation classes, *confrontation of the issue, ad hoc, technical, risk avoiding and risk taking*, differ in the way parties relate to each other, which type of language is used, how information is shared and which risks are taken. Innovative concepts of trust building that take into consideration soft powers like exploring not only mutual strength but also mutual vulnerability within and between organizations can be applied here (Voortman, 2012). We add that the way uncertainty is either decreased, named or its consequences are studied and taken into account in negentropic strategies co-determines the successful development of cooperation.

Both for the conflict and cooperation side of the continuum holds that the difference in objectively observable information and more subjective knowledge can be an important factor in power balances. The role of language in information and/or knowledge development in general and the specific case of shared water between Israel and Palestine deserves further analysis.

3.2.4. From hydrolectics to a hydro-social cycle and the umbrella IAHS research theme Panta Rhei Theoretical considerations and analyses of case studies within the CoCoon Project 'Groundwater in the political domain' reveal that more research focus is needed on the interrelationship between water governance regimes and its levels and scales, the different layers and patterns of conflict, cooperation and politics, different type of states, and on factors of change in order to fully understand the complexity of the data from the numerous field cases and narratives (Smidt et al., 2014). One of the main lessons to be learned, also by ourselves, is to make sure that the narrative of the cases being developed takes into account the interaction between the resource, the different users, other stakeholders and researchers. This process is dialectical[16] by nature and is considered special enough to be dealt with from a water-mankind dialectical or hydrolectical point of view (Linton, 2010). Linton's condensed message is 'water is what we make of it', meaning that it is much more than the chemical formulas or the water balance equations or cubic metres sold by a water company. The additional value is found in the social meaning of water and the way it is communicated and incorporated in the well-being of society. A short impression of how Linton adds politics of waters to hydro-politics is given in Box 2.

Hydrolectical thinking has contributed to the analysis of the hydro-social cycle as a socio-natural process by which water and society make and remake each other over space and time comprising a process of co-constitution as well as material circulation (Linton & Budds, 2013).

Concepts like hydro-entropy, the hydro-social cycle, hydro-psychology and socio-hydrology all form part of larger search to better understand the coupling between the natural occurrence of water and the social systems. The hydrological community represented by the International Association of Hydrological Sciences (IAHS) has realized the importance of this question and dedicated its new Scientific Decade 2013–2022 entitled

[16] Dialectical is used here in the sense of: concerned with or acting through opposing forces, ideas or thoughts.

Box 2. Hydrolectical sentences (Linton 2010, p 224)

Every relevant instance of water is realized by someone, whether a state planner, a well driller, a consumer, a researcher at NASA, or a child playing in the rain. Water is therefore conceived not as a self-identical object but as a process whose identity is formed in social relations. The possibilities for water are thus open to social change. In this sense, hydrolectics draws attention to the politics of waters instead of water politics. The politics of waters begins with the assertion that water is never simply "neutral stuff"; it is never merely given. The fact that water always becomes what it is in accordance with a particular kind of engagement means that it always becomes for someone or something. Wherever water is declared a resource, the nature of its resourcefulness is defined by the particular uses for, and interests in, water held by those who declare it thus.

"Panta Rhei—Everything Flows", to research activities on change in hydrology and society. The purpose of Panta Rhei is to reach an improved interpretation of the processes governing the water cycle by focusing on their changing dynamics in connection with rapidly changing human systems. The practical aim is to improve our capability to make predictions of water resources dynamics to support sustainable societal development in a changing environment (Montanari et al., 2013).

3.2. Creative information chaos as starting point for research agenda setting?

If we propose a hydro-entropic and hydro-social approach of the Israel- Palestine water issues by formulating new narratives from these viewpoints, we do so to widen the perspectives of the parties that have been talking already for almost twenty years after the Oslo agreements. The narratives need to be complemented by hydro-economic and ecological qualitative and quantitative analyses and scenario development. A preliminary research agenda includes but is not limited to:

1. Economics of desalinization (including options for temporary storage of water produced in periods when energy costs are low);
2. Total review of economics of conveyance and storage of water and its optimal economic allocation using climate change predictions and MYWAS regional applications (Fisher & Huber-Lee, 2011);
3. Linking the first two issues with optimization studies/techniques;
4. To investigate the possibility of applying theories that link water resources management, economy and sociology (viz. Mechanism Design Theory[17]);
5. How to translate the key issues of the IAHS Panta Rhei program and water diplomacy with concepts as hydro-economy, hydro-entropy, hydro-hegemony, hydro-lectics, hydro-politics, hydro-psychology and socio-hydrology in the practical situation of Israel-Palestine shared water issues. Table 2 shows the concepts discussed in this article, their key meaning and preliminary examples of issues to be addressed.

[17] Mechanism design can be seen as an attempt to combine economics with sociology as it focusses on the solution concepts or mechanisms to reach certain outcomes rather than predicting outcomes with predetermined mechanisms. (see http://en.wikipedia.org/wiki/Mechanism_design)

Table 2
Key-elements of concepts and issues to be addressed in the Palestine-Israel shared water case.

Concept	Key-meaning	Examples of issues to be addressed in the Palestine-Israel shared water case
Hydro-economy	Value and cost of real and virtual water, water footprint, role of water in the local and regional economy	Inventory of existing data and information and updating models like MYWAS Developing future scenarios
Hydro-entropy and hydro-negentropy	Physical and information/knowledge role of water, balance between chaos and order	Further elaboration of narrative presented in this article Quantification in coherence with hydro-economic results
Hydro-hegemony and hydro-politics	Description of power mechanisms at stake in the political domain with respect to water management and governance	Analysis of past and existing ways of cooperation Developing innovative forms of cooperation
Hydro-lectics	Linking the physical hydrological cycle with the social meaning of water and language	Inventory of the role of water in the different language groups Developing common understanding tools
Hydro-psychology	Human group and personal attitude towards water and its influence on water management and governance	Inventory of existing attitudes Developing of mutual exchange and learning methodologies
Socio-hydrology	Interaction between societal developments and water management and governance	Description of common practices Development of innovative practices
Integrative Panta-Rhei approach	Linking "sectoral" approaches to a "holistic" approach which still can be understood and used as existing hydrological models	Forming a special joint Israel – Palestine working group of PhD staff and seniors assisted by international co-workers

Framing these studies in such a manner that unbalances in access to information are solved and both parties benefit equally is a negentropic challenge.

4. Tentative application of hydro-entropy to different scales

Hydro-political, socio-hydrological and hydro-entropic thinking provide tools to water practitioners and scientists not to isolate the water issues from the political discourse. Access to and control over land and water resources has been vital for the Israeli policies and is related to the Zionist doctrine. Defenders of joint Arab-Israeli development plans will always be judged in the Arab world on whether or not they provide (lip)service to a Great Zion ideal and in Israel to a regional pan-Arabic ideal without a state of Israel. Joint Arab-Israeli or Israeli-Palestinian environmental or water peace initiatives denying that reality do have little chance of sustainable successes and create more chaos than new orders.

Wider political issues are combined with local or regional acute groundwater problems in a project Groundwater in the Political Domain. One study area focused on the Qalqiliya governorate in Palestine, which is severely affected by the number of Israeli settlements and length of the wall separating Israeli-controlled area within the borders of Palestine (called

area C) from areas totally under control of Palestinian authorities (Area A) or only at the civilian level (Area B). Within the project, action plans are developed by the Palestinian Water Authority with the main water users in the area to improve the economic situation of the area despite the impacts of the Israeli settlements and the wall. In workshops with the stakeholders, progress is made if bottom-up and top-down information flows are fine-tuned. Progress can be measured in terms of access to means that can improve the standard of living despite the actual political situation without blessing or justifying that situation which is considered illegal by the International Court of Justice and the UN. In that sense, it seems that the project builds on and contributes to negentropic forces in the region.

5. Conclusions and discussion

5.1. Conclusions

By combining the TWINS matrix and the hydro-entropy concept for the Israel-Palestine water dispute and its overall political setting, a hydrolectical narrative and qualitative information frame have been provided. Pattern recognition, feedback mechanisms and early signaling of windows of opportunities for change despite voids or threats of intensification of conflicts play an important role if we want to contribute to the negentropic forces in the region as we are aiming at. Directions are given to quantify the concept.

Such a conclusion can be considered a declarative and hydrolectical speech act within an actor-network based on information describing entropic and negentropic forces acting in the natural and socio-political domains.

As the natural water system has chaotic characteristics, water governance practioners can better incorporate uncertainties or even anarchy in hydrological modeling and in dealing with stakeholder involvement. Bottom-up processes do have a chaotic character by nature as well.

5.2. Discussion

The ideas developed here need improvement with respect to:

1. Quantification: both in general and especially for the Israeli-Palestine case the concept of hydro-entropy has to be clarified in more detail in writing and even more important in models showing also numbers. Feedback mechanisms can be analysed numerically or by fractal mathematics.
2. On a theoretical level the relation between structure and agency and speech acts – hydrolectics – hydro-entropy needs more research. Four domains are distinguished at this stage:
   a) Structure and agency reinforce and stimulate change processes (mostly by cooperation but also by open conflicts);
   b) Structure and agency frustrate and block change processes (by hidden and open conflicts and semi-cooperation;

c) Structure and agency keep each other imprisoned in a "void" of a non-changing situation;
d) What is actually happening in the case at stake is a chaotic mixture of the above mentioned domains in which the concept of dissipative structures might provide a useful framework for research and action. Agency-based models can be instrumental in further developing insight in this mixture.

Where external boundaries are rapidly changing, the human factor tends to grasp on internal boundaries. Real political leadership uses crises to create new internal and external territories and boundaries and thus challenges scientists to contribute to these processes in a negentropic manner.

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