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The book includes:
- Papers by leading international experts and academics
- New perspectives through in-depth analyses
- Numerous maps, charts and tables
- A wealth of ideas for specialists and non-specialists alike: scholars, policymakers, administrators, concerned citizens, development professionals, entrepreneurs, journalists, students and others.

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Damien Demailly, Raphaël Jozan and Sanjivi Sundar (Associate Editors)
Modelling and simulations have become essential tools for the analysis of the relationships between nature and society. The increasingly powerful calculation capabilities of computers has enabled the establishment of protocols and methods to integrate multiple databases, enabling the analysis of territorial problems in their multiple dimensions (physical, biological, technological, economic and social). Systems for monitoring and evaluation, which are at the heart of the methods and tools for strategic development and decision support, rely on calculation devices in areas as varied as natural resource management, urban development, agriculture, etc. To what extent do these systems facilitate changes to public policy? Do they enable real-world complexities to be taken into account in the decision-making process and allow the integration of new factors (particularly social and environmental)?

This paper examines the hydro-economic models used in water management in the Aral Sea basin. These models have been progressively introduced for the purposes of ‘saving the Aral Sea’ and to avoid a ‘water war’ between the former Soviet republics following the collapse of the USSR in 1991 (see Figure 1). This region, in which water management is considered as irrational and the least efficient in the world, is emblematic of international mobilization around an environmental problem. From the 1980s to the mid 2000s, the area has witnessed the deployment of a truly international laboratory for the creation of innovative tools designed to assess the environmental situation and (re)orient its development trajectory. In the context of the post-Soviet transition, the use of increasingly powerful models and computer simulations has raised hopes for the emergence of a new set of economic principles for resource management, and a renewed relationship with nature and technology. This analysis finds that, paradoxically, the apparent sophistication of the tools used does not guarantee the unlocking of a public problem and, depending on the way in which the models are used, can reinforce non-sustainable development trajectories. Large dams are not the only influence on Central Asia’s hydrographic network. However, successive models have continued to disregard important elements, particularly water resources. This has led to a hydraulic representation where only controlled water resources were taken into account. Accordingly, Uzbekistan becomes a vulnerable ‘upstream country’, whereas it has access to sufficient water regardless of the management regime of neighbouring Kyrgyzstan.

Towards more efficient management of the Aral Sea’s watershed

In Central Asia, the first modelling exercise was carried out through international scientific and technical
Large dams are not the only influence on Central Asia's hydrographic network. However, successive models have continued to disregard important elements, particularly water resources. This has led to a hydraulic representation where only controlled water resources were taken into account. Accordingly, Uzbekistan becomes a vulnerable 'upstream country', whereas it has access to sufficient water regardless of the management regime of neighbouring Kyrgyzstan.
cooperation in the late 1980s. Following the Chernobyl disaster in 1986, and in the context of perestroika, the Soviet government chose to accelerate international cooperation on the environment. In the context of an increasing focus on water at the international level, a subject that was at the heart of international negotiations on environment and development, the international community turned its attention towards the Aral Sea. This lake was rapidly drying up as a result of the exponential increase in the use of water resources for irrigation in a region undergoing a spiral of ever-larger construction works (canals and dams), legitimized by plans for an expansion in cotton production. Scientific and technical cooperation led to the publication of an article in the journal *Science* in 1988 that blew the whistle at the international level on the subject of the retreating Aral Sea. The cooperation continued with a team of American and Soviet researchers, brought together by the Stockholm Environmental Institute (SEI), created in 1989 by the Swedish Government in preparation for the Rio Conference (1992). This team chose the Aral Sea as the first site for the application of a model, the Water Evaluation and Planning System (WEAP), for which they developed algorithms to simulate the management of water resources in large basins.

The choice of the region and methods was in tune with internal developments in the USSR, which had placed an increasing attention on the Aral Sea since the late 1970s. Opponents of the Soviet regime that focused on the environment — the only area where criticism was possible in the USSR — targeted the Sibaral project, a disproportionate hydraulic project that aimed to divert Siberian rivers over thousands of miles towards Central Asia. Since the early 1980s, this programme was supported by the new Soviet ruling elite, i.e. the young economists that seized control of the government following the death of Brezhnev and who sought to reform the socialist economic system by: promoting the flexibilization of the economy (and innovation), moving away from productivist principles, ensuring a better rationality in the management of financial resources and bringing an end to the siphoning off of state budget by industrial sector lobby groups. Apart from the USSR, Central Asia was also a pilot region for the reform project, where the Soviet government planned to experiment with new principles of resource management through the introduction of new decision-making tools. These tools were provided by advances in computer and hydraulic technologies that were more efficient and effective than large-scale hydraulics, an already ongoing rhetoric in the USSR before the discourse of international expertise was established during the 1990s and 2000s.

The WEAP model achieved rapid success. The simulation results were published in 1992, ahead of the Rio Conference — and, by chance, just a few months after the implosion of the USSR — that formally certified the drying out of the Aral Sea and the need for change. The motto ‘Saving the Aral Sea’ appeared, which served as a catch-all for several objectives, including: the desire and need for Central Asian elites to cut ties with the USSR (which they nevertheless sought to maintain until the dissolution); the search for international finance by ministries and local research centres seeking to implement hydraulic projects and which were deprived of Soviet funding; the ambitions of international support organizations to lead the new republics towards the market economy; addressing pressure from international environmentalists regarding the shrinking Aral Sea; and the desire of a handful of international experts to provide models for the design of action plans to move away from socialism through a single variable — water.

Moreover, the strength of the WEAP model was that it allowed the aggregation, within new scenarios, of technical solutions (concreting of channels, modern irrigation techniques such as drip irrigation, etc.) and institutional ones, which are considered according to

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1. General Secretary of the Central Committee (CC) of the Communist Party of the Soviet Union (CPSU) presiding from 1964 until his death in 1982.

2. During the 1980s, Central Asia was particularly targeted by the Soviet government because of the excesses of the Sibaral project that was promoted by Central Asian policymakers, and because of the identification, in the early 1980s, of significant corruption networks formed around the hydraulic and cotton agro-industrial sector.
the same technicist and diffusionist approach. Several regional institutions were created and organized within the Interstate Council for the Aral Sea (ICAS) to propose the formulation of an action plan and the implementation of a funding body (International Fund for the Aral Sea – IFAS), integrated into the Aral Sea Basin Program supported by the World Bank, UNEP and UNDP.

From the ‘rescue of the Aral Sea’ to the ‘Central Asian water war’

The action plans developed through international cooperation were rapidly overwhelmed by new elements that were not represented in the problem as formulated by the WEAP simulations, which were built prior to the Soviet dissolution. The borders between the newly independent republics (especially Uzbekistan and Kyrgyzstan, see Figure 1) were becoming more defined and their political and economic trajectories differed. A new water use arose, or at least one that had not been previously taken into account in the formulation of the problem: this was the water used for electricity production in the dams, most of which were situated in Kyrgyzstan, a country dominated by high mountains which gather the majority of the precipitation that enters into the basin, before flowing into the Aral Sea and the irrigated areas, which are mainly in Uzbekistan and Kazakhstan. Whereas Uzbekistan was pursuing a development path that was largely dependent on irrigated cotton production (especially during the 1990s), Kyrgyzstan expected to benefit from these hydroelectric facilities (including the Toktogul Dam, the largest reservoir in the region – 19.5 km³) to ensure its energy security, especially during the winter period, which it considered incompatible with summer irrigation. The fact remained: the problem of Central Asian water management could not be resolved without taking the energy issue into account. Institutions and tools developed through international cooperation were inefficient: the organizations created had no jurisdiction over hydroelectric works, nor on stretches of international rivers, and were controlled by officials, particularly those from Uzbekistan, who promoted a hydro-agricultural vision of water management, in accordance with the sectoral balance of power inherited from the Soviet period, when the hydraulic structures were designed for the service of irrigation.

The emergence of the energy issue reinforced the idea, which had become fashionable at the international level, of a possible water war between the downstream countries (that focused on irrigated agricultural production) and the upstream ones where hydroelectric dams were sited. This thesis emphasized the importance of hydraulics as a factor in the issue of Central Asian development in the 1990s: while the level of the Aral Sea had previously been considered as the standard by which the sustainability of the development path should be judged, it was ultimately the Toktogul Dam that eventually stole the limelight, while the project to save the Aral Sea was completely ousted, thus signalling the virtual disappearance of environmental issues from the definition of the public problem. At this juncture, advances were made in the modelling field by experts at US research centres who developed the General Algebraic Modeling System (GAMS), which was more dynamic and powerful than WEAP, had the ability to factor in the energy sector (in addition to agriculture and the environment), to incorporate the differentiated national strategies and to include a number of economic calculations for the optimization of water allocations for the different usages.

Once again, the advent of a new tool raised hopes within the international community, as GAMS seemed capable of addressing the complexity of the problem. Its integrated dimension meant that this model could only be implemented by the intervention of a new player, the US Agency for International Development (USAID), which had an impact on water management as USAID already had an involvement in energy sector reform, particularly the privatization of the Kyrgyz energy sector, where a number of American companies were on the scene. The modelling simulations were then performed within a new arena, the Interstate Council for Kazakhstan, Kyrgyzstan and Uzbekistan (ICKKU), which was established in 1993 and was independent from Aral Sea Basin Program.
institutions, which destabilized the monopoly of hydro-agricultural expertise. Several simulations were produced during 1997, all of which demonstrated the need for the new states to enter into a cooperative plan, or run the risk of the Toktogul reservoir reaching a critical state that would jeopardize both electrical production and the availability of water for irrigation.

In 1998, with great fanfare, the new states signed an international treaty that had been promoted by the UN and a number of bilateral donors, such as USAID, which contained the terms of trade derived from the simulation work. While this step was initially seen as a great success, the treaty was soon challenged by the states themselves, who refused to comply with the recommendations. For instance, although the modelling results found that Uzbekistan was ‘extremely vulnerable’ and ‘dependent’ on the energy from the Kyrgyz dam, the country turned its back on the treaty until the early 2000s, despite repeated simulations that confirmed the same conclusion. From the early 2000s until 2005, the case was taken up by the World Bank, which built its own simulation tool with the objective being to persuade Uzbekistan to enter into cooperative arrangements. Despite the production of new results, which converged with those of the GAMS, Uzbekistan maintained its position of staying away from the negotiating table, an attitude that was hard to understand in terms of international cooperation, which considered Uzbekistan’s government to be irresponsible, given the recommendations of the models that seemed to show the rational path to follow.

Political economy in the use of modelling

Was it the realism of the model’s representation that encouraged states to sign up to the treaty? Should a more precise model be developed to better reflect reality and thus convince more countries to cooperate? An analysis conducted by the author showed that, for a long time, the GAMS models remained, surprisingly, at the stage of an abstract and theoretical representation of reality. The simulations were based on incomplete data and were considered as ‘highly uncertain’ by those working on the models: despite their missions in Central Asia, US experts were unable to get hold of the data that was available to the infrastructure management bodies who opposed de-compartmentalization of energy and agriculture. In any case, the simulations were dependent on administrative statistics that have been shown to exclude a significant proportion of agricultural uses (a massive 30% of the land area of Uzbekistan, the main water consumer in the basin, was unlisted).

The analysis of the models shows that they overestimate the water shortage of the region. Only the water controlled by dams is taken into account, but this represents a minor proportion of the water used by farmers.

In fact, the very objective of searching for a balance in the model imposes an enormous constraint on the research: modellers are forced to classify countries into two categories (upstream or downstream countries), which is the only way to obtain a digital solution for modelling, as has been well established by game theory. However, it has been demonstrated that Uzbekistan, which is considered as a downstream country, is in fact a ‘middle’ country, meaning that it receives water from Kyrgyzstan, regardless of the regime under which the Krygyz dams are controlled; the models, however, assign the dams with the capacity of absolute control over the water that falls onto the Kyrgyz mountains, an assumption that is contradicted by the analysis.

In fact, the water war that was declared by the experts, politicians and diplomats, exists only if one ignores an important part of the water resources and management methods of the hydraulic infrastructure, as well as a whole range of factors (geographic locations of electricity cables, structure of energy markets, technical means of electricity production) that are not represented by the model, and are thus excluded from the public policy issue, which only focuses on the dam regime. As a consequence, the model’s results are overwhelmed by elements that are not taken into account (including a surplus of water!). Paradoxically, the more the models were overwhelmed, the more the experts left aside new elements and offered truncated representations of reality, which was seen

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4. This is a major element that explains why the efficiency indicators for water usage are so low in Central Asia.

5. Water that is not controlled by dams flows into canals and agricultural fields.
when the simulations were carried out, especially when the World Bank took on the modelling work in the 2000s (the third stage of the modelling work described above). Everything shows that the experts were constrained to force the representation of reality to sustain the balance of the models.

Realistically, modelling should become increasingly precise as time goes on, as the accumulation of knowledge should enable us to get progressively closer to the real economy. However, hydraulic bias is a counterintuitive phenomenon. As time passed the representation actually became increasingly caricatured, excluding dissident elements that did not fit with the problem as it had been framed. The representations of the models were the common denominators of the interests and values of the represented stakeholders (in this case the states), which eventually aligned with the development models that the republics wanted to follow. On one side stood Uzbekistan, which the models represented as a country of thirsty cotton fields that was eligible for international funding to modernize its irrigation system; on the other was Kyrgyzstan, which was represented as a hydroelectric station that had control over water resources in their entirety, thus becoming eligible for international funding for the construction of new dams. The problem was that by truncating a part of reality, the models contributed towards the adverse effects of this grotesque situation: they built the water war – against which they proposed a solution, because they led states towards signing agreements which would ultimately be overwhelmed by those factors that were not taken into account, including water flows. In the specific case of Central Asia, they created transgression and therefore tension between states.

Conclusion

The Central Asian experience demonstrates that we should be especially cautious in the more generalized use of models for public policy, especially on topics that relate to sustainable development and natural resources.

Indeed, a model does not describe the world as it is: but it is a ‘symbolic narrative’ mobilized for action and decision by ‘partisan actors’ (Bouleau, 1999). The question is not whether models can accurately describe the world, but to see what ability they have to rearrange reality.

It is important to recognize the benefits of using models to explore complex systems that integrate multiple dimensions. However, in the example of Central Asia, it did not allow a paradigm shift. This led to the surprising situation where the use of models has contributed to the continuation of a hydraulic paradigm that was, however, criticized by those working on the models, and which ultimately neglected the environment and society. Over time, the model was no longer used to explore reality in its complexity and uncertainty, but was considered as a panopticon, while the model superimposed constraints on the results, and itself became part of the reality that the modellers sought to address.

REFERENCES


6. The issue of representation is as much that of actors around the negotiating table, as that which is proposed in the modelling work. Ultimately, the models only consider the strategies of states, which are based on fragmentary information (administrative statistics) that do not reflect all uses.
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