Chapter 4: Adaptive Community Learning

To our surprise, perhaps (after Chapter 3.4), the centralized wastewater treatment facility of the much denigrated, old, end-of-pipe, water-based paradigm of cities of the Global North, might now rather be looked upon as enabling, if not the *sine qua non* of beneficial nutrient supplements for enhancing watershed ecosystem services. For being "centralized" very often stands for the treatment plant being "riverside-proximate": at the end of the pipe, no less; and a location with therefore considerable appeal from the perspective of effective control over the issuing of those supplements.

It has been our purpose in this *Paper* to provoke just such thoughts, in particular, from the perspective of being deliberately contrarian: here, of turning to potential advantage attributes of a paradigm increasingly perceived over the past two decades as but an unmitigated disadvantage, with no redeeming features. Looking back at Box 1, then, dare we ask: is this 20th Century Technocratic Paradigm (20CTP) truly "broke"? Looking back further, to Chapter 2 and to the deeply challenging debate in the approach to the new millennium, have Chapter 3 and Box 3 now culminated in any case for rehabilitating (in the eyes of their critics) those engineering professionals who may have become intellectually downtrodden over the past two decades?[44]

Every bit as deliberately contrarian has been to argue, in effect, that alongside the titles of popular books and articles such as *When The Rivers Run Dry* (Pearce, 2006), *The Big Thirst* (Fishman, 2011), and *The Last Drop* (Specter, 2006) there is a companion story to be told: of *When the Soils (Do Not) Starve*. It would be the narrative, in large part, of the progression through Figures 1(a) and (b), to Figure 1(c), even Figure 1(d). The struggle is to write some alternative, attention-grabbing headlines.

And so our discussion may have spread divergence, disquiet, disorder, where we could instead have expected convergence and clarity in what it might mean to be less unsustainable. It is time to redress this tendency.

In keeping with the essence of sustainability, our thought experiments and their computational corroboration in Chapters 3.3 and 3.4 have been locked into the long view of the future, perhaps breathtakingly so in their tacit demands on the suspension of disbelief. This imbalance must also now be addressed. For when it comes down to it — for all the plurality of distant aspirations 25-75 years hence and for all the possible twists and turns of what is thought good and what bad over the generations (for the Environment as much as for Man) — one singular routine step forward must be taken "tomorrow", no matter the vagueness of working out how exactly to place that step.

Engineering, Engineers, Their Technologies, and Their Computer Models

Consider once again Figure 2.

As stakeholders in a community we are all free to have aspirations for the fate of our cherished environments in the long-term future. These are the green ovals of Figure 2: what we call sustainable IUWM within IWRM in our professional, technical phrasing. Some of us, binding together in a social solidarity, will broadly share a particular distant vision. Yet there is a plurality of such solidarities, each with its own vision, each defined in opposition to the others. We take such plurality not only as a given in a healthy democracy, but also as the point of departure in conceiving of how to move forward.

Motivated by the perception of Man bumping up against the boundaries of the Environment, the contents of these green ovals in Figure 2 should be authentic, lay expressions, of what constitutes primarily {environmental benignity}. Yet in being authentic aspirations, springing from the idiosyncratic life experiences of those shaping the views of the various solidarities, hence not tidily categorized, these contents cannot be disentangled from the ethical underpinnings of the various world views on economics and {economic feasibility} seen in Chapter 3.2. Nor will they be strictly separable from awareness,

[44] Even the mere asking of the question "Is There a Link Between Engineering and Autism?" seems a sign of the times (Baron-Cohen *et al*, 1997).

no matter how casual, of those technological alternatives of Box 1 that enable paths towards these distant societal aspirations, hence also their fashioning. The {social legitimacy} of these stakeholder aspirations, furthermore, will be gauged according to the collectively appreciated quality of the processes of social deliberation, debate, and negotiation from which they emerge. We know well enough now how sustainability is that immensely complex compound of {environmental benignity}, {economic feasibility}, and {social legitimacy}.

Writing from the perspective of Engineering and the engineer, it is unsurprising that we wish to make clear and specific points about their roles in the overall process of generating that singular routine, practical step "tomorrow", at the origin of Figure 2.

First, beyond the engineer as ordinary member of the community (with values, hopes, and fears, just like everyone else), s/he is *uniquely* well qualified to contribute, in respect of the possible contents of the red rectangles representing the alternative technological trajectories in Figure 2. That there are several of them is merely a reflection of the possibility of more than one school of thought on engineering for sustainable development (Box 1).

Second, it is in the destiny of Engineering to be heading towards simulation as Virtual Reality (NSF, 2006; Beck *et al*, 2009), whether we welcome this, trust the results, or view models simply as the latest incarnation of the ancients' oracles (Schaffer, 1993; Pilkey and Pilkey-Jarvis, 2007; Beck, 2007). Cynics jibe that engineering for sustainable development, succeeding half a century of expert technocracy, amounts to nothing more than engineers rediscovering a Society "out there". Such computational facility as we have today, however, presents a profoundly significant departure from the terms, conditions and dialogs of the Victorian era, when members of the lay public (medics, clerics, and so on) opined on matters of urban water engineering — and were heeded by the engineers of that former time.[45]

[45] As any viewer, technical expert or otherwise, will readily appreciate of portrayals of our possible, distant futures (or pasts) on the *National Geographic* (or *History*) television channels, not to mention the emergence of "decision theaters" for stakeholders (Hall and O'Connell, 2007; Gober, 2009; White *et al*, 2010).

4.1 Within the Frame of Figure 2: The "Engineering Mechanics" of Arriving at One Routine Step

We argue now expressly from a computational standpoint, as a mathematical "microcosm" in which to expose the mechanics of the process with the greatest possible clarity and specificity, including — perhaps paradoxically — all the uncertainty therein.

Consider the "system" here to be the city, its water-nutrient infrastructures, and the watershed. A model $\boldsymbol{M}$ of that system relates policy actions and incoming disturbances (such as a changing climate) — all collectively enfolded under the label $\boldsymbol{u}$ — to outcomes $\boldsymbol{y}$, the green ovals in the upper right-hand corner of Figure 2. The ovals are either to be reached (as hopes) or avoided (as fears), depending upon one's outlook on the Man-Environment relationship. Policy elements of $\boldsymbol{u}$ — caricatured as comprising that immediately pragmatic "one routine step tomorrow", $\boldsymbol{u}_{now}$ we shall say — are conceptually anchored at the lower-left origin of Figure 2.

Embedded within $\boldsymbol{M}$ are elements referred to as parameters (or coefficients) $\boldsymbol{\alpha}$. They characterize mathematical relationships for the mechanisms assumed to be involved in transcribing the consequences for $\boldsymbol{y}$ arising from the choices and assumptions about $\boldsymbol{u}$. These $\boldsymbol{\alpha}$ can be expressed so as to reflect the performances of all the alternative candidate technologies and unit processes that might participate in enabling us to proceed from the one routine step tomorrow ($\boldsymbol{u}_{now}$) to some set of distant future outcomes $\boldsymbol{y}$. Center-span in Figure 2 — and at the core of the model $\boldsymbol{M}$'s structure — the red rectangles of the alternative technological paths (conceptually, the $\boldsymbol{\alpha}$) bridge the gap between the $\boldsymbol{u}_{now}$ and the $\boldsymbol{y}$.

Simply put, we have a computational triplet, [$\boldsymbol{u}$, $\boldsymbol{M}$, $\boldsymbol{y}$], or [$\boldsymbol{u}$, $\boldsymbol{M}\{\boldsymbol{\alpha}\}$, $\boldsymbol{y}$], in slightly more refined terms. And like the mathematical textbook, we can have three basic ways of solving for one unknown given the other two components as knowns: (i) given $\boldsymbol{M}$, for the city-watershed system, and assuming a decision $\boldsymbol{u}$, find the outcome $\boldsymbol{y}$; (ii) given $\boldsymbol{M}$ and some expression of a desired (feared) outcome $\boldsymbol{y}$, find $\boldsymbol{u}$, such that $\boldsymbol{y}$ is attained (avoided); and (iii), given observed $\boldsymbol{u}$ and $\boldsymbol{y}$, find the model $\boldsymbol{M}$. This last will not be of direct concern *per se* herein, which is not to imply it presents no great challenges — quite the opposite. For these challenges

have significant consequences for how the other two textbook problems are to be solved, in particular, in respect of coping with the inevitable uncertainty of $\boldsymbol{M}$ never being the "real thing" (Beck *et al*, 2009).

To reiterate, what is important here is explanation of the mechanics of the process of going forward under (a) plurality, (b) uncertainty, and (c) the absence of myopia, not the particulars of any model that might be mobilized for such a purpose, nor whether a model might even be called for in the first place. Central are matters of technology exploration and assessment, for engineering and re-engineering the infrastructure of IUWM within IWRM. Doing something about our becoming less unsustainable, however, is hardly a textbook mathematical problem. This *Concepts Paper* is not about to assert that it is. Yet the elementary triplet $[\boldsymbol{u}, \boldsymbol{M}\{\boldsymbol{\alpha}\}, \boldsymbol{y}]$ can reveal much about the nature of this "becoming less unsustainable", with but little further elaboration.

Plurality and Disagreement

Our point of departure, once more, is the upper right-hand corner of Figure 2, with the cluster of green ovals of community aspirations for the environment. Chapter 3.1, and Figure 3 in particular, have made it abundantly clear: in a healthy democracy, $\boldsymbol{y}$ is not singular, but plural. Under the archetypal "world views" of the individualist (*I*), hierarchist (*H*), and egalitarian (*E*) solidarities (Figure 3), we should expect there to be outcomes (aspirations, hopes, fears) that may be distinctly different. That is to say, we should expect to have to deal with the multiple and disparate aspirations $\boldsymbol{y}(I)$, $\boldsymbol{y}(H)$, and $\boldsymbol{y}(E)$. *Dissentio ergo sum*![46]

To the left and below these community aspirations in Figure 2 is the technology portfolio of red rectangles. Box 1, from Chapter 3.1, has argued that there is also a plurality of styles of engineering sustainability, or schools of engineering thought. They have been labeled there as 20CTP, D&C, SOS, and so on. The candidate technologies, with their material, environmental, and economic performances parameterized as $\boldsymbol{\alpha}$ in our triplet, might equally so be subject to preferences for the future conditioned upon these several differing styles. We know that ecologists can hold to the disparaging view of engineers as purveyors of "quick fixes" (Poff *et al*, 2003). Thus could the ecologist be implacably opposed to the kind of engineering and technology to which the control engineer might incline ($\boldsymbol{\alpha}(D\&C)$). Much preferred in the ecologist's view would be technical innovations along the lines of $\boldsymbol{\alpha}(SOS)$. We must contend then with the plurality of $\boldsymbol{\alpha}(D\&C)$, $\boldsymbol{\alpha}(SOS)$, and so on. Worse still for we engineers (perhaps), it is conceivable that the control engineer would write his/her model $\boldsymbol{M}_{Control}$ altogether differently from the ecological engineer ($\boldsymbol{M}_{Ecology}$). Each would appeal to differing knowledge-science bases. The former might then intend the web of technology in the city's infrastructure to function as $\boldsymbol{M}_{Control}\{\boldsymbol{\alpha}(20CTP); \boldsymbol{\alpha}(D\&C)\}$, the latter as $\boldsymbol{M}_{Ecology}\{\boldsymbol{\alpha}(SOS); \boldsymbol{\alpha}(SiB;EC)\}$. Given the same $\boldsymbol{u}$, different $\boldsymbol{y}$'s are implied, and *vice versa*.

Such diversity — if not a plurality of fundamental principles for building a water purification plant (as we challenged ourselves in opening this *Paper*) — may seem alien to us working in the domain of IUWM nested within IWRM. It is not to those in other fields, however, such as in the model-based assessments of policies for coping with global climate change undertaken by van Asselt and Rotmans (1996). Solidarities *I*, *E*, and *H*, they assert, will build different elements of the science base into their respective $\boldsymbol{M}_I$, $\boldsymbol{M}_E$, $\boldsymbol{M}_H$ of the behavior of the global atmosphere.

Yet of no surprise to the engineer would be the way in which economists have vigorously contested the nature and form of what is to be done about the inter-generational discounting rate: whether it should be $\boldsymbol{\alpha}(I)$, $\boldsymbol{\alpha}(E)$, or $\boldsymbol{\alpha}(H)$ (as in Chapter 3.2 and Godard (2008)). Opponents of Cultural Theory might well dispute this threefold plurality, observing that the mainstream debate persists as that between the duopoly of just markets ($\boldsymbol{\alpha}(I)$) and governments with their regulations ($\boldsymbol{\alpha}(H)$). Cultural theorists, in their turn, would charge the mainstream debate with being impoverished and wholly inadequate as a result (Thompson, 2008b; Ingram and Thompson, 2010). It

[46] Our point (again) is not that social groupings and their world views *have* to be arranged according to the typology of Cultural Theory. It is rather that in a healthy, democratic community of stakeholders, groupings adhering to certain beliefs and archly opposed convictions will be manifest. This is in the nature of things, and in more ways than we might previously have cared to suppose. It should be acknowledged as such. It makes things more complicated, but it should not be wished way. Indeed, perhaps it ought to be celebrated. Several quite different ways of looking out on the world and the Man-Environment relationship imply plural wisdoms from which to benefit. As already observed in Chapter 3.1, some cultural theorists have put it this way: "I disagree; therefore, I am" (Nowacki *et al*, 2010).

takes little further reflection to recognize the sensitivity of the promise of any one of the red-rectangular technological trajectories of Figure 2 to such possibly vehement disagreement, not least when backed up by all the numerical results of the (plural) scientific and technical models.

Decisions, the $\boldsymbol{u}_{now}$ at the left-hand origin of Figure 2 and the focus of this Chapter 4, are always made under uncertainty. Their formal analysis as such has stimulated the development and accumulation of a vast body of mathematical and computational methods, generally referred to as Decision Making Under Uncertainty (DMUU) (for example, von Winterfeld and Edwards, 1986). Yet there are qualitatively distinct classes of uncertainty, for some of which the toolkit of DMUU is far from being well stocked (Beck *et al*, 2009). Unfortunately, our going forward "under plurality, uncertainty, and the absence of myopia" is especially prone to the most severe of these degrees of increasing uncertainty. Disagreement is again at the heart of the matter.

Consider that the greatest hopes for the future of the individualist grouping ($\boldsymbol{y}(I)$) might entail some of the gravest nightmares of, say, the egalitarians ($\boldsymbol{y}(E)$). The domains of aspirations $\boldsymbol{y}(I)$, $\boldsymbol{y}(H)$, and $\boldsymbol{y}(E)$ may enfold mutual contradictions. Counter-intuitively, the greatest uncertainty may surround coming to a $\boldsymbol{u}_{now}$ when decisions have to be made under the "contradictory certainties" (CC) passionately espoused by those promoting *their* $\boldsymbol{y}(I)$, or *their* $\boldsymbol{y}(H)$, or *their* $\boldsymbol{y}(E)$, i.e., DMUCC (Thompson, 1985). Things that truly matter to people evoke passion. Convinced of the validity of their beliefs — including *their* science and *their* technology — the intensity of the public debate can force parties into ridding *their* position of all uncertainty (while piling it up onto those of the others). Not only may the respective outcomes to which they aspire ($\boldsymbol{y}$) harden towards "certainties", but also the assembly and manipulation of the respective models of the system's behavior ($\boldsymbol{M}$). The plurality and diversity of view tolerated in civil, if disputatious, debate may harden towards the apparent impasse of sharply contradictory certainties, hence the severe forms of uncertainty arising from impassioned disagreements amongst the parties to the debate.[47]

Somehow, the singularity of an "actionable" $\boldsymbol{u}_{now}$ (at the bottom left-hand corner of Figure 2) must be wrung from the confusion of this welter of disagreement.

Uncertainty Under Consensus

Let us imagine agreement breaks out. Absent then the deeply entrenched disagreement amongst the foregoing *Weltanschauungen*, specifically the plurality of core beliefs about the basic nature of the Man-Environment relationship, other forms of uncertainty remain to be addressed. They are largely the customary forms. Given but one agreed model $\boldsymbol{M}$ of the way the world works, a host of constituent hypotheses and assumptions must nevertheless be assembled into it. These concern:

(U1) The contemporary science undergirding the way the current, future, and distant-future candidate technologies are believed to work (hence incorporated into the city's water and nutrient infrastructures); likewise, the contemporary science and approximations of the manner in which the fluxes of materials through and around the city-watershed system are modulated as a function of the watershed's ecosystem.

(U2) The expected economic performance of the technologies; likewise, identification and valuation of the services rendered by the watershed's ecosystem.

(U1) is the technical-statistical uncertainty — as opposed to that of disagreement amongst experts — about the science, (U2) that of the economics. Much greater uncertainty should intuitively be assigned to those scientific and economic parameters ($\boldsymbol{\alpha}$) of the model associated with nascent innovations in prospect over the next 5-20 years, than those attaching to the tried and tested technologies of the past several decades. Much of the discussion of Box 1 is about the risks associated with these (and other) uncertainties.

[47] In the setting of the assessments of the Intergovernmental Panel on Climate Change (IPCC), Patt (2007) has argued that the uncertainties arising from disagreements amongst the technical (professional) experts is rarely properly accounted for and probably greater in significance than the "technical" (statistical kinds of) uncertainties arising from the conventional, quantitative assessment of models ($\boldsymbol{M}$) and their forecasts.

Then there is the uncertainty arising from the differing psychologies of our public and private personas, with their influence over:

(U3) The effectiveness of policy, hammered out in the public space of debate amongst the collective, openly expressed voices of the solidarities (*I, E, H*), when contingent on the strictly personal, undisclosed choices of individuals, made in the isolation and quietude of their private space — choices about, for instance, the adoption of alternative household plumbing appliances and, subsequently, assiduous attention to their appropriate operation.

(U3) is the uncertainty regarding what policy $\boldsymbol{u}$ — including $\boldsymbol{u}_{now}$ — can actually deliver in respect of its commitments, no matter how sustainable and socially legitimate has been its genesis. Solidarities might have agreed in public to opt for innovations that are small, beautiful, and individually empowering (SiB). Yet the same individual who went with the crowd in public, may blithely ignore the smart device in the shower that warns of imminent excessive consumption of water and energy (Willis *et al*, 2010).

Absence of Myopia in the Face of Constant Change

The further any analysis is projected away from the myopia of just the here and now, both forward into the future and backward into the past, the greater will be the uncertainties clouding the making of a decision. From the framework of Figure 2 we wish somehow to extract from the daunting morass of even our mathematical microcosm just the one routine step for tomorrow. Our *singular* $\boldsymbol{u}_{now}$ at the bottom left-hand corner (of Figure 2) must be snatched from the jaws of all the plurality, vagueness, contentiousness, and uncertainty of the social aspirations $\boldsymbol{y}(I)$, $\boldsymbol{y}(H)$, and $\boldsymbol{y}(E)$; from the economic valuations V_0, V_C, V_E, or V_X ; from the schools of engineering thought, such as $\boldsymbol{M}_{Control}\{\boldsymbol{\alpha}(20CTP);\boldsymbol{\alpha}(D\&C)\}$ and $\boldsymbol{M}_{Ecology}\{\boldsymbol{\alpha}(SOS);\boldsymbol{\alpha}(SiB;EC)\}$; and with all of these being subject to flux and strategic change under the long view over future time (t_{future}).

We may attempt to do so calculating forwards with our notional model ($\boldsymbol{M}$), i.e., given a candidate policy/choice/decision $\boldsymbol{u}_{now}$, and given $\boldsymbol{M}$, determine the future outcome $\boldsymbol{y}$. We did just this across Chapters 3.3 and 3.4, developing a case there for re-engineering the city of Atlanta so that it might become a force for good in the Chattahoochee watershed.[48] Sustainability was gauged according to the nutrient spectra of the outcomes, under the PeFe aspiration ($\boldsymbol{y}$), and experimenting with a policy $\boldsymbol{u}_{now}$ gathered around the possible implementation of urine-separating toilets, truck transport, digesters, stripping towers, absorption towers, and so on. The logic of the exercise was wound forwards (many times) across the framework of Figure 2, essentially left to right. We asked, in effect, "what if" we were to take such and such a $\boldsymbol{u}_{now}$ to attain some (very) distant desired, sustainable, green-oval, environmental future, $\boldsymbol{y}(t_{future})$. In fact, those disillusioned, jaundiced, or cynical about sustainable development might scoff: $\boldsymbol{y}(t_{future})$ is $\boldsymbol{y}(t_\infty)$, as time t goes to infinity (t_∞)!

Inverse Approach

How might things turn out, were we instead to wind the logic backwards, as in the second of our mathematical textbook problems (determine $\boldsymbol{u}$ given $\boldsymbol{y}$ and $\boldsymbol{M}$), to run across Figure 2 from the expansiveness of the cluster of green ovals at its upper right-hand corner to the singularity of the one routine step at its lower left-hand corner, at the origin of Figure 2? This is not rhetoric. For we can ask this kind of question:

> To what extent, under gross uncertainty, can a candidate policy for taking "one routine step tomorrow" ($\boldsymbol{u}_{now}$) offer the prospect of: (a) not foreclosing on attaining (avoiding) the plural, not necessarily shared, positive (negative) visions of the future (the set of [$\boldsymbol{y}(I;t_{future})$, $\boldsymbol{y}(H;t_{future})$, $\boldsymbol{y}(E;t_{future})$]); (b) contingent upon which handful of key technologies $\boldsymbol{\alpha}_{key}$; and (c) amidst all the scientific, system-wide unknowns about how a local, context-specific technical innovation relates to a global environmental good?

[48] The metaphorical turning of each cog within the model $\boldsymbol{M}$ can be metered for the resources mobilized and the services provided, be they the materials, energy, and chemicals consumed in each local, unit process of the infrastructure, or the prosperity of each ecosystem service provider in the watershed. Numbers pertaining to determinations of those uncommon facets of {economic feasibility}, let us say V_E or V_X, can be generated, just as in using engineering simulation to generate conventional, marginal cost (V_0) data in the more pragmatic context of watershed nutrient trading (Jiang *et al*, 2005).

We already have the proven prospect of deriving pertinent answers, as in the Adaptive Community Learning (ACL) of Beck *et al* (2002) and the computational "inverse" approach of Osidele and Beck (2003) (see also Chen and Beck (1997), Beck (2002), and Villarroel Walker (2010)).

Conceptually, the mechanics of the process of going forward under plurality, uncertainty, and the absence of myopia, are a matter of going backwards across the framework of Figure 2: entry at the cluster of several green oval domains (plural $\boldsymbol{y}$); exit at the origin of one routine step "tomorrow" ($\boldsymbol{u}_{now}$). Formally and practically, it would be a sheer delight to find some way of digging a trench ($\boldsymbol{u}_{now}$), as the epitome of that one hum-drum, routine step for tomorrow, which may not be to the liking of all the stakeholders (*I, H, E*), but which does not undermine their capacity to hold fast to their respective distant, cherished aspirations, of $\boldsymbol{y}(I;t_{future})$ or $\boldsymbol{y}(H;t_{future})$ or $\boldsymbol{y}(E;t_{future})$ — at least for a while (Δt) — as $\boldsymbol{u}_{now}$ is put into practice, from $\boldsymbol{t}_{now}$ to $\boldsymbol{t}_{now} + \Delta t$.

Given all the varied perspectives, the trench might need to be seen as pointing metaphorically every which way down the street. Far from narrowing the hopes of our distant visions, moreover, this immediately pragmatic decision ($\boldsymbol{u}_{now}$) should instead expand our horizons. How should we dig such a trench, under the prevailing thinking of 20CTP (from Box 1), so that in 5, or 10, or 15 years' time the equipment and pipework laid down today would need minimal adaptation in order for a neighborhood to migrate towards either of the structural rearrangements of Figure 1(c) (in pursuit of S@S) and 1(d) (to promote EC)? How could this trench pave the way for incorporating ever more of the styles of D&C or SOS into the three basic configurations of that Figure 1? Inspired by an SiB style of engineering sustainability, how might the trench honor systematic decentralization of any one of the three strategic configurations? The possibilities for the form of any such marvelously "sustainable trench" are combinatorially complex (Figure 12).

The metaphor of the model ($\boldsymbol{M}$) has served its purpose, of enabling as much clarity as possible regarding the mechanics of fashioning the one routine step tomorrow from the plurality of the community's innate aspirations for the distant future. The naked, rattling bones of the yet intricate anatomy of the challenge of Chapter 2.4 have been laid bare. We know that whatever candidate policy steps are to emerge from Figure 2, courtesy of the mechanics of the foregoing process, none will be successfully implemented — as *sustainable* actions — if the scheme of their generation lacks {social legitimacy} in the eyes of the community of stakeholders.

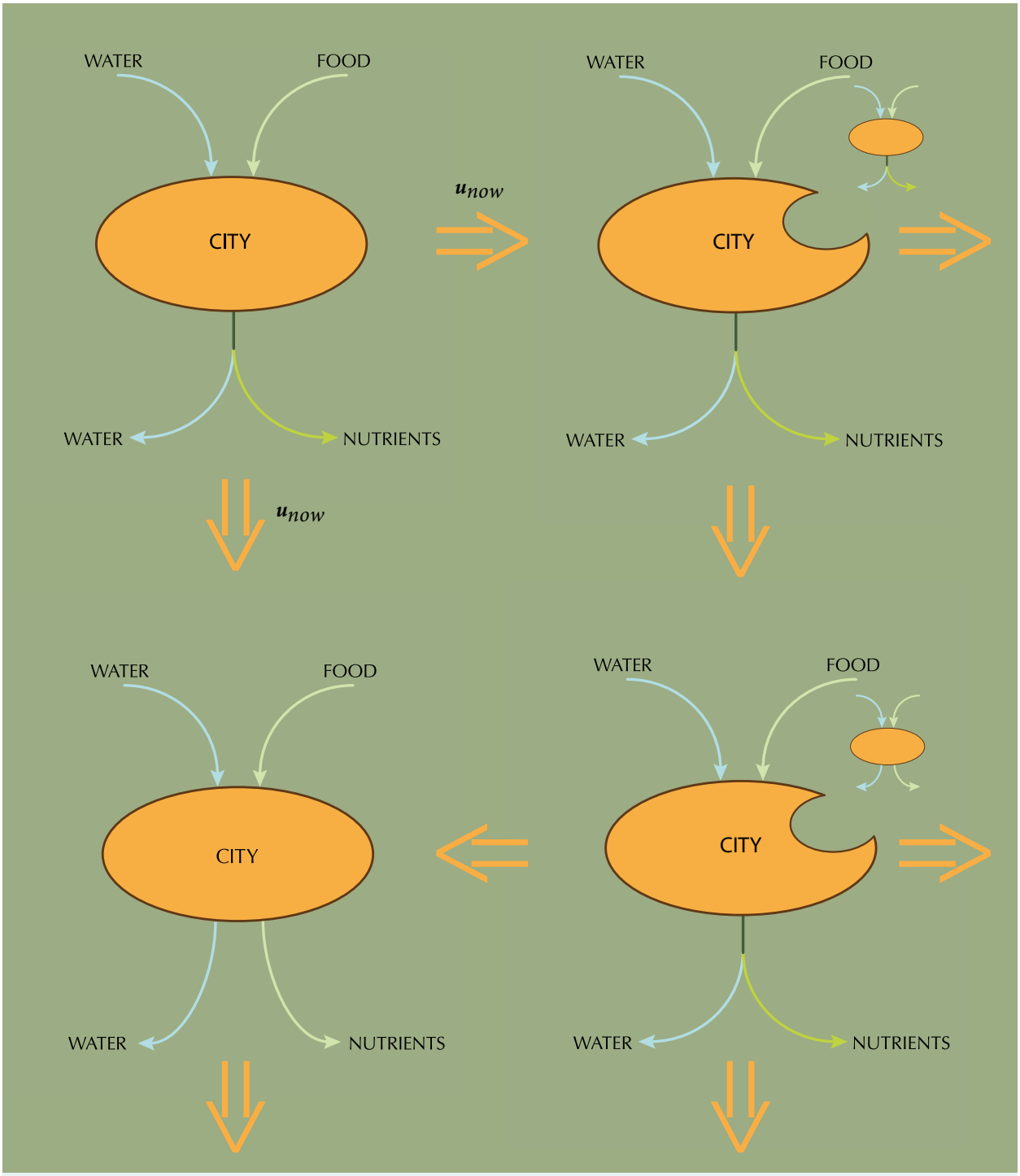

Figure 12
One routine step "tomorrow" ($\boldsymbol{u}_{now}$): the combinatorially complex challenge of inventing the "sustainable trench". This figure has been assembled from the iconic caricatures of the structural arrangements of the city and its water-nutrient infrastructures of Figure 1, namely Figures 1(a), (c), and (d). Starting from current arrangements (top left icon), and signaling incremental decentralization according to the top right icon, just a few of the many structural re-configurations are imagined (as structural transitions, =>). The challenge is to conceive of what kind of trench, pipework, and other fittings might be integral to facilitating the maximum number of transitions (=>) over time into the distant future, while being environmentally benign, economically feasible, and socially legitimate in an inter-generational sense. The alternative of dry sanitation (the icon of Figure 1(d)) has been omitted in the interests of bounding the potential visual complexity.

4.2 Around and About the Frame of Figure 2: Legitimacy of the Social Process of Arriving at One Routine Step

Our argument has reached out for the elegance and tightness of mathematical metaphor to expose the *inner* workings (in concept) of Figure 2. Since governance can be either enabling or disabling of those mechanics, we now appeal to some elevated principles of democracy for conducting the public debate *surrounding* the entire space of Figure 2.

Succinctly put, and to reiterate (from Chapter 3.1), each solidarity within the given community should have a voice; that voice should not be rendered inaudible by any other voice sufficiently raising its volume; each voice should instead be acknowledged by those of the other solidarities and be credited with a reasoned response from them. Ney (2009) has proposed the simplicity of a matrix for assessing exactly where any particular governance structure lies in terms of *access* — being granted a voice in the debate — and *responsiveness* (these being Dahl's (1989) two crucial dimensions of pluralist democracy). The strong implication is that the greater the access and responsiveness of a scheme of governance, the greater will be the probability of {social legitimacy} being accorded not only to that scheme but also its outcomes.

The Specialist Group on Sustainability in the Water Sector of the International Water Association (IWA) has begun experimenting with its own microcosm of such a pluralist democracy, namely the (2006 and 2008) biennial Sustainability *Agora* (Beck and Jeffrey, 2007). In the spirit of good-humored theater, the *Agora* stages the scene of a market place wherein problem framers pitch their stalls and vie with each other for the attention and purchasing power of IWA shoppers — as professional engineers — seeking to sell them genuine articles of sustainability problem-solving.

As Box 4 relates, there is a growing appreciation of how to construct the stalls and identify the stall-holders — to get into the processes of Figure 2 — but not of the shopping experience, i.e., the manner of "buying into" that one routine step tomorrow, hence exiting subsequently from the deliberations of Figure 2. The uncertainties surrounding the process, moreover, may technically render no one routine step tomorrow unambiguously worth buying into by a majority.

This uncertainty, of course, is the whole problem, yet we may know which key uncertainties are the prime targets for our collective attention in order to reduce them, by what ever manner of research or policy action.

These Sustainability *Agora* have been experiments: two trials; two volumes of errors. How might we now translate insights from a concocted, simplified, laboratory-theater microcosm into better designs for structures of governance in the complex, practical, messiness of the "real world"? Is there a particular structure, or scale, of governance lending itself to experimentation, learning, and adaptation? Or, at the least, how should we re-design the next *Agora* as a device for catalyzing improvements in the quality of governance in a real-world community? In closing the discussion of Box 4, we draw upon practical experience from South Asia — on water, sanitation, and human settlements — to illustrate the conceptual distinction between a form of governance enabling "constructive engagement" amongst the vying parties and that disabling such, hence destructive impasse (Gyawali, 2004). The business of the *Agora* is clearly unfinished. Its purpose has hitherto been solely that of learning about constructive engagement, not the occurrence of destructive impasse. A sound appreciation of both is important. There is plenty of scope for further experimentation.

Experimentation, Learning, and Adaptation

In just two steps this discussion has now vaulted over the mathematical abstraction of a model (***M***), as metaphor for exposing the mechanics of our working within Figure 2, up to the highest ideals of pluralist democracy, for navigating around that picture, hence bestowing {social legitimacy} on its enfolded processes of seeking {environmental benignity} of action. Command of such mental gymnastics, we might say, is what sustainability is all about. It is every bit as necessary in making the most of these tensions: between the sharply juxtaposed "one routine step tomorrow" and the "inspired visions generations hence"; and between achieving ever greater efficiency and reduction in the city's metabolism of its daily water, for example, and manipulating the metabolism of the city's daily bread as a force for good in the watershed.

Making decisions is not a static thing, wherein participation of the community occurs once and for

all during a process itself restricted to a finite period of time (Shepherd, 1998; Steinemann, 2001; Borsuk *et al*, 2008). Making credible commitments to, or buying into, one routine step at time t_1 (t_{now}), towards the origin of Figure 2, should take the state of affairs — of community-environment interaction — to that at time t_2 ($t_{now} + \Delta t$) in Figure 13. That is to say, we should be quite deliberate about the fact that the community's aspirations for the distant future (green ovals), as well as the candidate technological trajectories (red rectangles), will have evolved, or been rearranged with the passage of time. Beyond the framing of Figure 2 and working within and around it, now subsumed as merely the first of endless such iterations in Figure 13, we must consider by what means a community should move itself from one state of affairs (at t_1) to the next (at t_2), prudently experimenting with its style of governance, as it proceeds.

This begs various questions. What exactly is to be learned from a preceding iteration (at t_1), by the solidarities within the community as a whole, and by the engineers, in particular? How is that learning to be put to good use in proceeding to the subsequent iteration? How does the action or policy emerging from the "origin" at t_1 create the possibilities evident at t_2, while yet "solving" the central problems on the minds of community members as they were at t_1? In sum, the challenge is to assess how community views (on sustaining and stewarding a given piece of the environment) may change over time as a function of iterative interaction with engineers as generators of technological options (and with the science base, in general), within the overall framework of Adaptive Community Learning (ACL; Beck *et al*, 2002).

We know what adaptive management is (Holling, 1978; Figure 14(a)). In essence, policy therein fulfils two functions: to probe the behavior of the environmental system in a manner designed to reduce uncertainty about that behavior, i.e., to enhance learning about the nature of the *physical* system; and to bring about some form of desired behavior in that system (an adaptation itself recommended as the next step in IWRM; Pahl-Wostl *et al*, 2007a). ACL ought both to subsume the principles of adaptive management (so defined) and

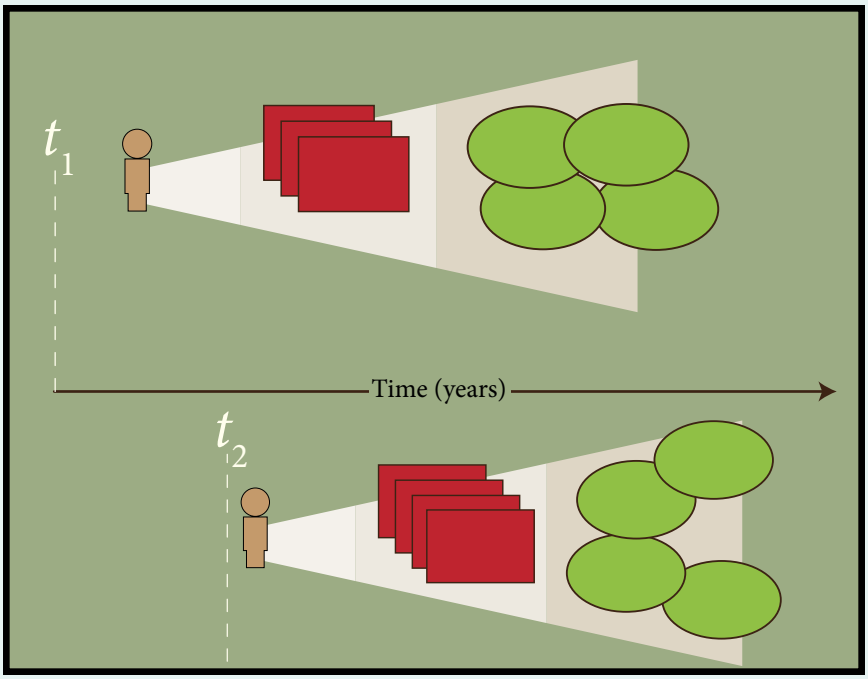

Figure 13
Two frames in the evolution of the "big picture" of Figure 2 frozen in time at t_1 and t_2, with different numbers of distant, inter-generational futures (green ovals) and alternative technological paths (red rectangles), all with their contents changing over time.

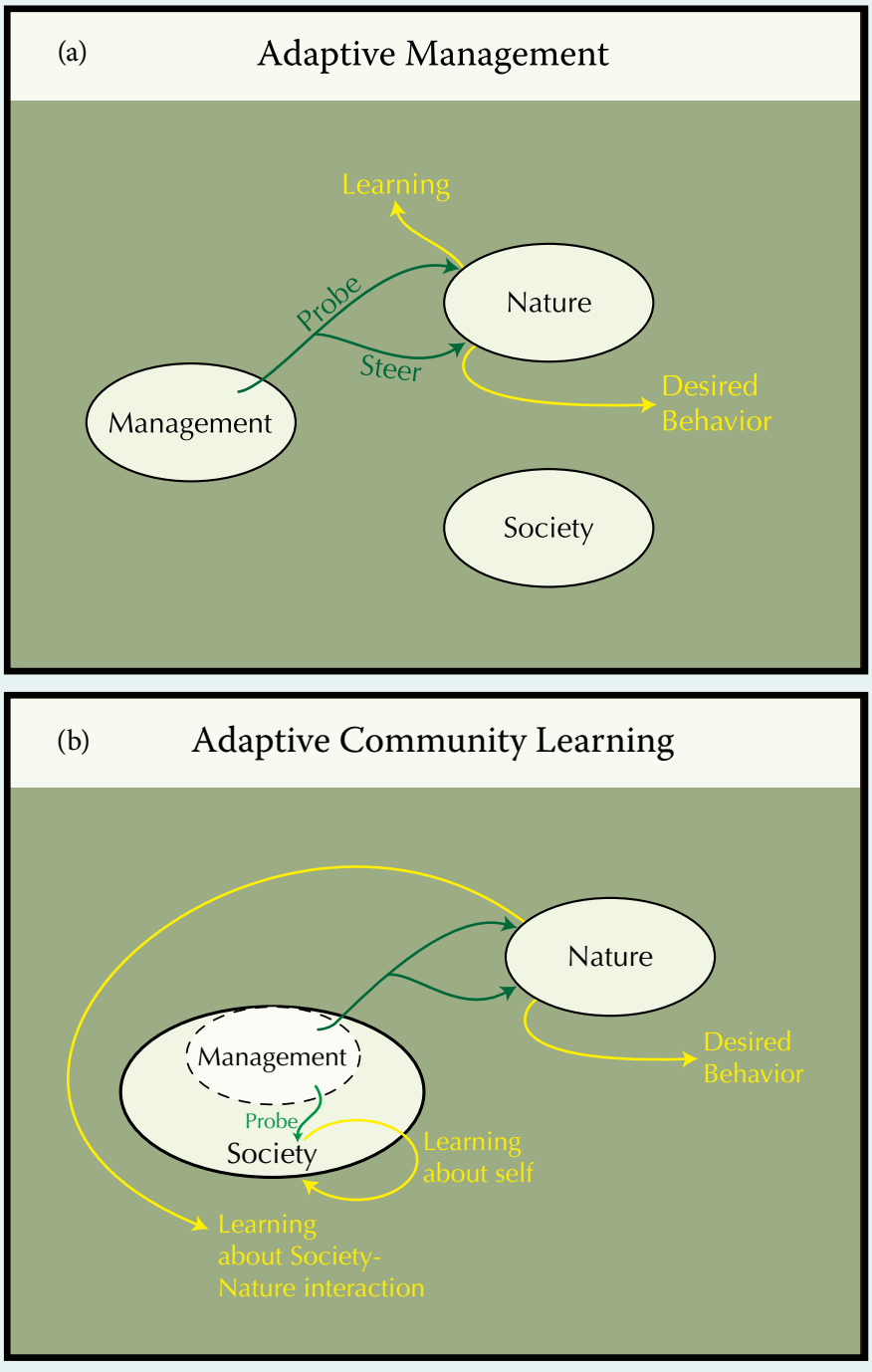

Figure 14
Figurative renderings of the ideas of "learning" and "management": (a) adaptive management, in which the dual purpose of policy, emanating from "management", is to steer the behavior of Nature (or the Environment) in some desired direction while probing the nature of that behavior (at one and the same time); and (b) adaptive community learning, wherein "management" is seen not as somehow separate from Society, but embedded within it, and the purposes of policy are not only those of adaptive management but also that of probing the nature of Man's interaction with Environment and Man's interaction with Man.

include actions, or a process of decision-making, whereby the community of stakeholders experiences learning about *itself*, its forms of governance, its relationship with the valued piece of the environment, i.e., the community-environment relationship, and the functioning of the physical environment (Figure 14(b)).

When ACL was first conceived (Figure 15(a)), "Analysts" were considered to be standing quite apart from "Society" (Box 4). Just two "green ovals" of future aspirations were supposed. They had been generated from a professionally facilitated "Foresight Workshop", as a matter of the *collective* imagination (aspirations) of all the workshop participants, i.e., independently of

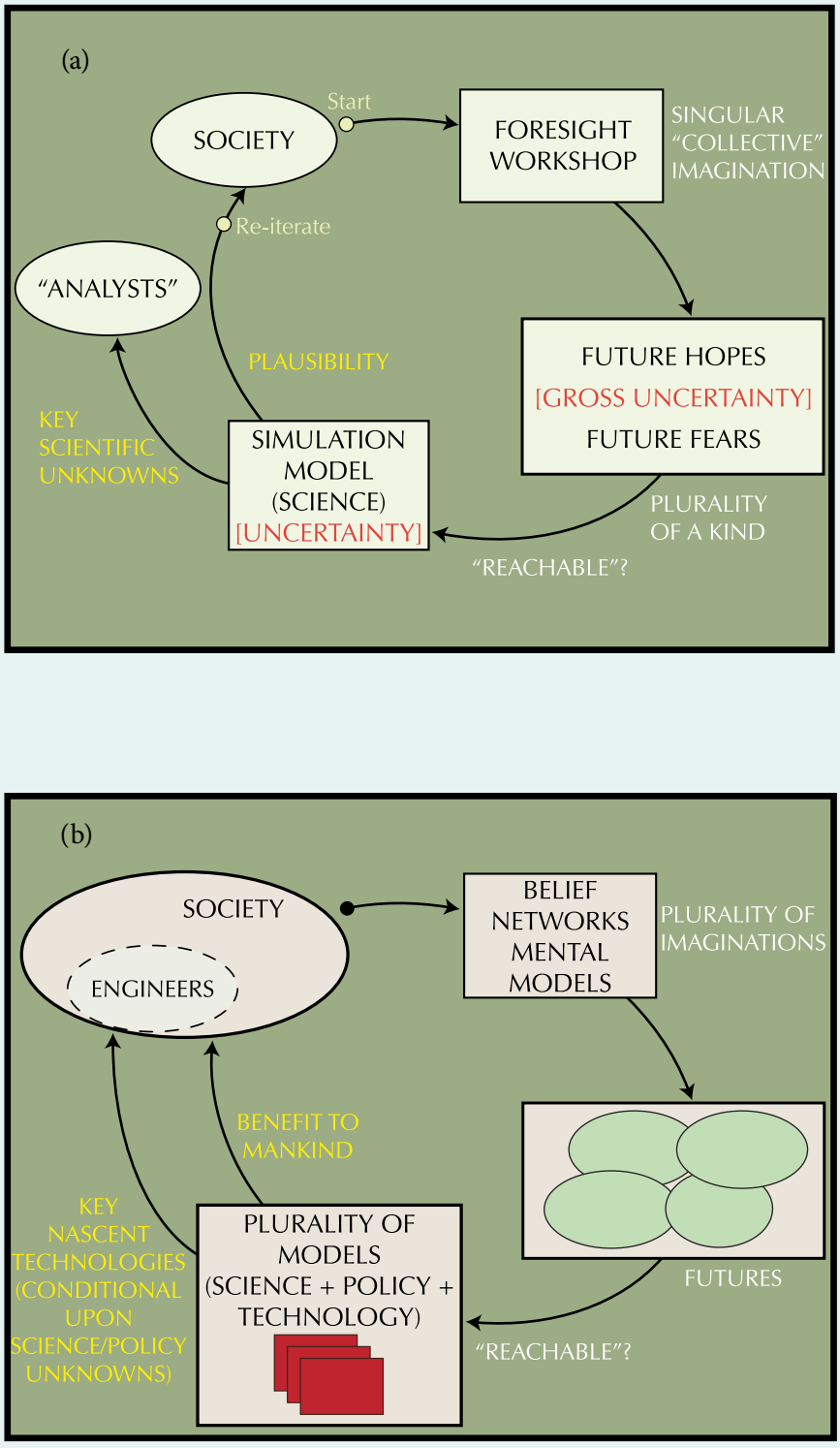

Figure 15
The endless iterations of "going forward in spite of vagueness": (a) as originally envisaged in an earlier prototypical study of adaptive community learning in the context of assuring the ecological health of Lake Lanier (in the Upper Chattahoochee watershed, Georgia; Beck *et al*, 2002); and (b) as adapted in the presently wider purview of seeking strategies for re-engineering the city as a force for good and sustainability in the water sector. The authentic green oval aspirations of the plurality of solidarities within the given community (in (b)) have replaced the single set of future hopes and single set of future fears derived from a professionally facilitated workshop (in (a)). Likewise, a plurality of plausible models (***M***), formally embracing respectively differing sets of red rectangles for the alternative technologies appealing to each solidarity, has in (b) replaced just the single notional model of (a), which covered but the bits of the science base (and their respective uncertainties). Furthermore, the "Analysts" previously conceived of in (a) as strictly and clinically separate from "Society" are in (b) viewed as integral members of "Society".

any solidarities. They were that whole group's greatest "Hopes" and worst "Fears". In other words, they were not the set of disparate aspirations $\boldsymbol{y}(I)$, $\boldsymbol{y}(H)$, and $\boldsymbol{y}(E)$ introduced earlier (and which are of concern in Box 4). "Society" was to learn something of the "Plausibility" (or "Reachability") of these "Hopes" and "Fears", conditional upon the current "Science" base, all its uncertainties notwithstanding. The "Analysts", for their part, were to acquire a sense of what might be the small handful of "Key Scientific Unknowns" crucial to the reachability of society's hopes and fears (Beck *et al*, 2002; Osidele and Beck, 2003; Fath and Beck, 2005; Hare *et al*, 2006).

In proceeding thus from t_1 to t_2 in Figure 13, what members of the various solidarities within the community acquire is several-fold:

(B1) an appreciation of the plausibility, or otherwise, of their distant visions (at t_1) (Figure 15(a); or its future realization as Figure 15(b));

(B2) reassurance — perhaps — of no foreclosing on the promise of attaining their distant hopes, if not the express pursuit of these hopes, for the time being (over Δt); and

(B3) a sense of how those visions might be re-shaped, when the time (t_2) comes, according to their personal exposure to the technology and science as they too stood at t_1.

For their part, the professional engineers acquire:

(B4) an appreciation of those key technologies ($\boldsymbol{\alpha}_{key}$) likely both to better serve the community's longer-term aspirations, as imagined at t_1, and to promote burgeoning possibilities for both those aspirations and the technological options the next time around, at t_2.

For Boulanger (2008), the deliberative style of democracy should succeed over any mere aggregative style, as the means for the community to be collectively engaged in taking prior societal preferences (at t_1) and fashioning posterior preferences by t_2. Thompson (2002), envisioning future times t_3, t_4, t_5, ... (beyond t_2), would call this a "Road Without End". Mutual learning amongst his various solidarities would ensue at each t_k, as they proceed along that way — with now these refinements and embellishments of (B2):

($B2_1$) some getting more of what they want, others — having realized the possible threat of getting absolutely nothing attractive (Gyawali, 2004) — getting less of what they do not want (which is what the others would want), or (as related in Thompson (2011)), no one group having things all its own way, no one getting much more than the others, each getting much more than nothing, and each getting more of what it wants than it would have got, had it "gone it alone" and succeeded in imposing its needs on all the others;

($B2_2$) all, perhaps essentially, being allowed still to cherish what they hope for (and harbor what they fear) in the ever distant long term (multiple Δt's ahead, in $\boldsymbol{t}_{future}$), i.e., to hold fast to their differing views of the Man-Environment relationship; and

($B2_3$) all collectively moving forward to t_{k+1} — albeit some grudgingly and for just a while (Δt) — when plans and experiences (some surprising) may all change once more ("always learning, never getting it right").

Looking to a future realization of Adaptive Community Learning, we imagine Figure 15(b) as a procedural and conceptual advance upon Figure 15(a). "Engineers", we note further, have there been gathered back into "Society"— in fact, welcomed, we trust(!) (Figure 15(b)).

These high-minded ideals are not floating entirely free of their counterparts in the mechanics of the models ($\boldsymbol{M}$) and computation. The fruits of their application must be channeled back — given all the outcomes ($\boldsymbol{y}$) and models $\boldsymbol{M}$ — into the singularity of a $\boldsymbol{u}_{now}$ and the intensely practical action, for example, of digging the sustainable trench (according to Figure 12). Working thus on the prospects for broad-scale adoption of the urine-separating toilet (part of a red rectangle in Figure 2), in a framework ($\boldsymbol{M}$) of Multi-Criteria Decision Analysis (MCDA), Borsuk *et al* (2008) envisage a sequence of incremental transitions, away from today's Business-as-Usual towards *inter alia* the distant-future target vision of Perfect Fertilizer (green oval).

The computational studies of Janssen and Carpenter (1999) on the decades-long resilience of farmer-landscape systems, with agents (simulated farmers) imbued with the differing perspectives of Cultural

Theory (Thompson *et al*, 1990), could be imported into the urban setting. There, the model (***M***) could be used to play out the endless negotiations amongst citizens and other agents (public- and private-sector) over this, that, or the other technology and policy prescription for moving away from unsustainability in IUWM, as the years pass by. Might there be a "social tipping point" — of mass buy-in to the ideas of the sustainable lifestyle — somewhere in the person-centric beliefs of the kind set out in Figure B2.1 of Box 2? Would it be ethical for engineers to ponder fashioning a $\boldsymbol{u}_{now}$ as an intervention intended to push the affairs of the community towards any such tipping point? These types of agent based models (ABM; ***M***) are the focus of Lempert's (2002) analysis of the adoption and diffusion of alternative technologies in the energy sector, under the prospect of climate change.[49] They might even be put to investigating schemes of inter-generational discounting, such as those of Sumaila and Walters (2005) from Chapter 3.2, with new agents entering the fray as they come of age, acquiring the right to vote — better, as Boulanger (2008) would assert, to deliberate (and, as we shall assert in Chapter 5, to deliberate with improving quality).

Just as adaptive management celebrates a prudent measure of experimentation, so should ACL (Norton and Steinemann, 2001). And so we ask:

> Can there be a routine, policy action designed to probe uncertainties in the performance of the current structure of governance?
>
> Can it be one designed to inspire improvement in the deliberative quality of the scheme for attaining {social legitimacy} of that and future actions?
>
> Could it be designed to increase creativity in inventing, re-arranging, and re-shaping all the icons in Figure 13 (both the greens and the reds)?

Experimental and Adaptive Governance on an Urban Scale

Our focus is on integrated *urban* water management (within IWRM). Yet for all the global recognition of the current water crisis as a crisis of water governance (GWP, 2000b, 2002; WWAP, 2006), hardly anyone has pointed specifically to the institutions of *urban* governance as bearing any promise of a means of resolving the perceived crisis. The work of Gatzweiler (2006) is therefore of special interest. For he has recently proposed "borrowing from the organization of public economies in *metropolitan* areas" (emphasis added) in order to suggest design principles for polycentric, multilevel governance in a coffee forest conservation project in Ethiopia.[50] This he labels a "public ecosystem service economy for sustaining biodiversity".

If Gatzweiler can borrow thus from the focus of our discussion herein (in this *Paper*) to explore a form of governance *enabling* the maintenance, if not expansion, of ecosystem services, this surely has to be of some interest to us. Little imagination should therefore be required to appreciate the benefits for I*Urban*WM of its being lodged already within metropolitan governance and those further benefits that might then flow outwards therefrom to IWRM in respect of watershed ecosystem services.

Gatzweiler (2006) opens with this:

> Scholars have suggested that the governance of complex systems should be dispersed across multiple centers of authority and that any regulative system needs as much variety in the actions that it can take as exists in the system it is regulating.

He then executes a swift, comprehensive sweep across the foregoing elements of solidarities, voices, and pluralist democracy, which together amount to {social legitimacy}. This he does apparently independently of the contributions from Dahl, Thompson, and Ney, to the betterment therefore of our own present arguments.

[49] For the energy sector, however, simulated agents might not require priming with the same diversity of cultural inclinations as they would for assessing human-engineering interactions in the water sector. Energy as fire can have some significance for some cultures, but this will not be the case — we suspect — for energy in the form of an electricity grid system.

[50] Echoes of which polycentric governance can be found in proposals for future structures of governance operating at the somewhat wider scale of IWRM (Pahl-Wostl *et al*, 2007a). Crossing scales in the opposite direction, as it were, Bai (2007b) suggests there is a persuasive body of evidence in favor of issues of *global* environmental change being addressed effectively at the scale of *city* governance.

Because of market failure, he reports, there are those who argue we need public intervention, adding (Gatzweiler, 2006):

> Preferences of citizens also vary sharply across regions within a state, and if one takes such heterogeneity into account, the optimal level of authority may be lower than economies of scale dictate.

However, yet others assert that (again according to Gatzweiler):

> Because so many individuals and businesses are involved in the production of environmental public goods, the government cannot manage their output and therefore the market has to be involved ...

whereupon he concludes (Gatzweiler, 2006):

> The better truth is probably that neither markets nor states, nor other governance types alone are panacea for the governance of a public ecosystem service economy.

And in this we can find resonance with the three actor-voices of "markets", "states", and "other" introduced into the discussion of {social legitimacy} in Chapter 3.1. Amongst the last of these voices (the "other") might be heard that of civil society.

We are reminded too (by Gatzweiler) of Solow's (1991) moral dilemma, embedded in the earlier discussion of {economic feasibility} in Chapter 3.2: that those of us who would care so much for the well-being of the next generation might thereby seem to care so little for the masses of today's poor. This Gatzweiler (2006) articulates in these terms:

> If not immediately required for the production or harvest of private goods, the maintenance of ecological regulation functions is reduced to a minimum, eventually resulting in resource degradation. Poverty (usually defined by the rules of the market economy itself) enforces this process because escaping from poverty requires individual farmers to adopt short-term survival strategies and disables long-term investment strategies.

Gatzweiler intends, therefore, to borrow from the better of the schemes of metropolitan governance to begin illuminating (for us) a path through Solow's dilemma (Gatzweiler, 2006):

> In sum, we know how to arrange for the private delivery of private goods and services by the means of the market and we also know how to organize the public delivery of public goods and services by bureaucracy. What we need to learn is how to better involve the private in the delivery of public services (e.g., co-production) and how to better involve the public [civil-society actors (?)] in the delivery of public ecosystem goods and services which are now exclusively organized privately.

All of this, nevertheless, remains merely something with promise in concept. For it is *scholars*, we note, who have pointed to the potential experimental benefits of polycentric governance, just as much as the same have engaged in further conjecture (Gatzweiler, 2006):

> Other hypothesized benefits of multi-level governance are that it provides more complete information of constituents' preferences, is more adaptive in response to changing preferences, is more open to experimentation and innovation, and that it facilitates credible commitments.

We might very well want this form of metropolitan governance to surround the mechanics of entry into and exit from the processes of Figure 2.

4.3 Cities as Forces for Social Good

In this *Concepts Paper*, we have arrived where we are now through an argument driven by the prospect of cities as forces for good (CFG) in respect of {environmental benignity}. Economist and activist Paul Romer, however, has for quite some time been thinking of CFG in respect of {social legitimacy} and good governance — "charter cities", in his vocabulary (Romer, 2010). "How to free people from bad rules?", he asks (Romer, 2010) and proclaims: "Forget aid — people in the poorest countries need new cities with different rules. And developed countries should be the ones that build them" (Romer, 2010). People, the argument runs, should be encouraged to move to places with better rules (better governance), specifically and importantly at the scale of the city. "The choice is not whether the developing world will urbanise or not — merely where and under what rules"; and for Romer that "where" should be some "piece of uninhabited land". This would be a rural-to-urban migration deliberately motivated by the desire to escape poor governance, as opposed to that of the rural-to-urban migrants of 19th-century Europe, who simply happened to take with them their culturally acquired styles of water governance (Barraqué *et al*, 2006; Chapter 3.2).

Could a "charter city" succeed for urban-to-urban migration, however, for impoverished individuals seeking to escape from the corruption and mafia-style water operations observed in modern times by Bakker (2006)? For they, acting alone or within their community, would essentially have to "decide for themselves", under the "right" incentives[51] — and surely not as a matter of any "bad" rule of governance, such as coercion. Much more clear is the fact that Romer's charter cities would require nation-to-nation agreements. And between these two scales — the local-individual and the national — that of the city is pivotal, precisely as it is for Gatzweiler (2006) and, indeed, for this entire *Concepts Paper*.

[51] Hong Kong during the 1950s and 1960s and post-independence Mauritius (from 1968 onwards) are suggested as models for charter cities.

BOX 4

Atlanta-Chattahoochee, the IWA Sustainability Agora, and Some South Asian Experience: Governance in the Microcosm and Macrocosm

Salutary Experience

Around the turn of the millennium, the concept of Adaptive Community Learning (ACL) was being developed and its prototypical procedure assembled in a "participatory study" of shaping policy for community-led stewardship of the long-term (inter-generational) ecological integrity of Lake Lanier (Beck *et al*, 2002; Osidele and Beck, 2003; see also Beck *et al*, 2011b). It is whence the "inverse approach" of Chapter 4.1 derives.

Constructed in 1958 through impoundment of the Chattahoochee River, Lanier lies to the north of Atlanta in the north-east corner of the framed "Area of Metropolitan Atlanta" in Figure 8(a) (from Chapter 3.3). The lake is the city's principal source of potable water. The way in which impounded water is released from Lanier to flow downstream, and the legal basis for Atlanta's appropriation of the impounded water, lie at the heart of the two decades of as yet unresolved "water wars" amongst the states of Georgia, Alabama, and Florida. It was known then (in 1998/9) that this research on ACL would be entering a highly charged political situation (as already noted in Chapter 3.3).

The experience was salutary and to this day has shaped the writing of this *Concepts Paper*. Much was learned, as recounted briefly in Hare *et al* (2006). What was funded as research intended to puncture the impulse towards litigation, over rules and policies emanating from the US Environmental Protection Agency (EPA), in due course provoked the issue of a formal threat of litigation to the project's Principal Investigator.[1] In retrospect, one may conjecture that a small solidarity within the governing committee of a stakeholder association — a solidarity, let us say, holding one of the positions in the Cultural Theory (CT) diagram of Figure 3 — came to fear that the research team's survey instrument would reveal sizeable numbers of the rank and file members of the association with quite other positions on the Man-Environment relationship of Figure 3. Indeed, there is some statistical evidence of this (Fath and Beck, 2005). Any such lack of a singular solidarity across the entire association, i.e., the position held by the governing committee, may have been perceived by the committee as undermining its stance (of implacable opposition) towards some of the other actors and agencies in the scene. Looking back, all this appears ordinary and unsurprising.[2]

IWA Sustainability Agora

In the much less politically charged setting of technical sessions of the World Water Congresses of the International Water Association (IWA), the Association's Specialist Group on Sustainability in the Water Sector has begun experimenting with its own microcosm of the kind of refurbished pluralist democracy already introduced in Chapter 3.1 (and the subject not only of the present Chapter 4.2, but also, more expansively, Chapter 5). This has been called the IWA Sustainability *Agora*, now twice hosted in 2006 and 2008 (Beck and Jeffrey, 2007).

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[1] This was myself. Thus I learned that engineers and computational analysts can, in practice, become a part of the problem, not its solution (Hare *et al*, 2006; Figures 15(a) and (b)).

[2] Doubtless too, there was an under-current: that we academics (not merely myself) may have conveyed the impression of being more interested in the outlooks and mind-sets of the stakeholders than in addressing the practical resolution of *their* issues.

BOX 4

With the benefit of learning from the experience of the prototypical 2006 Sustainability *Agora*, the 2008 edition was altogether more carefully plotted and better stage-managed, without in any way constraining the eventual flow of the market-place "banter" amongst its sellers and buyers (of styles of sustainability problem-solving). An earlier notion of plural "champions" of certain postures was adapted into three "actors", each primed to speak the archetypal "voice" of a particular (active) CT solidarity: George Crawford of CH2MHill (consulting engineers) as the individualist (*I*); Margaret Pageler (sometime president, City Council, Seattle, USA) as the hierarchist (*H*); and Ger Bergkamp, at the time transferring from the International Union for the Conservation of Nature (IUCN) to become Director General of the World Water Council, as the egalitarian (*E*). The remit of the *Agora* — in effect, the challenge of CFG from Chapter 2.4 — was specified for the actors beforehand as:

> What kind of technological innovations, and which paths towards alternative future metropolitan water infrastructures, might lower the global nutrient and (virtual) water metabolisms, i.e., uncouple human and economic development from industrial N fixation, for example, while yet securing essential public health for citizens — and all under the prospect of global climate change?

Armed this second time with a greater appreciation of quality in governance — of access to the democratic debate and responsiveness within it — and with Michael Thompson present to assist Dipak Gyawali as master of ceremonies, the *Agora* was arranged such that each voice was obliged formally to respond to each pitch of the third proponent of his/her style of tackling the challenge. Participants, i.e., the entire audience, could join the debate, to endorse, applaud, or criticize the various goods on offer. After the primary debate amongst the three protagonists, participants in the Agora were exposed to the theory behind it, demonstrated at work in practice in examples from South Asia.

South Asian Experience

Just as IWA's *Sanitation 21* document feared (in Chapter 3.1 and Box 2; IWA, 2006), the agenda of water and sanitation in South Asia has often been hijacked by one particular party. For example, argues Gyawali (2004), in the case of flood embankment defenses in the Indian state of Bihar (on Nepal's southern border), only a hierarchical government problem was framed — and one so very well attuned to the conventional solution of such a bureaucracy. As a result (Gyawali, 2004):

> Alternative solutions to achieving security from flooding would have been cheaper and environmentally more beneficial, but were never pursued in the single solidarity policy terrain of hierarchs [*H*]. Among these are many traditional practices such as building houses on stilts, raising the plinth level of village housing, crop insurance, etc., which market [*I*] and activist [*E*] now advocate. The very sciences of different solidarities, their framing of problems, the questions they ask and the areas they look into for answers are different.

Since India's independence in 1948, the embankments have caused more land to be removed from production as a result of water-logging than the land newly and productively irrigated by the associated infrastructure (Gyawali, 2004). The "closed hegemony" of entertaining only the single position

BOX 4

of one (powerful) party in the (non-)debate would not be described as an enabling form of governance — any more than some would say of the IPCC in respect of climate change (Pielke, 2010).[3]

It becomes pertinent to ask (and answer) this (Gyawali, 2004):

> Since the definitions of a problem vary from a social solidarity to the other, can we even ever hope to find the 'right' solution? ... [W]e should not be looking for 'a' solution at all. Because there are at least three different solutions (one from each of the three active social solidarities), the trick is to see:
>
> a) if there are overlaps in the solutions proposed which could serve as a point of consensus among the differing definitions;
>
> b) if the social solidarities are constructively rather than destructively engaged with each other; and
>
> c) if the proposed solutions are inflexible (and hence vulnerable to nasty surprises) instead of being open to adaptive improvements by people themselves at the local level without depleting their 'risk resilience'.
>
> If the three [voices of H, I, E] are constructively engaged, they could discover an area of consensual stability ..., which is less than what each would have individually liked to have, but is more than nothing they will have if there is a destructive impasse.

In respect of item (a), just such "overlaps in the solutions" of constructive engagement might reside amongst the $\boldsymbol{\alpha}_{key}$ technologies sought from the analysis of "reachable (*I, H, E*) futures" through the inverse approach embedded within the Adaptive Community Learning of Chapter 4.2. The technical attribute of being "key" (in $\boldsymbol{\alpha}_{key}$) could be cast in the sense of "not necessarily foreclosing on the attainability of each and every one of the disparate aspirations of $\boldsymbol{y}(I)$, $\boldsymbol{y}(H)$, and $\boldsymbol{y}(E)$ for the future".

Given Gyawali's vantage point, as a professional engineer and former Minister of Water Resources for Nepal, he can claim some requisite experience of politics and governance in the real world. Its essence was infused into orchestration of the microcosms of the two IWA Sustainability *Agora*. His constructive engagement (our enabling governance), he conjectures (Gyawali, 2004), should flow from a failing state undergoing the following changes: policy reform of national bureaucracies (*H* actors); a distorted market becoming populated with socially sustainable, far-sighted businesses (*I*); and disruptive civil-society actors (or auditors, as Gyawali calls them) evolving into non-violent, creative entities (*E*). His destructive impasse (our disabling governance) would see these instead coming to pass: the state becoming a fortress world of privileged cronies; the market becoming populated by Enron-style "hyper-globalisers"; and the social auditors turning into violent "rejectionists" in "communard" enclaves — altogether quite disabling (from our perspective herein).

All this, moreover, is taught to Nepali engineering undergraduates as "*Basic Water Science*" (Dixit, 2002).

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[3] In a different setting, economist Pearce provides a most insightful analysis of why Market-based Instruments (MBIs) are found so rarely in the practice of environmental stewardship (Pearce, 2004). Amongst various reasons, one is referred to as "regulatory capture". In this, scientists and engineers within a government agency fear (are threatened by) the fact that implementing economic instruments would undercut much of their role as experts. It might even make them redundant. Pearce's "regulatory capture" would seem to have much in common with what is here referred to as "closed hegemony".

BOX 4

From Good-humored Theater to the Gladiatorial Arena of Life in the Real World

To summarize these experiences of the two *Agora*, its staging has been proved and the profile of the human dimension within an association of professional engineers (the IWA) has been raised thereby. There is a growing appreciation of how to construct the stalls and identify the stall-holders, but not of the shopping experience. Neither *Agora* was designed to reveal the manner of (mass) "buying into" what must be, in all situations of policy making, decision-making, and choice, that singular "one routine step tomorrow" — setting off on some specific technological path towards realizing a CFG on the horizon (as in Figure 2).

Yet one might well wonder what, if anything, can individuals and communities learn from experience of the good-humored theater of an *Agora* (constructive engagement), when their "real world" is something of a gladiatorial arena (destructive impasse) — highly politically charged and a heart-beat away from litigation. We dare to push thinking somewhat beyond the experience of the two Sustainability *Agora* in Chapter 6.