Cities as Forces for Good

Book Review

Antifragility, Resilience, Sustainability & the City — Bring on the Floods!

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A Review of the Book 'Antifragile: Things That Gain from Disorder' by Nassim Nicholas Taleb Random House (November 27, 2012)

> At the close of 2011, sustainability and environmental advisor Tony Juniper asked "Will 2012 be the year of the R word?". He meant R for Resilience. It may have been so. I for one had a conversation in 2012 in which I was told that R was (somehow) easier to define than the S word (for Sustainability), hence its purported advantage. Whatever the case, now we have the A word to assimilate: Antifragility (Taleb, 2012). To my mind, Antifragility essentially reinforces what I have long greatly valued about Holling's notion of *ecological* Resilience, but in ways that may make the A and R words more than just the sum of their respective parts.

Bet on a Big Failure

Assimilating the A word, reconciling it with my understanding of ecological resilience, and making the outcome relevant to Cities as Forces for Good (CFG) in the Environment, became altogether rather too much in the end. Too much to express concisely, that is.

Had I not been drawn into attempting all that, I would have simply and incompletely (naïvely perhaps) taken home but these two messages from Taleb's book, *Antifragile. Things That Gain from Disorder*:

> first, an elucidation of the differences among the behaviors of fragile, robust, and antifragile systems; and
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> second, given such — hence the rudiments of a nose for spotting and characterizing fragile systems (especially large ones) — betting gainfully on their eventual collapse.

This latter is skewed. Re-balancing it has taken much of my time in composing this review. It was surely time *not* wasted.

But what exactly, you should ask, do these things have to do with cities? Think floods. Think specifically, if this helps, of the city of London.

In the Nature of the System

Consider the city as an entity buffeted about by storms, torrential downpours, and, in the case of London, all these disturbances piled up not least on steadily rising sea-levels and the oncoming climate change. Think, furthermore, of how the city, its infrastructure, and its people sense and respond to such buffeting over time.

Comfortable Fragility of Life in the City

A city is ***fragile*** in its behavior when the accumulating experience of buffeting-yet-muted-responses — the absence, in fact, of any significant flooding — induces the ever more comfortable, familiar, ordered, and hardening expectation of nothing untoward in the future. Nothing unexpected, that is, until the utter devastation of the flood of a lifetime.

The city makes itself fragile as it becomes progressively more deeply locked into the comfort of its 24h-7d rhythms, and to the exclusion of all else in the rich spectrum of fluctuations in nature, from seconds and minutes to decades, centuries, millennia and beyond. The city appropriates its services from the environment in a manner dedicated to serving the comfort of just this narrow 24-7 bandwidth. Indeed, all rhythmic variation would be flattened out if that much vaunted phrase "the city never sleeps" were true. All the variations in nature would be subjugated to delivering invariance.

That this occurs is in no small part a consequence of conventional city infrastructure: the sea walls, barrages, sewers, and so on, which make up the city's traditional, pre-emptive defenses against flooding. The city is protected from the harm of the flood. Over the years and decades, its citizens lose whatever capacity they might once have had for coping with a flood. The buffeting-and-muted-response couples become occasions for neither learning nor strengthening one's resolve to meet the slings and arrows of outrageous fortune — and Taleb's Black Swans, for that matter.[1] The city's infrastructure is quintessentially designed for disturbance rejection, up to a point.

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[1] The title of his earlier best-selling book, where the phrase is defined as (p 6 in *Antifragility*): "Black Swans (capitalized) are large-scale unpredictable and irregular events of massive consequence — unpredicted by a certain observer, and such unpredictor is generally called the "turkey" when he is both surprised and harmed by these events." According to Ingram, Tayler, and Thompson ("Surprise, Surprise. From Neoclassical Economics to E-life", *Astin Bulletin*, **42**(2), pp 389-411 (2012)), twelve varieties of surprise are possible. They derive from twelve ways of combining "erroneous" expectations of the way the world should be (models) with four regimes of the way the

Bring on the Floods!

A city is ***antifragile*** when it seeks to learn from the buffeting-and-muted-response couples: so much the better then to prepare itself — even over-compensate — for surviving the "big one", when it comes (and come it will). The city and its citizens gain strength in facing future disturbance and disruption from the continuing stresses of disorder, randomness, and volatility. They gain from the inconstancy and discomfort of being jolted out of the regular, monotonous beat of the 24-7 routine, from time to time. In short: "Bring on the floods!". Reject them not. Embrace and welcome them as learning experiences — up to a point!

The city ***robust***, therefore, occupies the neutral space between fragility and antifragility. It is not harmed in the longer term by the apparent benefits of flood protection in the shorter term (fragility); nor is it benefitted in the distant future by the palpable harms of experiencing any near-term floods (antifragility) — up to a point.

That is my first take-home message.

The Agent and the System

The essence of antifragility is to seek out the positives of forearming and learning in the negatives of the harm and the failure. Becoming and being antifragile are therefore good things. But is betting on a big failure? Great prosperity for one, misfortune for the many — this is not so uplifting, no matter how deserved the misfortune may appear from the winning agent's perspective. The imbalance of the second take-home message has to be sorted out.

To do so, we can make a start by being less sloppy in our use of language. We must be careful — very careful, in fact — to distinguish between an "agent" and the "system". It was quite natural (for an engineer) to use the example of the city as a system to categorize the notions of fragility, robustness, and antifragility, hence to define the A word. Some facets of antifragility, however, have more to do with agency and agents. We shall need to inspect these before crafting an explanation of my second take-home message.

To begin, consider the following clarifying definitions from Taleb's book (p158):

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world actually is. In four instances (out of the total of sixteen possible model-reality combinations), expectations are aligned with actualities, hence there are no surprises there.

Fragility implies more to lose than to gain, equals more downside than upside, equals (unfavorable) asymmetry.

Antifragility implies more to gain than to lose, equals more upside than downside, equals (favorable) asymmetry.

It would be quite inadequate to confine these facets of fragility-antifragility solely to contemplating the behavior of a system. Indeed, it would be useful to theorize about the interaction between agents and systems and, moreover, to create the verbs “fragilize” (as does Taleb) and “antifragilize”, to give substance to the sense of agency here.

Intuitively, then, it is the antifragile agent who is in a position to bet gainfully on the eventual collapse of a fragile system. Fragile agents meanwhile — assumed to be in the ascendancy with respect to stewardship of that system (such as the system of banking and finance, for example) — may be making it (and themselves) ever more fragile, yet be unaware of this. The astute antifragile agent, who is astute by definition (of course), observes this. Indeed he has a model of it in his head, not on his computer — likewise by definition, since Taleb abhors the excesses of quantitative analysis and generally does not believe in computer models and their predictions.

Thus we can conceive theoretically of the following pairwise combinations of agents-agency and systems. They are not exhaustive of the possibilities, merely illustrative of the differences between the system and the agent:

(i) The fragilizing agent working within an increasingly fragile system; this would seem readily to be largely the “way of the world”, according to Taleb.

(ii) The fragilizing agent working within an increasingly antifragile system, which strikes one as strange and counter-intuitive at first, but not impossible (since the other antifragilizing agents are here in the ascendancy, with therefore the greater influence over the system).

(iii) The antifragilizing agent working within a (hopefully) decreasingly fragile system, where the status of the agent-system couple (as a whole) is, in effect, identical to that of (ii).

(iv) The antifragilizing agent working within an antifragile system, as the (unattainable) culmination that should (arguably) be drawing us all ever onwards and upwards.

Both system and agent can fail in their behavior on the downside (from negative Black Swans). Conversely, both can experience the complement of what can best be described as a "benefits explosion" on the upside (a positive Black Swan).

The second take-home message encapsulates a benefits explosion for the agent alone, *not* in the behavior of the system. Therein lies the principal reason for the significance of distinguishing between the two (agent *versus* system).

Abrupt Failure and Episodes of Abundance

It is easy to conceive of the downside for the system. It collapses. It fails catastrophically. It is equally easy to picture the agent who benefits mightily from betting successfully on either a big systems failure or benefits explosion. Conjuring up a credible illustration of such a positive explosion in the behavior of the system — for us, the city (and its infrastructure) — is especially challenging.

In many ways, our outlooks are biased towards collapse — the breaking asunder of that which is fragile — spotting its possibility, and betting on gaining from it. After all, without survival, *sine qua non*, there can be no prosperity. Considerations of exposure to failure (risk) take precedence over those of any exposure to unimaginable, *inconceivable*, success. It is easier to grasp the essence of antifragility in this: one man's gain — the antifragile agent with knowledge of the fragile system on the brink of collapse — is the loss of all those participating in that fragile system.[2] This, however, is abrupt abundance for the agent. One does not hear of abrupt abundance in the infrastructure of London — abrupt failure, yes. To reiterate, this is a reason to be both careful and clear about the distinction between the agent and the system.

Abrupt, beneficial abundance in the behavior of a system seems indeed inconceivable — hard to conjure up — until one simply re-admits considerations of nature. But even there the manifestation of such abundance is never quite as swift or utterly unpredictable (for most of us) as catastrophic collapse and destruction. Seasonal abundance in nature's blossoms and blooms in the spring and its fruits in the summer is more or less predictable. And it keeps on coming around (predictably), unlike the aperiodic failure whose timing is brought about (each time) by a unique, unpredictable set of causes. The

[2] And yes, it is of concern for Taleb to take care of the ethics of s/he who bets on the collapse of the whole, with its asymmetry of benefits to the one individual, losses and damages to all in the population. Their discussion occupies the last two chapters of his book. In particular, when an agent has something to gain, perhaps a great deal, and *nothing* to lose, Taleb would certainly not bestow upon that agent the accolade of being antifragile. To be cynical, we may conjecture that there will be those acting as fragilizers in public — with the power to do so — with yet a view to behaving as an antifragile agent in private (betting furtively on the eventual collapse of the system they will have made fragile). But take a moment's reflection. This hardly requires any conjecture, does it?

occasional super-abundance in nature's productivity is not unknown, but it is less predictable than the annually occurring, *ergo* regular, abundance.

These events can surely lead to social and economic prosperity for a given agent, to whom accrues the positive payoff from positive episodes of abundance in the system's behavior. Thus it was in antiquity for Thales of Miletus.

In the Nature of the Agent

Given an appreciation of the differences among the fragile, the robust, and the antifragile — hence the rudiments of a nose for spotting and characterizing fragile systems and betting gainfully on their eventual collapse (within the gambler's life-time, however!) — Taleb expresses my second take-home message with, I acknowledge, the complementary positive spin.

Thales' Option

Thales of Miletus was a pre-Socratic Greek philosopher and mathematician, who turned his attention briefly to making money, to prove a point. He did so by betting on nature's somewhat unpredictable seasonal abundance, in this instance from the production of olives and the subsequent profitable trade in olive oil. As Taleb relates (p 174):

> Simply, [Thales] had a contract that is the archetype of what an asymmetry is, perhaps the only explicit asymmetry you can find in its purest form. It is an option, "the right but not the obligation" for the buyer and, of course, "the obligation but not the right" for the other party, called the seller. Thales had the right — but not the obligation — to use the olive presses in case there would be a surge in demand; the other party had the obligation, not the right. Thales paid a small price for that privilege, with a limited loss and a large possible outcome. That was the very first option on record.
>
> The option is an agent of antifragility.

There is something latent in this tale, however. For those of us who have an interest in risk and decision-making under uncertainty, *and* the constructive use of computational models (in sharp contrast to Taleb), it needs now to be illuminated. This requires us to call on what Taleb labels Seneca's Asymmetry (or "Seneca's Barbell", or the "Fundamental Asymmetry").

Seneca's Barbell

This is it, as defined on p 427:

> When someone has more upside than downside in a certain situation, he is antifragile and tends to gain from (a) volatility, (b) randomness, (c) errors, (d) uncertainty, (e) stressors, (f) time. And the reverse.

It is upon the word "uncertainty" that Taleb alights to introduce his barbell strategy for decision making under (indeed) *uncertainty* (p 161):

> This brings us to the solution in the form of a barbell — about all solutions to uncertainty are in the form of barbells.
>
> I initially used the image of the barbell to describe a dual attitude of playing it safe in some areas (robust to negative Black Swans) and taking a lot of small risks in others (open to positive Black Swans), hence achieving antifragility. That is extreme risk aversion on one side and extreme risk loving on the other, rather than just the "medium" or the beastly "moderate" risk attitude that in fact is a sucker game (because medium risks can be subjected to huge measurement errors).
>
> Someone with 100 percent [of holdings] in so-called "medium" risk securities has a risk of total ruin from the miscomputation of risks. This barbell technique remedies the problem that risks of rare events are incomputable and fragile to estimation error.

To re-state it, the barbell image is (p 161) "... a combination of extremes kept separate, with avoidance of the middle. In our context it is not necessarily symmetric ...". There is no middle ground (p 163):

> There are so many fields in which the middle is no "golden middle" and where the bimodal strategy (maximally safe plus maximally speculative) applies.

Downed Decision Tree — Almost

We need another metaphor to grasp what Taleb is telling us.

Formal decision analysis — for decision making under uncertainty — invokes the image of a decision tree. More specifically, picture the entire, fully mature tree at the height of its summer foliage: trunk; principal bows; branches; shoots; twigs; leaves; leaf-tips and all. Each conceptual "branching point" represents either a decision or a random event, each conceptual "branch" either one of several choices for the decision or one of several possible outcomes of the event. A vast body of scholarly work is available for its analysis, which rather condemns it to being of little value in Taleb's eyes. He would, we may surmise, have two objections to such analysis.

First, as we have just seen, making decisions according to the formal quantitative mathematical expectation over all the tree — from the base of the trunk to the tips of each and every one of its host of leaves — would be objectionable because of the very nature of this (particular) computational procedure. It seeks out the average, middle ground. This would be a non-starter for Taleb: to choose that course of action embarking on a path to the leaf-tip yielding the largest *average* (expected) payoff.

Second, in any case, he would claim, we have nowhere near the volume of knowledge required to construct the tree in the first place (p 174):

> Thales put himself in a position to take advantage of his *lack* of knowledge.

What Thales needed to discern (to know) was but the one salient, fat bow weighed down with the fruit of the massive positive payoff, with crispness in the remaining image of the tree in respect *only* of a fringe of those shriveled leaf-tips with paltry negative payoffs. Everything else about the tree could remain unrevealed in the fog of the unknown.

Having made a correct assessment of the option — just the fat bow; its likelihood of being there in a reasonable span of time (the gambler's time); and the small, disconnected arc of the feather-light fringe — knowledge of large tracts of the ways and workings of the world is irrelevant, Taleb would argue (as I understand it). "[T]he option is a substitute for knowledge", he writes (p 186).

Why then are we all not ridiculously wealthy in this way? The answer, I submit, is because we do not all have intuitive noses for sniffing out the "correct assessment", just as we are not all wildly successful entrepreneurs like Sir Richard Branson! No matter how Taleb and Branson strive to communicate their gifts to us, they are their gifts, not ours.

TAKEN TOGETHER: THE R WORD AND THE A WORD

Two Kinds of Resilience

Eminent ecologist Holling has argued persuasively that we have engineered most of our urban infrastructure, technologies, and industrial production systems so as to enslave their functioning to achieve what he calls "engineering resilience". For as long as the system is not subject to significant disturbance, it can be managed to maintain function in some desired domain, usually constant or narrowly circumscribed, because that — like the 24-7 routine — so often seems to be much more to our liking and comfort. In the face of substantial disturbance, however, engineering resilience can be revealed as brittle in quality. The performance of the system may be knocked out of its comfortable equilibrium and descend into an altogether quite different pattern of function that is not at all to our liking.

"Ecological resilience", on the contrary, would enable the maintenance of essential (if not desired), functions even under such circumstances.

Such ecological resilience has much to do, first, with redundancy and inefficiency of function in the several, if not many parts, of the system. Neither of these attributes would be the priorities of customary engineering design. Yet the not inconsiderable evolutionary opportunities acquired by warm-blooded creatures (endotherms) depend crucially upon them: possessing, as they do, multiple, not notably efficient mechanisms for maintaining body temperature just below a level that would be lethal. Second, redundancy and inefficiency of function in an ecosystem are manifest in a diversity of species-entities with overlapping functions. And third, such diversity may derive from the rich spectrum of disturbances to which the ecosystem has been subject over the aeons of evolutionary time. The high diversity of fish species found in the ecosystems of some rivers is there precisely because of all the pulsating and pounding variety of the disturbances — most surely storms, hence floods, of all magnitudes — with which that ecosystem has co-evolved.

The resilient ecosystem is broadly coherent over time; it retains its identity (as perceived within our living memory), but its structure is surely not immutable (over the millennia). Its behavior is in sympathy with the rich (or poor) spectrum of perturbations to which it is, and has been, subject.

A Dialog

Let us take stock, in the form of an imagined exchange between Holling and Taleb.

“What is brittle, as the adjective describing the quality of engineering resilience”, might begin Holling, “if not a synonym for fragile?”.

Warming to the rhetoric, Taleb could proceed to explain one of his chapter sub-titles, “Antifragile Responses as Redundancy”, by drawing liberally on the same insights as Holling regarding endotherms (p 44):

> Layers of redundancy are the central risk management property of natural systems. We humans have two kidneys (this may even include accountants), extra spare parts, and extra capacity in many, many things (say, lungs, neural system, arterial apparatus), while human [hence engineering?] design tends to be spare and inversely redundant, so to speak — we have a historical track record of engaging in debt, which is the opposite of redundancy (fifty thousand in extra cash in the bank, or, better, under the mattress, is redundancy; owing the bank an equivalent amount, that is debt, is the opposite of redundancy). Redundancy is ambiguous because it seems like a waste if nothing unusual happens. Except that something unusual happens — usually.

To which Holling would proffer the rejoinder and extension:

> At least some aspects of ecologically resilient control are equally familiar to the control engineer, for operation at the edge of instability is characteristic of designs for high-performance aircraft. Oddly, the result is opportunity. Effective control of internal dynamics at the edge of instability [perilously close to a lethal body temperature for endotherms] generates external options. Operating at the edge of instability [ever in a state of incipient failure or imminent regime shift] generates immediate signals of changing opportunity.
>
> That surely is at the heart of sustainable development — the release of human opportunity.

Touched off at the thought of flight, Taleb might volunteer his experience of London’s Heathrow airport, notably a large technocratic system. And in doing so, he would provide us with the most succinct distinction of what we should wish for of engineering resilience *vis à vis* ecological resilience (p 283):

> smooth functioning at regular times [delivered within engineering resilience] ... rough functioning at times of stress [bestowed by ecological resilience].

If Holling's engineering resilience equates to Taleb's fragility, I suggest that this is not least because both Holling and Taleb needed a counterpoint by which to illuminate the benefits, if not the superiority, of their respective new notions of ecological resilience and antifragility. Both, in their own ways, are wary of the engineering mindset, of technocracy, of "mathematizing nature", and of optimizing the behavior of systems. Holling's expression of appreciation for engineers — of the "control" variety — is the exception rather than the rule. Their heaping of disapproval upon fragile systems, albeit for the sake of argument, overlooks the positive attributes of engineering resilience. Many features of fragile systems benefit in some way from their engineering resilience, as in disturbance rejection, especially rejection of those disturbances with frequencies just to each side of the 24-7 bandwidth (respectively, the flash flood from short intense storms and the weeks- and months-long drought).

For the city, engineering resilience (as defined by Holling) is about achieving the comfort of the narrowness of the 24-7. Ecological resilience, if we could imagine it for the city, should be about embracing the full spectrum of variations (or at least significantly more than just the 24h and the 7d), coping with it, even benefitting from it — which is to borrow now more obviously from Taleb's notion of antifragility. Conversely, it is not just Taleb's undifferentiated "variations" that matter to the ecological resilience of the system, but the pattern in the spectrum of their frequencies.

Eking Out Some Useful Distinctions

Thus have Taleb's ideas on antifragility been threaded through an understanding of Holling's concept of ecological resilience. The two appear to map almost identically over one another, even at a deep level (I confess, I have so far been defeated in my several attempts to prize them significantly apart). Substantial agreement has broken out. Only in respect of agency and the ***agent*** — not the ***system*** — has it been possible to pinpoint differences, wherein might lie the seeds of novelty.

These differences will be revealed shortly. For the moment, more important is that Holling and Taleb agree in placing much emphasis on learning.

For Holling, agency in association with resilience resides in decisions and policies that mimic what the engineer would call dual control, but which most will know as "adaptive management". The decision to be taken combines two functions: steering the system in some desirable direction; and deliberately injecting a disturbance (muted, albeit) into its behavior, the purpose of which is discovery, learning, and the reduction of uncertainty in the agent's knowledge of the system's behavior, for when the next decision becomes due. In the metaphor of the decision tree, wisps of fog are to be puffed away — nothing more vigorous, given the controlled restraint of the muted disturbances — to reveal something of significance in the tree for the next decision. The model of the decision tree will be adapted with each

successive decision-point in time. And the structure of the tree "in truth" will be believed to evolve too, being different as each point comes and goes.

For Taleb, agency in association with antifragility is as follows (from p 170):

> The rational flâneur is someone who, unlike a tourist, makes a decision at every step to revise his schedule, so he can imbibe things based on new information ... often guided by his sense of smell. ... The flâneur is not a prisoner of the plan. Tourism, actual or figurative, is imbued with the teleological illusion; it assumes completeness of vision and gets one locked into a hard-to-revise program, while the flâneur continuously — and, what is crucial, rationally — modifies his targets as he acquires information.

There is a certain playfulness about this, even impish mischief. Notice too the role of the nose. But is the continuous "rational" modification of targets informed by any deliberate probing (as in dual control)? I think not. For my dictionary tells me that a flâneur is an "aimless idler".

Taleb continues (from pp 171 and 213 respectively):

> This ability to switch from a course of action is an *option* to change.
>
> You make forays into the future by opportunism and optionality.

Are then the opportunities multiplied the more things are "[o]perating at the edge of instability" (to quote Holling) and their apprehension heightened there — by "immediate signals of changing opportunity" (Holling again)? It would seem so. Indeed, mindful of the surprise game and e-life of Ingram and co-authors, some judicious re-phrasing of Holling's original words might go a good way towards extruding some novelty (by forcing Holling apart from Taleb):

> Anticipating the cusp of a regime shift sensitizes and alerts stewards of the system to an accompanying strategic shift in their style of stewardship, hence to react promptly to the regime shift, when it occurs, as it will.[3]

To generalize somewhat his message, that "[t]he option is the agent of antifragility", as in Thales' Option, Taleb writes (p171):

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[3] Ingram and colleagues would call this "rational adaptation".

> [A]n option is what makes you antifragile and allows you to benefit from the positive side of uncertainty, without a corresponding serious harm from the negative side.

Comparing the two expressions of agency, these then (at last) are the essential differences:

> ***Holling's Agent***: is presumed to be responsible for the system; moreover, this will generally be a natural system, e.g., an ecological or environmental system; and the agent is active with respect to acquiring knowledge of the system's behavior, with some presumption of reducing uncertainty in that knowledge base.

> ***Taleb's Agent***: is not responsible for the fate of the system; in general, the agent's attention is trained on the human system, i.e., a socio-economic, financial system; the agent is passive — s/he is no helmsman at the tiller, but detached from steering the system in any desired direction; this passivity (a kind of neutrality) extends to an outlook in which there is no presumption about the growth or decline of knowledge of the decision tree.

What new thoughts, if any, does this elucidation of such differences liberate? A decent response could be quite another story, to be written on another occasion (to spare us all now).

Instead, let me volunteer first something of a hypothesis on what we might want of some abstract agent-system couple and then tailor that to what we want for the city and, yet more tangibly and specifically, Cities as Forces for Good in the Environment.

What we Want for the City?

Stripped to its bare bones, three entities frame thinking about antifragility: the three axes of agent-payoff-system, as it were. The agent is fragilizing or antifragilizing; the payoff is negative or positive, for either the agent or the system; and the system is resilient in the engineering (fragile) or ecological (antifragile) senses. Imagine the following, with the operative words emphasized, as a description of some future aspiration within this three-dimensional state-space:

> An ***antifragilizing agent*** working among other fragilizing agents in a fragile system and seeking the positive payoff of a ***benefits explosion*** in the behavior of that ***system*** before

it (very nearly) collapses — or, more generally — shifts from one regime of behavior to another.

What would be the key ingredients of any arrangements for nudging matters towards this target? They are, we hypothesize, of the following nature:

(I1) The system is being pushed toward the edge of instability, or again, and perhaps better, the boundary of a regime shift.

(I2) Redundancy in the system's (internal) functions is being increased — "up to a point" (to use this phrase one penultimate time).

(I3) There is the perspicacity to spot likewise where efficiency of function should/should not be shed.

(I4) Decisions are directed, on the one hand, at learning and forearming in the community of agents and, on the other, at steering the system, with yet those agents absorbing (indeed benefitting from) the harmful payoffs of shocks through the rough functioning of the system during periods of stress.

(I5) Actions are deliberately tilting the behavior of the system toward positive payoffs, i.e., increasing (to coin a phrase) the "anti-risk" of exposure to inconceivable abundance.

Something controversial is buried in these ingredients. But before unearthing it, something else of central significance to the idea of an antifragile-resilient city is just plain absent from the way in which the differences between Holling and Taleb have been expressed above. And once more, we shall be forced into thinking more carefully about the distinctions among the words we are otherwise using so easily and loosely here.

Coupled Human-Built-Natural Systems

The essential unit of many of the studies of the Cities as Forces for Good Network (CFGnet) is the city-watershed couple or the city-hinterland couple. These couples, sectioned slightly differently, are the coupled triplet of human-*built*-natural systems.

In human sub-systems, agents observe human agency and other human agents. In the built sub-system they observe the engineered, inanimate, material fabric at work.[4] In the natural sub-system they observe the agency of other species and nature's non-engineered material fabric at work.[5] We have hitherto written easily of "collapse" and "destruction". But what do they mean, more precisely?

For an engineering system, and for a financial system (or business entity), *collapse* (as in flood wall) and *failure* (as in insolvency or bankruptcy), do fit their descriptive purposes. Yet this is *not* so for an economy (an economic system), which merely "recedes", for a while, even though we all refer to this as "collapse" and "bust".

Nor is this so for natural systems. Think of floods in cities and the destruction wrought by fires in wooded city suburbs. For these reveal the difference between using collapse and destruction with reference to the human and built environments and the *inability* to describe behavior of the natural environment in such words. Floods and fires are part and parcel of the enduring integrity and viability of watershed and forest ecologies, where they bear no anthropocentric, emotional, or ethical attachments.

That said, let us return to filling in what has so far been missing from this review.

Holling drew his inspiration from studying natural systems, Taleb his from studying human systems. Yet it is the built environment of urban infrastructure that is central to re-engineering a path toward realizing Cities as Forces for Good in the Environment. The built environment *is* the odd man out; it exhibits no intuitively obvious benefits explosion in its behavior. Is such even plausible, let alone possible? Yet, if we could incorporate antifragility and ecological resilience into the built environment, how much more resilient and antifragile might the whole be, if realizing these desirable properties in each were to be mutually reinforcing around the whole of the triplet?

Bet on the Bloom

Think of a "wrong" infrastructure: "conventional" sewerage and sewage treatment. In fixing pollution of the natural environment, which pollution arose historically from fixing the problem of a decidedly unhealthy human environment in the city, this built environment deals 24-7 with our otherwise inconvenient and discomforting metabolic residuals. When wastewater treatment did not exist, and

[4] Still, with the unstoppable influx of "smart" technologies into the likes of "intelligent buildings", our infrastructure may be becoming more agent-like (less inanimate) by the minute.

[5] Distinctions between the three sub-systems are inevitably somewhat arbitrary. Today's common talk is of "green infrastructure", as in creating sacrificial flood depressions in grassy urban parks, and of "importing nature into the city", where it will be put to work in such ways.

where it does not exist today, the nutritious nitrogen (N) and phosphorus (P) in the food we eat emerges eventually from the city to fertilize a "wrong" abundance in the aquatic environment. We perceive these blooms of algae — an abundance of microscopic green matter at the base of the aquatic food chain — as an unhealthy eco-system *dis*-service. That is why we treat as pollutants the N and the P in "waste"water. They are to be "eliminated", got rid of, even "preferably" ejected into the air as greenhouse gases (in the case of N).

A "right", and indeed "unconventional", infrastructure for tomorrow[6] would be re-arranged to extract occurrence of the unwanted abundance of the bloom from the natural environment and oblige it to happen instead within the built environment of the city, to utilize it there as a precursor of fuels and fertilizer — *and* to deploy the fertilizer most prudently as a generator of health-enhancing ecosystem services. Surprise, surprise, this is happening today on the west coast of the USA-Canada, to reconstruct and support declining salmon populations.

If someone were to bet on the bloom in London, s/he could profit from this "right" abundance to the tune of up to $100M or $200M each year. But would this be an exercising of Taleb's *option* as antifragilizing agency? For this still mystifies me somewhat. A modern-day Thales would have to pay for the right (not the obligation) to generate algae under the happy conjunction of the sporadic, cloudless, heat wave and a temporary surge in Londoners eating N- and P-rich foods.[7] And that sounds awkward and contrived, if not bizarre. This, however, is the end-point of my wrestling with the imbalance in my second take-home message. I must have failed to understand the essential nature of the option, yet (hopefully) in some otherwise useful manner.

Nothing New Under the Sun

Blooms of algae are notoriously unpredictable, beyond the rather bland, uninformative expectation that they will occur in most years: when sunshine is plentiful; water temperatures are high; all the right ingredients — the macro-nutrients of N and P, together with a host of other trace minerals — are accessible in sufficient amounts and in just the right proportions; their immediate predators are absent; or the predators of their predators are abundant; and so on ...

[6] Though it was, in fact, "right" in part before today's "conventional" become conventional, before the past century.

[7] Consider this too. Industrialized agriculture has a phrase CAFO, for Confined Animal Feeding Operations. What is the city, if not a Confined Human Feeding Operation (a CHFO)?

Buried among the key ingredients of conjectured arrangements for nudging matters towards this target — of now betting on the sun-soaked bloom occurring *within* the city's infrastructure — were (I1), with its boundary of the "edge of instability", and (I2), with its favorite phrase of "up to a point". Such *boundaries* and *points* are exactly what we would *so* wish to have predictable, not least by a model. But let me not rise to the abundant bait cast down in Taleb's book, in defense of the computational model; not just yet, anyway.

Nothing New Under the Rain

So "bring on the floods". I claim no novelty in this thought, however. For here is what Liao has said in a recent (2012) paper in *Ecology and Society*[8] on the flood-resilient city:

> In the [ecological] resilience-based flood hazard management, periodic floods are learning opportunities for cities to become better fit for extreme floods.

What now of Tony Juniper's musings at the end of 2011 and what of my conversation in 2012 regarding the R word and S word? Here again, so timely, is Liao:

> With growing popularity, the term resilience is increasingly used vaguely such that it is becoming like the word sustainability, i.e., having a diluted and unclear meaning.

No surprise here, either.

[8] Liao, K.-H. (2012). A Theory on Urban Resilience to Floods: A Basis for Alternative Planning Practices. Ecology and Society, **17**(4).