This paper is part of the edited volume:
Improving Risk Regulation, International Risk Governance Council, Lausanne, 2015, irgc.org

EMERGING STRATEGIES TO MANAGE SYSTEM-LEVEL RISKS

AN EXAMINATION OF PRIVATE SECTOR, GOVERNMENT AND NON-GOVERNMENTAL ORGANIZATION INITIATIVES

by Terry F. Yosie[1]

Escalating global megatrends generate new sources of risk to public health and the environment, and present challenges to the effectiveness of existing regulatory processes and management of global companies. Collaboration between non-governmental organizations (NGOs) and leading global companies has intensified leading to a better understanding and management of these risks at local, regional and global levels. Such collaboration is yielding insights into the scale of risks, new governance models, opportunities for innovation, and specific risk management strategies that incorporate sustainability. Discussion of these inter-related issues can generate important information and case studies for the design of future regulatory strategies by: modifying the scope and locus of decision-making, improving scientific tools and methods, identifying opportunities for collaboration across government, NGO and private sector institutions, and developing a future research agenda.

1. The changing context of risk

For several decades, academics, policymakers, business managers and non-governmental organizations have taught, designed and implemented regulatory policies and corporate practices to assess, mitigate and manage individual public health and environmental risks or discrete clusters of risks. The risk agenda has ranged from exposure to individual chemicals (e.g., trichloroethylene in ground water) to groups of inter-related chemical families (e.g., dioxins in soils, or the atmosphere, or the release of ozone-depleting compounds that reach the stratosphere). The many successes in ameliorating the management of such risks have become the foundation for regulatory policy and corporate management systems as well as the international certification standard ISO 14001 developed by the International Organization for Standardization.

More recently, the emerging knowledge of global megatrends related to climate change, water scarcities, challenges to expanding food production,

[1] President & CEO, World Environment Center, www.wec.org

changes in disease vectors, loss of biodiversity and other effects associated with a globalized economy, expanded global population and an increasing middle class has begun to transform the understanding of risk. This changing context of risk, as displayed in Figure 1, developed by the World Economic Forum[2], recognizes several important factors:

- Risks co-exist simultaneously at the local, regional and global levels.
- Economic, geopolitical, environmental, societal and technological risks increasingly co-exist and migrate outside their own boundaries (e.g., water shortages contribute to political conflicts, then failure to invest in infrastructure contributes to water-borne diseases or exacerbation of storm surges and flooding that, in turn, lead to disruptions in the electricity supply).
- Managing inter-connected risks effectively requires the development of new decision-making frameworks and institutional capacity and new types of regulatory arrangements based on collaboration across value chain participants.

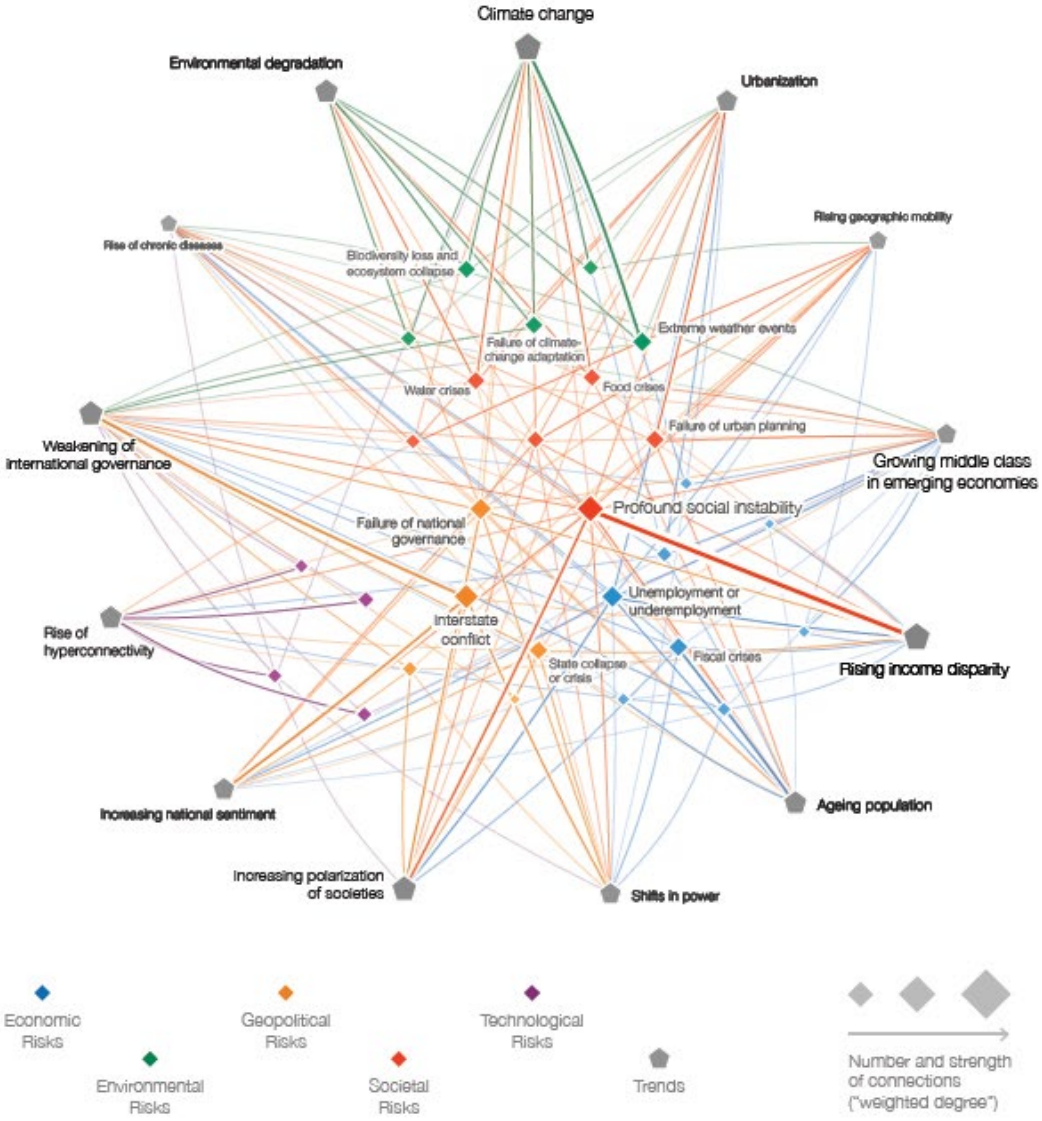

Figure 1: Global Risk Perception Survey 2014, World Economic Forum. Survey respondents were asked to select between three and six trends and to identify for each the risk they believe is most interconnected.

[2] www.weforum.org/globalrisks2015

The transformation of these and other risk characteristics greatly contributes to the growing complexity of decision-making and the potential for disruption at differing levels of scale. Irrespective of whether the risks manifest themselves in turbulent financial markets, the transmission of the Ebola virus or the ability of terrorist groups to fill political vacuums in failed states (e.g. ISIS in the Iraqi and Syrian territories), they have transcended existing decision-making frameworks and institutions and have evolved into broader system-level challenges.[3]

2. Tools and methods for managing system-level risks

System-level thinking and governance in public, private and other non-governmental institutions that have to manage environmental, health, safety and sustainability risks are considerably aided by the emergence of new sets of tools and analytical frameworks. These include:

- End-to-end traceability of ingredients or compounds that provide a system-level view of their movement across supply chains and markets and identify potential risks. For example, traceability systems utilize information technologies that 'track and trace' the sourcing, production, processing, distribution and use of food ingredients from 'farm to fork' to provide a better understanding of growing practices, disease prevention, steps to prevent spoilage and waste and increase consumer safety. The use of traceability sensors that are embedded across these functions provide private companies, regulatory agencies and consumers with additional information to make their individual decisions 'smarter' and timelier. In the US, the 2010 Food Safety and Modernization Act provided the Food and Drug Administration with increased authority and capability to implement such traceability systems. An example of the application of a traceability system in the food production sector is provided in Figure 2.

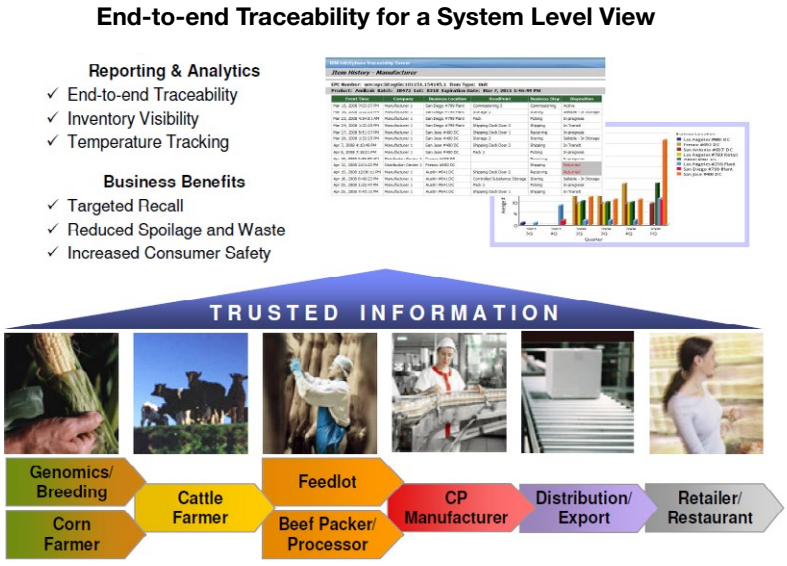

Figure 2: IBM-World Environment Center, Innovations for Environmental Sustainability Council Workshop, February 2012

Traceability technologies, and the data reporting and analytics that result from them, are finding increased and more diverse applications across a range of business functions. They include chemical companies that seek to prevent the diversion of chemical products into weaponry; pharmaceutical producers committed to preventing the development of counterfeit drugs and medical devices; automotive and technology companies that have to manage thousands of sourced materials in the production of cars

[3] Terry F. Yosie, "Rethinking Governance for a Changing World," www.greenbiz.com, April 18, 2013.

or mobile phones and ensure a robust recycling system for the afterlife of product components.

- Emergence of value chain analysis. A value chain consists of the economic participants involved in the creation and use of a product or service. The functions involved in a value chain include: product or service design; sourcing and storage of raw and processed materials; procurement of goods and services from suppliers; manufacturing, packaging, distribution and logistics for produced goods, customer/consumer use; and re-use or recycling of the goods, materials and waste for the product afterlife. As an illustration, Figure 3 presents the value chain for the natural gas sector. In recent years, as concerns about the adequacy of food supplies, water and other essential materials have emerged, business managers and policymakers have focused their attention on leveraging value chains for sustainability objectives. Companies such as Marks & Spencer and Unilever, for example, have applied a value chain approach to estimate and offset their global greenhouse gas releases. Such analyses build upon the evaluation of their respective carbon and water footprints and have informed corporate goal setting, development of strategic initiatives and collaboration with other business partners and stakeholders. The US Environmental Protection Agency's proposed controls of greenhouse gases for existing power plants has also utilized a value chain approach for reducing pollution.[4]

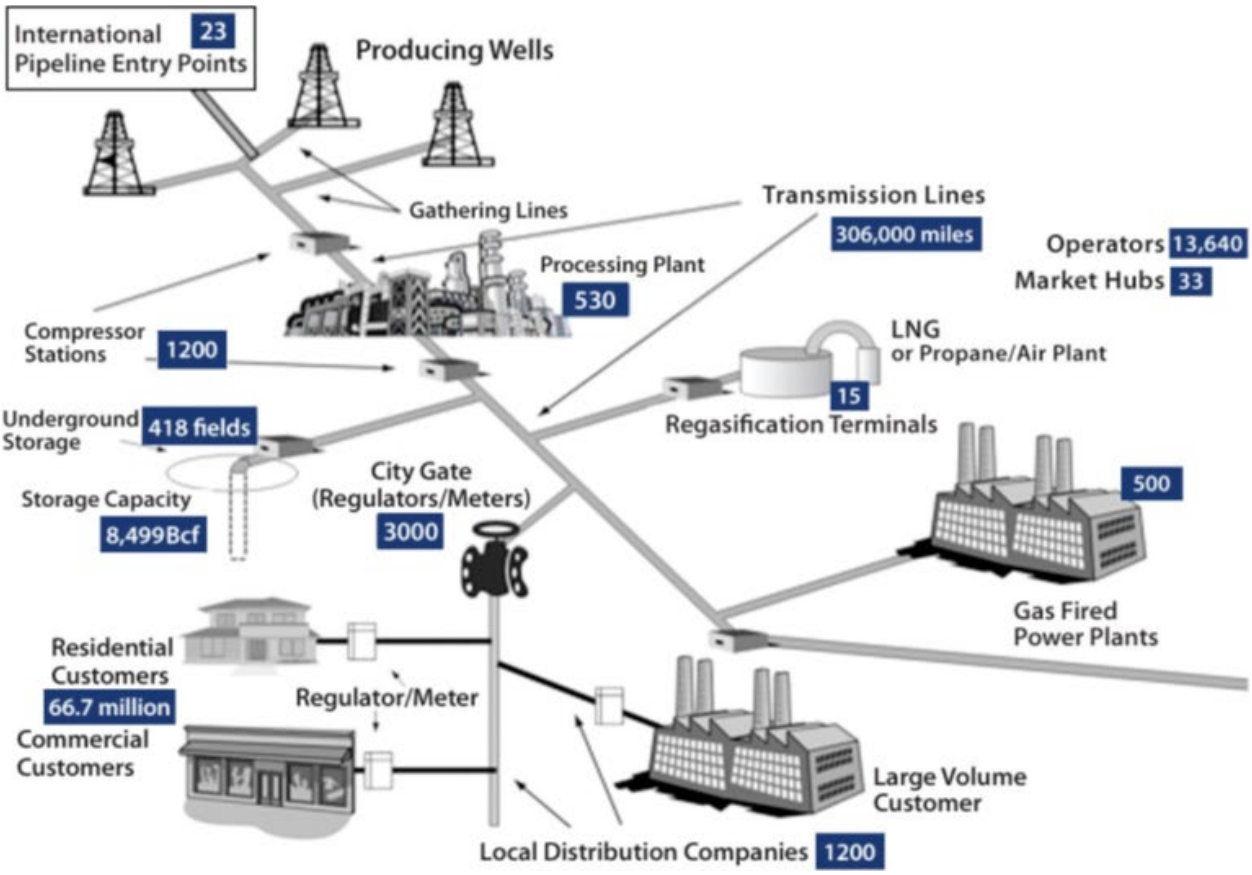

Figure 3: The natural gas infrastructure in the United States, Massachusetts Institute of Technology, 2010, p. 59.

[4] Yosie T. (2015), "The Marketplace as Policy Innovator," in The Environmental Forum (January-February), www.eli.org

- Expansion of financial and sustainability reporting. For decades, the standards for corporate financial reporting have focused on 'material' issues: those issues that impact, or are reasonably expected to affect, company decisions, including liquidity, capital resources, operational performance and broader reputation. Such reporting parameters shape both business planning and disclosure to shareholders. More recently, environmental and sustainability reporting has begun to incorporate aspects of materiality as it has an influence on the economic, environmental and social impact of a company. These 'materiality assessments,' as recommended by the Global Reporting Initiative and other entities, survey both internal and external stakeholder expectations concerning issues such as: risks facing the company; business priorities; and future performance outcomes. A growing number of companies have decided to integrate their financial and sustainability reporting to acquire a more systemic view of risks and opportunities and to strengthen the understanding of the relationship between sustainability and business strategy among senior managers and executives. The evolution of more formal processes and standards for integrated reporting, such as those being developed by the Sustainability Accounting Standards Board (SASB), will provide a further incentive to achieve integrated reporting and to embed sustainable development more formally into the corporate governance process.[5]

The National Research Council of the US National Academies recently issued a report evaluating a broad array of existing and emerging tools and methodologies for improving the policy frameworks of environmental sustainability. The recommendations of the report are based on an examination of global megatrends, private sector case studies and an evaluation of collaboration initiatives between non-governmental organizations and global companies. A major purpose of the report, funded by the US Environmental Protection Agency (EPA), was "to strengthen a system-thinking approach" by EPA.[6]

3. Emerging strategies to manage system-level risks

An examination of strategies to manage system-level risks reveals an increasing degree of experimentation across government, business institutions and NGOs to develop programmes and initiatives that can be scaled to the level of the problems presented. These efforts are also noteworthy for their innovations in areas such as the scale of collaboration with independent partners; emergence of improved governance processes; and the thought leadership agenda. What follows are a set of examples that illustrate the transition towards managing system-level risks.

[5] See, for example, the recommendations being developed by SASB, www.sasb.org

[6] National Research Council (2014), Sustainability Concepts in Decision-Making: Tools and Approaches for the US Environmental Protection Agency, US National Academies.

3.1
Coca-Cola's global water strategy

Because water is the single largest resource utilized in the company's supply chain, a resource that is under increasing pressure, the company began to assess water-related risks in its business more than a decade ago. In 2004, it conducted a qualitative assessment of water risks to individual business units. The risk portfolio included wastewater compliance, water supply economics and efficiency, water resource sustainability and supply reliability, and societal risks. This initial assessment was followed by a more detailed, plant-level quantitative risk assessment prepared in 2005 and 2008-2009.

From these evaluations emerged the conclusions that Coca-Cola needed to manage water risks as part of a core business framework that included four elements: plant performance, watershed protection, sustainable communities and global awareness and action. It developed specific goals and made them public to improve water efficiency 20% by 2012 using a 2004 baseline; recycle 100% fully treated effluent water; by 2020, replenish water supplies to communities and watershed to the same level as they had been withdrawn; achieve more sustainable water sourcing plans for all plants by 2012; and integrate the company's supply chain – encompassing water use, soil health, biodiversity, and sugarcane production – into its water strategy.

To implement these and other initiatives, Coca-Cola developed a series of partnerships with organizations that had strong technical capabilities, on-the-ground presence in major watersheds and markets, and global scale. These partners have included the US Agency for International Development, the United Nations Development Programme, the World Wide Fund for Nature (WWF), The Nature Conservancy, the International Finance Corporation, and the Global Water Challenge. The company periodically provides public updates on its performance for each of the major global water strategy elements.[7]

3.2
Unilever's Sustainable Living Plan

Unilever is a global consumer products company that, beginning in November 2010, has committed to decoupling its future growth from environmental impacts, while increasing the benefits of its products and other activities to society. Through the Unilever Sustainable Living Plan (USLP), the company is seeking to achieve three large goals supported by the attainment of nine specific commitments by 2020. The three goals include: 1) helping more than one billion people take action to improve their health and well-being; 2) reducing environmental impact by halving the greenhouse gas impacts of its products across the lifecycle, and achieving a 50% reduction in water consumption associated with the consumer use of its products; and 3) enhancing livelihoods.

As part of its analysis of global environmental risks and challenges, Unilever has conducted a global carbon footprint analysis. Its 2014 analysis reveals that only 8% of the company's global carbon footprint is attributable to its own operations (manufacturing, transport and retail operations), while another 1% results from the disposal of waste. Approximately 21% of emissions result from upstream sourcing of raw materials, and 70% of emissions are attributed

[7] www.coca-cola.com/sustainability

to consumer use of Unilever products (resulting primarily from energy used in heating water for showers or cleaning laundry).[8]

Because so much of Unilever's global carbon footprint is not directly within the company's management control, it has evolved a strategy to collaborate with both consumers and upstream business partners and suppliers to offset and/or reduce greenhouse emissions. Specific initiatives include:

- Integrating sustainability into the company's multiple brands as a means to educate and ultimately transform consumer behaviour.
- Developing carbon offsets by protecting biodiversity and changing agricultural practices.
- Collaborating at market scale with other consumer goods and retail companies through the Consumer Goods Forum for the phase-out of hydrofluorocarbons, a potent class of greenhouse gases used in refrigeration, by 2015.

These and other steps are often either incremental or experimental and assist the company in learning how to develop more innovative products and achieve sustainability results at a greater scale. Moreover, its USLP provides Unilever with the ability to demonstrate shorter-term successes, while building momentum with its employees and consumers for larger scale changes that will also involve transformation in consumption patterns and behaviour.[9]

3.3
WWF and the transformation of risk governance

WWF, a global non-governmental organization, has invested many years in research, collaborative efforts with the private sector and development institutions, and public policy advocacy to address the inter-related issues of population growth, food production and the world's natural resource base. From this work has emerged a rising level of concern about the stewardship of planetary resources and, in particular, the ability to provide sufficient food supplies for a global population expected to reach 9 billion people by the year 2050.

Several key assumptions underlay WWF's recent efforts to manage the global risks of insufficient food supplies. They include:

- Population growth that, per se, is not the principal defining issue for maintaining sufficient food supplies in the future. Rather, increases in per capita income levels are driving current and future food consumption (and the kinds of food being produced). The speed of global change in food consumption is the game changer.
- The world has not yet experienced the full impact of increased demands from India for natural resources, and manufactured and consumer goods.
- Governments at the national and international levels have proven ineffective at managing the necessary steps (e.g., eliminating water subsidies,

[8] Unilever Sustainable Living Plan Update (2014), Scaling for Impact Global Summary, "Unilever's Greenhouse Gas Footprint," p. 5.

[9] For an update on the Unilever Sustainable Living Plan, please refer to www.unilever.com/sustainability.

adopting policies that reflect the true cost of food production, preventing soil erosion) to ensure that food production can be sustained over the longer-term.

One innovative approach in thinking about the challenge of feeding a world with 9 billion people is to redefine it as an opportunity to transform risk governance. Jason Clay of WWF and his colleagues have examined the multiple complexities of food production in the marketplace and concluded that there are multiple leveraging opportunities for introducing a sustainable production of key food commodities. For example, a number of the world's major food commodities (e.g., beef, cocoa, palm oil, sugar, salmon) are produced, processed and marketed by a relatively small number of very large companies. Many of these companies co-exist in common food value chains and, thus, have pre-existing business relationships with each other, or they possess detailed knowledge of each other's operations because they are competitors. Figure 4 illustrates the participation of major companies in key food commodity sectors.[10]

Figure 4: Participation of major companies in key food commodity sectors, Jason Clay (2013)

Using its power to act as an independent convener of global food companies, WWF has assembled roundtables of key commodity producers for a number of purposes: sharing best practices for sustainable food production; collaborating to share information where they possess a common interest; and building support for voluntary standards. Believing that such partnerships with marketplace actors can move faster and achieve more substantial results than the slower pace of government policy, WWF is aiming to transform agricultural production through a new model of networked governance.[11] This model addresses issues such as soil health, food waste reduction, opportunities for technological innovation, information sharing and learning, creation of new metrics to better define productivity, environmental impact and nutrition, and development of certification standards.

[10] Clay J. (2013), "Feeding 9 Billion," in tedxtalks.ted.com/video; and Clay, J. (2013), "Spawning a Sustainable Industry for Farm-Raised Salmon", in Guardian Sustainable Business, August 14, 2013.

[11] Clay, J. (2013), "Feeding 9 Billion".

3.4
New York's PlaNYC[12]

One of the most comprehensive sustainable governance initiatives (PlaNYC, Plan a Greener, Greater New York) has been developed in New York City. Originally published in October 2007, PlaNYC received added impetus, definition and scope in the aftermath of Hurricane Sandy in October 2012. The core goal of PlaNYC is not only to develop an economically stronger metropolitan area but also to ensure its economic, environmental and social resilience over time through its ability to manage and adapt to a widening range of risks and opportunities.

As presently designed, PlaNYC represents a comprehensive rethinking of managing housing and neighbourhoods, water supply and waterways, energy sourcing and distribution, wastewater management and economic development. PlaNYC currently involves 25 participating city agencies and multiple stakeholders from academia, business, community, environmental and other organizations.

This collaboration has committed to implementing a number of specific goals for each major PlaNYC element, including the application of 5 million square feet (464,515 m^2) of reflective rooftops and other energy efficiency measures; upgrading building codes (e.g., installing flood-proof equipment and elevating critical energy and wastewater treatment equipment to higher levels – even within existing buildings); planting 850,000 trees; reducing carbon emissions by 19% since 2005 as part of an overall commitment to achieve a 30% reduction by 2030; investing in natural systems; upgrades to wastewater treatment facilities to protect against storm surges; redesign of storm water drainage infrastructure; and restoring coastal ecosystems (PlaNYC, 2014).

To guide city officials and their stakeholders in understanding infrastructure vulnerability to climate change impacts, the city applies a climate change advisory process with leading scientists and engineers evaluating current and longer-term climate scenarios through the 2050s for average temperature changes, sea level rise and other variables.[13]

3.5
San Francisco Bay Region's resilience initiatives

Infrastructures of other urban areas are threatened similarly by climate change and other risk factors. In addition to its on-going concerns about earthquake damage, the San Francisco Bay region is at risk from sea level rise estimated to range between 16 to 55 inches (40.64 to 139.7 cm) by 2100 even while the region expects to experience continued population growth. To extend this analysis to a more granular level, significant portions of the railway lines, stations and other infrastructure within the Bay Area Rapid Transit (BART) system are at varying degrees of risk from sea level rise. An Alameda County Vulnerability Assessment (encompassing the area that includes the City of

[12] www.nyc.gov/html/planyc/html/home/home.shtml

[13] www.nyc.gov/planyc, and author interview with Carter H. Strickland, Jr., Commissioner, New York City Department of Environmental Protection, September 10, 2013.

Oakland) continues to examine options for making BART and other transportation assets, habitats, and land use more resilient with significant investments in infrastructure being planned.

Within the City of San Francisco, a set of goals to improve the sewer system are balancing green and grey infrastructure to address the following challenges: an aging collection system, excess storm water, seismic activities, sea level rise and optimization of operations. Specific improvement goals call for a compliant, reliable and flexible sewer system that can also respond to catastrophic events. Collecting and treating both sewage and storm water, the system modifies the resilience of the sewer system to adapt to climate change (including sea level rise). It looks to achieve economic and environmental sustainability while maintaining ratepayer affordability.

City officials are applying a Triple Bottom Line (TBL) assessment model to identify planning options and optimize their decision-making. The TBL evaluation criteria include capital, operational and other costs, environmental factors (e.g., climate, habitat, water use, water quality, air quality, natural resource inputs), and social factors (e.g., ratepayer affordability, recreation and open space, employment, cultural resources, construction impacts, the pedestrian environment, noise and odor). The TBL model works as a screening process, but also embodies a ratings system of potential responses across financial, environmental and social variables. A TBL Community Values Survey is used as an overlay to inform the TBL model.[14]

4. Required skills and behaviours for system-level risk management

The transition in thinking to establish new policy frameworks, business strategies and market-scale collaboration efforts is well underway. A major by-product of this development is the redefinition of important skills and behavioural attributes that are critical for future success. Evaluation of these issues has yielded a clearer understanding of the critical skills that need to be taught in business, engineering and public policy schools. These skills include:[15]

- Expertise in one or more areas of foundational knowledge: economics, finance, marketing, operations management, and physical, biological or social sciences.
- Understanding of basic legal standards or requirements (e.g., clean air or clean water legislation and regulation).

[14] San Francisco Public Utilities Commission, Citizen's Advisory Committee, Wastewater Subcommittee, *Triple Bottom Line Analysis*, June 14, 2012.

[15] Examples of recent thinking on these evolving skills' needs include: "Business Skills for a Changing World: An Assessment of What Global Companies Need From Business Schools", in *World Environment Center and Net Impact* (October 27, 2011); Neil C. Hawkins, Robert W. Patterson, John Mogge, and Terry F. Yosie, "Building a Sustainability Road Map for Engineering Education", in *Sustainable Chemistry and Engineering* (November 2013); and Terry F. Yosie, "Sustainable Innovation for Private and Public Sector Infrastructure: Next Generation Challenges for Engineering Education", in *American Society of Civil Engineers International Conference on Sustainable Infrastructure*, Long Beach, California, November 8, 2014.

- Comprehension of how markets function and the role of customers' needs and expectations in stimulating market responses and change.
- Integration of sustainability into core business processes – sourcing of materials, supply chain management, manufacturing, logistics and distribution and post-consumer materials management – or public sector decision-making (e.g., command and control regulation, calculating the social cost of carbon or water, integrating risk assessment and life cycle analysis methodologies).
- Understanding the role of 'smart' technologies and knowledge of data analytics to identify core trends and recognition of data patterns for the purpose of designing more 'intelligent' business processes and public policies.
- Ability to work in teams that have differing skills, behaviors, cultures and geographic locations.
- Knowledge of how to manage complexity and disruption to existing business models or processes, policy assumptions and outcomes.

One expression of how new skill sets emerge is through an examination of efforts to value natural capital. The idea that nature itself contains tangible forms of economic value has long been established as evidenced by businesses that provide eco-tourism services, pharmaceutical companies that obtain critical ingredients for new or modified products from tropical rainforests, and the emergence of green accounting methodologies.

Advocates for protecting key environmental resources and ecosystems from excessive human development and other risks have increasingly focused on natural capital valuation, or the extension of the economic definition of capital (e.g., manufactured means of production) to environmental goods and services. Natural capital is thus the stock of natural ecosystems that yield valuable goods and services, now and into the future. By better understanding the interrelationships that convert wastes into nutrients, for example, economists can better calculate the quantitative and qualitative value of ecosystem resources in the marketplace and help design policies that harmonize their use and preservation for longer-term societal needs.

Emerging from this examination of natural capital is not only a refinement in the skill sets needed but also new collaboration strategies that involve business and non-governmental organizations (principally) but sometimes include government agencies and universities. A recent example is the partnership between The Nature Conservancy, one of the world's largest non-government organizations, and the Corporate Eco Forum, another NGO but with business members. Together, they mobilized approximately 25 global companies and their in-house experts to examine natural capital valuation approaches and identified a growing number of opportunities to apply them in business operations for purposes such as wetlands preservation, pollution abatement and infrastructure planning.[16]

[16] Corporate Eco Forum and The Nature Conservancy (2012), *The New Business Imperative: Valuing Natural Capital*.

5. Additional factors in building new collaboration strategies and policy frameworks

Corporations, non-governmental organizations and other major institutions increasingly conclude that they will be more successful in attaining their individual objectives by collaborating with other partners with aligned interests. This realization has accelerated because of the emergence of a growing number of global scale problems – e.g., water resource scarcities, challenges to producers in providing sufficient quantities of food products, limits for key raw materials in manufacturing operations – as well as a heightened understanding that there is no single institution capable of providing a solution to these and other challenges.

The practice of collaboration is a familiar one to most organizations as it is a normal feature of customer-supplier relationships, specific government-business partnerships or through individual initiatives that are developed with non-governmental organizations, universities and other partners. What is changing the collaboration imperative is both the need and the scale for new kinds of thinking about partnerships that goes beyond the traditional focus on individual topics such as plant performance, mitigation of discrete environmental risks or management of research projects. Succeeding this traditional focus is an agenda aimed at addressing newer sources of disruption and risks to businesses and natural systems; the need for new business models that can sustain profitability while providing solutions for societal needs; strategies for optimizing natural resource management, product and service innovation; and differentiation of brand value, to name a few.[17]

As efforts to build global-scale collaboration evolve, additional insights have emerged. They include:

- **Business executives and policymakers must possess a 'system-level' understanding of societal and environmental changes that are transforming the global economy and civil society**. An important consideration in the design of future collaboration strategies is the skill set of senior executives of global companies, governmental agencies and NGOs. Where they possess competencies in collaborating with partners outside their sectors, these were not generally obtained through formal academic training but, rather, through on-the-job experience, a personal open mindedness about other organizations and cultures, and a recognition of potential value creation. Another major hurdle that many executives need to overcome is a tendency to consider themselves as solvers of individual problems rather than builders of systems of inter-connected capabilities and solutions. Policymakers in regulatory agencies, for example, are often slow to recognize and modify decisions that account for pollution as part of an entire value chain of economic relationships. Instead, they focus on emissions from an individual firm or source category. Some business executives are beginning to learn that issues such as population growth, accelerated urbanization, concerns over food security and natural resource

[17] Jane Nelson (2013), "Scaling Up Impact Through Public-Private Partnerships," in L. Chandy, A. Hosono, H. Kharas and J. Linn, ed., *Getting to Scale*: Brookings Institution Press, pp. 305-362.

scarcities may impact their firms in ways that can significantly affect return on investment metrics or payback periods for invested capital.

As one example, future investment decisions to upgrade power generation systems will need to take into account demand for electricity from individual and networked passenger vehicles, or the interconnected energy and water use in building design and maintenance. Only a 'system-level' understanding of the characteristics and goals across these functions will enable executives and policymakers to develop more innovative approaches to understand both customer and societal needs. Organizations and their partners that accelerate their common learning on system-level challenges will, over time, accrue important advantages in their ability to deliver business or policy solutions to their customers and citizens.

- **Voluntary collaboration initiatives are important but not sufficient to develop solutions to global scale problems**. For two reasons, it is unrealistic to expect that voluntary collaboration alone can ultimately provide effective responses to emerging megatrend challenges: 1) there are too many free riders in the private sector who will seek to avoid modifying their business plans in ways that may affect short-term financial returns; and 2) policymakers in many nations will seek to game any system of collaboration in order to protect subsidies, tax, trade or other advantages against other national competitors. At the same time, despite numerous proposals for some form of global authority to regulate the behavior of enterprises or nations, this option lacks legitimacy in most national, regional or global forums. A more viable alternative at the present time is the creation of global company networks, national agencies, multi-lateral institutions, NGOs or foundations, such as those created for the cross-border regulation of pharmaceutical products or the eradication of malaria. Jointly, they can develop licensing standards and transparency practices.[18]

6. Implications for regulatory policy

Existing regulatory policies that focus on the management and abatement of individual risks such as air and water pollutants, hazardous wastes and other chemical risks will continue to be needed to provide protection to public health and the environment from identified risks. The transition to more collaborative decision-making frameworks can also be applied to current regulatory bottlenecks such as the introduction of negotiated sustainable remediation technologies as an addition or substitute to traditional pump-and-treat approaches in hazardous waste management. Another example is the mandatory phase-out of hydrofluorocarbons through the international Montreal Protocol process that is combined with the voluntary initiative taken by the Consumer Goods Forum (a global organization of major consumer goods and retail companies) to accelerate the phase-out of key ozone depleting and/or greenhouse gases.

[18] For a discussion of these and other issues involved in greater scale collaboration, see, Terry F. Yosie, "How Collaboration Creates Value and Accelerates Change," in www.greenbiz.com/blog/2013/04/29/how-collaboration-creates-value-and-accelerates-change.

However, as the scale of global economic activities accelerates, and as sustainability challenges transcend multiple boundaries, new policy frameworks are needed. There are several critical areas where regulatory policies need to be rethought if governments and their stakeholders are to effectively respond to and prevent global-scale risks. These elements include:

- Policymakers should invite as observers or contributors those experts from business or NGOs who have expertise and have engaged in designing and implementing approaches previously described. Those who are familiar with the processes necessary for creating new collaboration strategies can provide valuable and practical insights to establish policy frameworks that are more suited to the challenges posed by system-level risks.
- Policies should embody a 'systems' approach to effectively assess and manage risks. The examples cited previously provide evidence of various efforts that are underway to build policy frameworks and capacities. They need to be expanded and accelerated across a host of system-level problems.
- More emphasis should be placed on the development and use of integrated tools and methodologies to aid policymakers, business managers and others charged with evaluating and reducing risks.[19]
- Policymakers should work to transition from the regulation of individual pollution sources and sectors to the design and implementation of regulatory frameworks for entire value chains. Regulatory agencies such as EPA and the US Food and Drug Administration have developed processes and accumulated experiences to make this transition. They and other agencies need to accelerate planning to keep pace with sustainability impacts in the marketplace.
- Regulatory policies need to be guided by the insights provided by smart technologies and data analytics to discern key trends and opportunities for policy interventions. Greater investments in policy analysis that embody data analytics and expanded partnerships with the private sector are pathways towards this outcome.
- The co-benefits of reducing system-level risks (e.g., the additional public health benefits that accrue by reducing ambient particulate matter through the control of greenhouse gases or the adoption of energy efficiency measures) should be identified and communicated in a more transparent manner with key stakeholders.[20]
- Regulatory agencies should develop more formal plans to identify and recruit the critical skills and competencies necessary to evaluate and manage system-level risks.

In considering these elements, there are two additional factors that are important to keep in mind: 1) public agencies (regulators) possess important convening authorities to assemble the requisite data and stakeholders and, where appropriate, effective and legal, they should consider directly facilitating processes aimed at resolving system-level risks; and 2) the range of

[19] US National Research Council, *Sustainability Concepts in Decision Making*, cited above, is a good start in identifying and evaluating the utility of a variety of tools, methods and forms of collaboration between regulators and affected parties, for a variety of sustainability-related challenges.

[20] A series of co-benefit examples can be found in US EPA (2015), *Climate Change in the United States: Benefits of Global Action: Office of Atmospheric Programs*, EPA 430-R-15-001.

governance options for system-level risks will continue to expand and will range from traditional command and control regulation, voluntary initiatives, expanded reporting, to ultimately shared forms of governance that are co-designed and implemented by government authorities, regulated entities and non-governmental organizations. Such creativity should be encouraged not only to enhance problem-solving but also to build trust among stakeholder organizations and the public and attempt to de-politicize risk governance without forgetting the importance of designing and maintaining sufficient provisions for transparency and improved performance.

As additional experience is gained with system-level risk governance alternatives, it will be important to develop practical guidelines, or suggested typologies, that further delineate the capabilities, roles and responsibilities of regulatory agencies, the private sector, NGOs and the affected publics to better answer such basic questions as “who is responsible for doing what?”.

Conclusion

As the understanding of emerging risks grows and stimulates additional thinking on the design and implementation of system-level solutions, inevitably, new roles and responsibilities for regulatory agencies, private sector and non-governmental organizations will also arise. Respectively, their evolving roles and relationships will continue to depend on the implementation of tasks where they currently maintain core competencies – e.g., to develop and enforce essential public health and environmental protection, improve living standards by creating additional wealth, and provide essential oversight and advocacy for major societal needs. Just as importantly, these and other institutions need to branch out, simultaneously developing additional capabilities and collaborative approaches to resolve planetary-wide challenges that are beyond their individual capacities. While the need for such a transition is beginning to be recognized, the unresolved question is whether or not it can be successful in a sufficiently timely fashion.