1.2 THE SIGNIFICANCE OF CONCEPTS OF UNCERTAINTY, RISK AND COMPLEXITY IN DECISION-MAKING AND PLANNING

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Introduction

The awareness of risk, uncertainty, and complexity in the social science and technology literature has been growing resolutely since the second half of the 20th century and has reached almost fever pitch in the first part of the 21st century. This has led us to seek a much greater appreciation and clarity of these concepts before we come to address them, and the issues they potentially pose, in the context of decision-making and planning for mega urban transport projects (MUTPs).

This section is a review of literature in which we attempt to come to grips with the key basic concepts of risk, uncertainty and complexity and their interrelationships as they are viewed in management and the social sciences. The meaning of terms is critical to clear thinking in collaborative research of the kind undertaken for both the VREF Smaller Project and the CoE research programme to help arrive at operational definitions to carry forward into the debate about MUTPs.

Risk and uncertainty are social constructions that have no relevance or value except in the context of decision-making. Since decision-making is pervasive throughout personal and organizational life then risk and uncertainty are highly significant factors. Complexity, on the other hand, is more than a severe case of complication. We set out here to explore how the theory that surrounds the concept of complexity has spawned a science and a sophisticated extension to Systems Theory and discuss the overriding influence of the theory on the whole field of risk-taking and uncertainty. We go on (with additional contributions in Working Papers #2 and 3) to examine various decision-support methods, tools and techniques that have been developed with the explicit aim of addressing risk, uncertainty and complexity in a range of different environments (contexts), and close with a series of conclusions relating to the ways in which this study takes us forward, what lessons can be learned and what needs are yet to be met.

The terminology of risk and uncertainty

In everyday usage the terms ‘risk’ and ‘uncertainty’ are invariably employed interchangeably. Since semantics are important, we need to explore their meanings and adopt specific terminology in order to carry the debate forward into the ultimate field of specialisation that we wish to address.

The dictionary defines risk as ‘danger, hazard and/or exposure to mis-chance or peril’ (OED, 2007). We can, however, trace an operational definition of risk, uncertainty (and ignorance) back to Knight (1921) (in Zinn, 2004a:5) based on the following other definitions:

- ***A decision under conditions of risk*** is where there is a known range of possible outcomes, with a known probability for the occurrence of each state (e.g. a fair roulette game).
- ***A decision under uncertainty*** is where there is a known range of possible outcomes but the precise probabilities are not known (e.g. a sports event).
- ***A decision in conditions of ignorance*** is where neither the probabilities of, nor indeed the range of possible outcomes is known.

The Royal Society for the Prevention of Accidents Study Group Report entitled 'Risk Assessment' (1983) defines 'risk' as:

> *"… the probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge. As a probability, in the sense of statistical theory, risk obeys all the formal laws of combining probabilities*." (quoted in Adams 1995:8)

The same source goes on to define 'detriment' as the integrated product of risk and harm; this often being a numerical measure of the expected harm or loss associated with an adverse event.

Adams (op cit.) observes that over the long term there has been consensus within the safety literature in particular that progress lies in refining methods of measurement and collecting more data on probabilities and magnitudes of adverse events. Engineers, scientists and economists, especially, tend to regard risk as a rational, quantifiable measure of loss or failure. In a Project Management context, 'risk' denotes "…an uncertain event or set of circumstances that, should it occur, will have an effect on the achievement of the project's objectives" (APM, 2004).

A report by the UK government Cabinet Office (2002: 7) cites two overarching concepts for risk. It argues that "a risk refers to the uncertainty of outcome, whether positive opportunity or negative threat, of actions and events", and that risk is "the combination of likelihood and impact including perceived importance".

Adams employs the 'hazard' interpretation of 'risk' and identifies three categories for the concept (2005):

- ***Directly perceptible risks***: This relies on the use of judgment – a combination of instinct, intuition, and experience. One does not undertake a formal, probabilistic, risk assessment before crossing the road, he argues. Crossing the road in the presence of traffic involves prediction based on judgement. Here one must judge vehicle speeds, the gaps in traffic, one's walking speed, and hope one gets it right, as most of us do most of the time.
- ***Risk perceived through science***: Most of the published literature on risk management falls into this category. Here Adam's explains one finds not only biological scientists in lab coats peering through microscopes, but physicists, chemists, engineers, doctors, statisticians, actuaries, epidemiologists and numerous other categories of scientist who have helped us to see risks that are invisible to the naked eye. Collectively, he argues, they have improved enormously our ability to manage risk – as evidenced by the huge increase in average life spans that has coincided with the rise of science and technology.

- ***Virtual risk***: The realm where science is inconclusive is where we are thrown back on judgement. These risks, Adams claims, are culturally constructed – when the science is inconclusive people are liberated to argue from, and act upon, pre-established beliefs, convictions, prejudices and superstitions. Such risks he suggests may or may not be real but they have real consequences. In the presence of virtual risk what we believe depends on whom we believe, and whom we believe depends on whom we trust.

Adams recognizes that only those risks perceived through the natural and physical sciences can be calculated in the sense of Knight's definition of quantifying probabilities and the magnitude of effects. The other two risk categories rely on the exercise of judgement, rather than on a rationality based on quantification.

Risk and the social sciences

In the world of determinism within the physical sciences - where closed systems operate and Newtonian laws rule outcomes - uncertainty may exist *within* any given situation, but it responds to the application of knowledge gathering resources, and the consequences of action are quantifiably predictable.

In the realm of the social sciences, however, it is a very different proposition. Research within an on-going programme *Social Contexts And Responses To Risk* (SCARR) conducted by a network of social scientists from 14 UK universities, reinforces the key point that the risks people perceive and respond to in everyday life often differ from the risks identified as objective facts or assumed to be high priorities by business, planners or policy-makers (SCARR, 2008). An examination of the output of this network reveals the wide range of factors (social group identification, life experience, and the perceptions of others, our emotions and apprehension of other people's emotions) that can influence the recognition of risk in many different social contexts.

Economics and risk

Economic approaches to the treatment of risk are primarily based on 'rational actor models' and the assumption that individuals make deliberative choices between alternatives (Zinn, 2004a:14). 'Alternatives' here are seen as outcomes to which probabilities can be attached From this standpoint, "risk is a special case of decision-making under uncertainty where the probability of an event, or the full range of outcomes, is unknown" (ibid.). The majority of economic literature adheres to the argument that there is an objective and measurable risk on risk-taking and assumes that the decision on how to reduce this risk can be made rationally on the ground of statistical methods. At the core of the economic approach to the treatment of risk is the notion of decision-making by 'single agents', and not in co-operation with other parties.

A recent literature review of the treatment of risk by economists (see Zinn 2004a) reveals that actors are not simply, and always rational in their choices in the classic sense (op cit: 2). In economic decision-making the same source describes the use of heuristics, i.e., the influence of the framing of issues through context, the degree to which rationality is bounded (i.e., assumptions about the limits of this context), and the importance of trust and emotion in real-life choices. These observations have in turn led

to examinations of the influence of context, social practices and institutions and to approaches which take learning into account (op cit: 14)

Research on decision strategies has however shown that people systematically deviate from the assumed rational behaviour of economic theory (see Tversky and Kahneman, 1987, cited in Zinn, 2004a: 6). They adopt instead simplified models of rationality leading to strategies of what is called 'bounded rationality' with sub-optimal outcomes. These include (after Simon, 1976):

- ***Lexicographic outcomes*** – choice of the option that performs best on the most important attribute;
- ***Outcomes that involve elimination*** – choice of the option that meets the largest number of criteria deemed important;
- ***Satisfying outcomes*** – choice of the option that reaches a satisfactory standard on most criteria.

Another behavioural response to the complexity of assessing probabilities and predicting values is to exercise judgement based on a limited number of heuristic principles Tversky and Kahneman, 1974: 35). These rules of thumb include (op cit 1974: 46):

- ***Representativeness*** – here issues are compared with others by superficial indicators, and categorised through the logic of stereotypes.
- ***Availability*** – here the probability of an event is gauged by the ease with which such occurrences can be brought to mind.
- ***Adjustment and anchoring*** – here different starting points yield different estimates which are biased towards the initial values

Developments in game theory have been most significant in addressing how choices in multi-actor interactions are made, which in turn has provided insights into reciprocity and trust.

Sociology and risk

A central assumption in the sociological perspective is that risk is a social construction in a particular historical and cultural context (Zinn 2004b:5). Discussion has ranged over the objectivist view which interprets risks as susceptible to description independent of the social context, in contrast to the constructivist standpoint which argues that there can only be a subjective and social interpretation of risk. Academic debate appears to have settled around a position that acknowledges that there is *no* access to objective risk independent of the social, and risk interpretations are *not* absolutely independent from objective events. This accepts that objective risks are not an absolute description of reality but should be viewed in relation to their social functions and effects (Wynne 2002: 462, cited in Zinn, 2004b: 5).

This conclusion has important implications for the distinction between lay and scientific knowledge, and their use by lay and expert individuals in the perception and taking of risks. They are different, but neither is superior to the other. There is thus no clear distinction between expert and lay knowledge, each has elements of the other embedded within it (Ibid). One possible exception is that lay knowledge might be said

to have the edge over scientific knowledge when it comes to dealing with practical reality. This resonates with the Surowiecki (2004) thesis on 'the wisdom of crowds' in which he argues that the aggregation of information in groups, results in decisions that are often better than could have been made by any single member of the group.

In Zinn's overview of research in the field of sociology and risk (2004b) he distinguishes between two main themes: reflexive modernity; and socio-cultural theory.

Reflexive modernity

The best known approach to risk in the sociological sphere is that presented by Ulrich Beck in his book 'Risk Society' (Beck, 1992). Here he argues that the term 'risk' has two distinct meanings:

- ***A world governed entirely by the laws of probability,*** in which everything is measurable and calculable; and
- ***Non-quantitative uncertainties*** giving rise to risks that 'cannot be known'.

He seizes on the latter sense of uncertainties, in developing his concept of the 'Risk Society' in which contemporary risks are seen to arise as the unintended consequences of modernity as, quote, 'distanciated' over space and time but inescapable; and as invisible to the senses and dependent on scientific knowledge for identification (Beck, 1992)

The Risk Society 'describes a phase of development of modern society in which the social, political, ecological, and individual risks created by the momentum of innovation increasingly elude the control and protective institutions of industrial society.' (Beck 1996: 28). In these terms the Risk Society is then a wholly contemporary concept.

Commenting on the ideas presented by Beck in his 'risk society' thesis, Goldblatt (1996: 155) explains that: 'At the heart of Beck's explanation of the dynamic of change from industrial modernity to an emergent Risk Society are the new primarily environmental risks created by the unintended consequences of enlightenment rationality'. According to Bulkeley (2001: 431), the concept of this kind of society is perhaps most clearly illustrated through the phenomenon of climate change Here the causes are rooted in modernity and industrial development; the experiences of climate change are indeterminately 'distanciated' over space and time, stretching social and natural relations and responsibility. Though climate change may be sensed by individuals, the understanding of the processes through which greenhouse gases affect climate systems depends on scientific understanding.

The concept of risk is largely confined, by Beck, to technical and environmental dangers or hazards that are the unforeseen consequences of industrialisation. This somewhat narrow interpretation has attracted critical comment proportionate to the widespread impact of the original work. There is, nevertheless, widespread agreement that modernity brings with it a new quality and scale of dangers.

At the broader level society has developed the concept of risk as a specific historical strategy to manage uncertainties, particularly with reference to insurance in the contemporary world. Technical and statistical risk management is itself seen here as insufficient, lacking the emotional, aesthetic, and socio-cultural dimensions pertinent to complex decision situations. Zinn (2004b:7) highlights the work of Bonss (1995) who

argues that a societal approach has to start with the concept of uncertainty rather than risk. The probabilistic concept of risk in these terms is thus a sub-set of uncertainty. In modernity, he points out the repeated experience of catastrophes which show the limits of absolute rationality in probabilistic risk calculations. Recognition of these limits he argues leads to the greater politicisation of judgements.

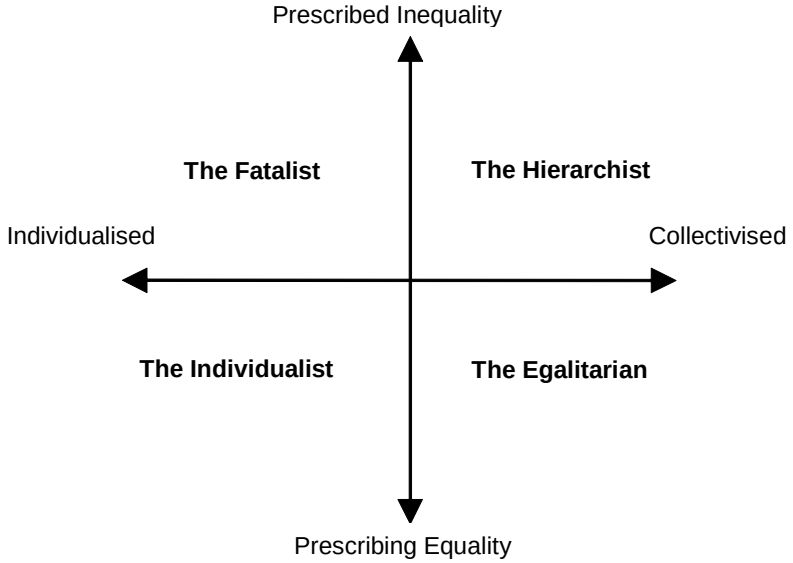
Following this logic, a risk calculation is therefore seen *not* as an objective matter, but as a cultural construction only valid for special cases (contexts). The objective-subjective debate on assessments of risk has not in these terms so much polarised, but found a new acceptance that they are determined by subjective influences and closely bound by context (an observation of immense importance). There is then an acceptance that there is no single rationality, but a variety of rationalities that are employed according to different social and cultural contexts.

Bonss (1995: 80, cited in Zinn (2004b: 8) argues that uncertainty is a fundamental modern experience and that the view on problems of uncertainty has to be changed. He proposes it should no longer be defined as a problem of *how* to produce 'order' and certainty. This reference first to uncertainty is widely viewed as a more promising route to broaden the understanding of risk. Here, Bonss argues, different strategies may be used to transform unmanageable uncertainties into manageable risks.

Socio-cultural approaches

Perhaps the most prominent contemporary theory of sociological risk research is the 'Risk and Culture' approach presented by Douglas and Wildavsky (1982), subsequently elaborated upon by Douglas (1985) and Thompson *et al.* (1990). The Douglas cultural theory of risk, gave rise to the grid/group scheme in collaboration with Wildavsky (see Figure 1). It is a paradigm that represents the different rationales of risk as they are expressed in social groups or organisations.

Figure 1: The Grid/Group Typology (after Douglas and Wildavsky,1982)



The central theme of 'Risk and Culture' is that risk is culturally constructed. This was distilled into a typology defined by two bi-polar axes as shown in Figure 1: the Individualised-collectivised axis intersects the Prescribed Inequality-prescribing Equality axis at the centre which results in a four-fold typology of rationalities characterised as follows (after Adams 1995: 208):

- ***The fatalist*** – who argues we cannot manage risk better, life is unpredictable, end of story;
- ***The individualist*** – who devolves managerial responsibility from bureaucracy to the individual;
- ***The egalitarian*** – who exercises more caution and co-operation; and
- ***The hierarchist*** – who advocates doing more research and introducing more regulation.

Each of the types is likely to hold a distinctive view of how or whether risk might be managed better, and in their co-existence each helps to curb the potential excesses of the other three.

While the Risk Society approach advocated by Beck provoked a great deal of critical comment, The Cultural Theory of risk has tended to inspire both a quantitative and qualitative evolution of its understanding. Inevitably, understandings about risk are dealt with via membership of cultures and sub-cultures (acting as different forms of shared contexts), as well as through personal experience (personalised contexts). Risk knowledge in these terms may therefore be seen as historical and local, individual and collective . It becomes clear here that risks are multidimensional, and that risk- taking can be regarded positively as well as negatively. This latter point is taken up strongly by Adams' seminal work on risk (1995) in which 'risk compensation' is a major theme and where individuals are seen tolerate or even seek-out varying degrees of risk in their lives (the rock-climbing librarian). The thesis here is that an imposed reduction in risk in one avenue leads to compensating behavior that heightens risk elsewhere.

Different, competing and sometimes contradictory knowledge systems (heavily influenced by cultural context) are available in different life stages and situations. In these instances 'expert knowledge' emerges as merely a single point of reference amongst many influences on decision-making behaviour (Zinn 2004b:11). In this context, the role of mass media in the perception and communication of risk is crucial although other factors in the mixed spectra through which risks are discursively constructed, alongside individual experience, include local memory, ideologies and personal judgements. Studies that compare media coverage of risk tend to show that an appreciation of the contemporary social and political context is essential to understanding the perception of risk. The portrayal of risk perception by the media can only be understood by analysing the context within which reports are embedded *and* the cultural social and biographical contexts of the reporter. Even with the best of reporting intentions, 'objectivity, rationality, and accuracy have been shown to be illusory'. In this context 'trust' becomes a critically important factor especially in relation to the credibility of the source as reflected in Section 2.8 of Working Paper #2).

'Trust' has far wider implications as a significant variable in risk perception, rational decision-making and social relations. As such it is attracting increasing attention in the social sciences. Trust like risk itself is a multi-dimensional construct. An early insight came from Simmel (1968: 393, cited in Zinn 2004(1): 7) who described

trust as a 'middle state between knowledge and ignorance'. In this sense it is incompatible with complete ignorance of specific future events, and also with the belief that disappointment is emphatically excluded. Trust is connected with risk in that it has relevance in decision making and has consequences for the trusting agent if that trust is upheld or betrayed (Op.cit:18).

There is though a systematic difference in the conceptualisation of trust between economists and sociologists (Anheier and Kendall, 2002: 347 in Zinn, op. cit.). In economics, trust is defined as an efficient mechanism to economise on transaction costs and it is rationally and explicitly given or refused. In sociology it is neither explicitly nor rationally generated, but given in advance and taken for granted. It may be reinforced through routines, shared values and experiences.

Sources of uncertainty

We have discussed above definitions of risk and uncertainty, and different perspectives and treatments of these concepts, together with the influence of context on such treatments, particularly from the social sciences perspective. What is self evident is that uncertainty is pervasive.

Adams (1995: 25) observes that virtually all the formal treatments of risk and uncertainty in Game Theory, Operations Research, economics or Management Science require that the probabilities and magnitudes of possible outcomes are each quantifiable. He asserts that, in practice since such numbers are rarely available (and one can add even 'knowable'), they are usually assumed or invented, to avoid any admission that these formal treatments have nothing useful to contribute to the solution of the problem in question.

It is evident that the vast majority of literature and discussion surrounding risk and uncertainty centres on the level of expectation and the magnitude of future occurrences of risk. 'Uncertainty' here is seen an expression of confidence about the state of knowledge in a given situation. That situation can be in the present as well as the future. Issues of scale, transparency and capacity (see Table 1 below) can each generate uncertainty. The difference between those factors and complexity-rooted uncertainty is that the former group can, to a greater or lesser extent be attenuated through the application of resources. The economics of information come into play alongside the law of diminishing returns; it may be that the price of reducing or eliminating uncertainty exceeds the value of the certainty gained, in which case the original level of uncertainty is tolerated.

Table 1:Sources of Uncertainty

Sources of Uncertainty	
Complexity	it appears more complex than abstractions and models imply
Scale	it is too large or interconnected to observe everything at once, or too small to observe at all
Transparency	it is too opaque to be observed
Capacity	there are inadequate resources to observe it.

Source: after Brown, 2004: 371.

Complexity Theory

As already indicated in the Introduction, complexity is more than just an extreme case of complicatedness. The study of complexity has spawned a science and a coherent theory that is fundamental to any examination of uncertainty.

Complexity Theory is still in its infancy and continues to be 'work in progress'. Concepts of complexity are being developed in a diverse range of subjects, from evolutionary biology to adaptive computing. The body of Complexity Theory has been accumulated from many sources associated with the recognition of complex systems, their characteristics and distinct behaviour. The theory offers a framework that provides an insight into a number of social phenomena. We are familiar with expressions such a 'Murphy's Law' ('if it can go wrong it will') as personal plans go awry, and 'the law of unintended consequences'. Popular social science authors have given us 'tipping points' (Gladwell, 2000), 'the wisdom of crowds' (Surowiecki, 2004), and 'black swans' (Taleb, 2007). In urban planning we have 'wicked problems' (Rittel and Webber, 1973).

What unites these expressions and concepts? Each is based on empirical observation, articulated in a narrative of varying degrees of sophistication, and crucially, in retrospect, each phenomenon is explicable by being enacted within a context of complexity, and each exhibits characteristics that are wholly consistent with the tenets of complexity theory. It is instructive to look closer at the literature on 'wicked problems', emanating as it does from within the planning arena. Rittel and Webber (1973) who first distinguished these in this context of professional activity saw *every* decision around strategic risk as having potentially severe social, political and environmental impacts (also see Dimitriou, 2007:71). These authors argue that assessing and managing strategic risk is itself a wicked problem.

Several decades ago Churchman (1967: B141) described these types of problems as:

> *"... a class of social system problems which are ill formulated where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing*".

Rittel and Webber (1973) characterise wicked problems by their juxtaposition to 'tame' problems where the latter can be solved by conventional analytic methods, whereas wicked problems have no objective measure of success, require iterative steps and possess no right or wrong solutions (only better or worse). The pervasive and perplexing complexity of wicked problems defies traditional linear methodologies of problem solving and hence, traditional approaches to risk assessment.

The characteristics of 'wicked problems' are wholly explained by Complexity Theory since its basic premise is that there is a 'hidden order' to the behaviour (and evolution) of complex systems, whether that system is a national economy, an ecosystem, a city, or an organization. Proponents of Complexity Theory believe specific traits are shared by most complex systems. These systems are the combination of many independent actors behaving as a single unit. These actors respond to their environment (context), much as stock markets respond to news of changing economies, genes

respond to natural selection, or the human brain responds to sensory input. All of these 'networks' also act as a single system made of many interacting components. Complexity Theory attempts to explain how even millions of independent actors can unintentionally demonstrate patterned behaviour and properties that, while present in the overall system, are not present in any individual component of that system.

Embodied in Complexity Theory is its assumption that there are principles underlying all 'emergent properties,' or traits that emerge from the interactions of many different actors. For example, within an ant colony that switches to a better food source, no individual ant made the decision; it was a result of their interactions (Resnick, 1994).

Complex adaptive systems

Complexity Theory finds its operational expression in complex adaptive systems (CAS) (Dooley, 1996:1). Examples include economies, ecologies, weather, traffic, social organisations, and cultures. While there appears to be no universal agreement about terms and terminology surrounding the concept of complexity, the following quotations offer a flavour of the many definitions employed:

> *"… a system is complex, in the sense that a great many independent agents are interacting with each other in a great many ways. (Waldrop, 1993: 11)*
> *… you generally find that the basic components and the basic laws are quite simple – the complexity arises because you have a great many of these simple components interacting simultaneously. The complexity is actually in the organization – the myriad possible ways that the components of the system can interact".* (Stephen Wolfram, quoted in Waldrop 1993: 86)

> *"Complex adaptive systems consist of a number of components, or agents, that interact with each other according to sets of rules that require them to examine and respond to each other's behaviour in order to improve their behaviour and thus the behaviour of the system they comprise".* (Stacey, 1996: 10)

A minimalist definition of a complex system offered by Batty (2007: 3) is 'a system that is composed of complex systems'. In the past, through conventional Systems Theory, there has been a tendency to see levels of a system as being systems in their own right which can be isolated easily and conveniently from the rest of the world. However, as soon as systems theory came to be applied to society, it became clear that any assumptions about independence between levels of systems were no longer tenable. As the Rand Corporation discovered in the 1960s it was possible with the aid of a systems approach to management to put men on the moon, but the same methods did not work when applied to alleviating problems of the urban poor.

In the last thirty years or so, complexity scientists have developed a theory and method which is rapidly gaining credence within and beyond the social sciences. The prevailing view of society that existed in the mid-20th century - which treated social structure as analogous to the way machines function - has been largely transformed in the social sciences, through a radical shift into a metaphor of societies as organisms – as biological rather than physical systems. This is reflected in the view of the evolution of cities as presented by Batty (2007) and perhaps importantly for this research can be extended to city infrastructure systems as well.

The definition of a complex system as being composed of complex systems, by virtue of this recursion, and evasiveness is however of limited utility. For greater insight we therefore need more understanding of the nature and characteristics of complex systems. The first paradox is that no individual complex system can be precisely defined, in the sense that boundaries cannot be unambiguously delineated in terms of constituent agents, span and depth. This is the root of any attempt to understand complexity. The magnitude of their infinite variety is a distinguishing aspect of complex systems. So too is the understanding of the process of change from the bottom-up in that order and structure emerges through the dynamics of actions and interactions.

Durlauf (2005, cited in Batty, 2007: 12) identifies four key characteristics that a system must portray in order to be classed as complex:

- ***Non-ergodicity*** – here the characteristics of systems lack any kind of probable behaviour over the long term. Path-dependent behaviour can be generated where initial conditions or unpredictable shocks determine the long term behaviour and structure of the system. Unpredictability can be generated through endogenous change that can trigger the emergence of new varieties of behaviour. (Systems which are ergodic are those whose dynamics are predictable in that they are well behaved and often converge to some stable equilibrium.)
- ***Phase transitions*** – here transitions occur often abruptly implying some form of threshold which if a system reaches or breaches, leads to qualitatively different structures and behaviours. In this way, complex systems have 'tipping points' where unusual sets of conditions come together and propel the system in one direction or another. This resonates with Gladwell's (2000) empirical observations and conclusions. The intrinsic non-linearity in behaviour over time again limits predictability.
- ***Emergence*** – both non-ergodicity and phase transitions are consistent with the notion of emergence. 'Emergence' is the result of the action and interaction of system components in the absence of any higher level coordination function, it is akin to 'self-organisation' – the generation of spontaneous order from the constituent parts.
- ***Universality*** – this is a characteristic defining the degree of order in a complex system. If a system is the 'same' at different spatial and temporal scales (i.e. fractal in nature) then it is deemed 'universal'.

The context for understanding and managing complex systems is thus that they have too many variables and too many interactions to be handled by traditional methods of management planning and modeling, and that such systems are therefore unpredictable.

One of the defining characteristics of complex systems is the inability to predict the outcome of any given change to the system. Because a system depends on so many intricate interactions, the number of possible reactions to any given change is infinite. Minor events can have enormous consequences because of the chain of reactions they might incite. Conversely, major changes may have an almost insignificant effect on the system as a whole. Because of this, strong control of any complex system may be impossible.

- Another important concept in Complexity Theory is that there is no master controller of any system. Rather, coherent system behaviour is generated by the continuous competition and cooperation between actors. A 'self-organizing' system

adapting on a continuous basis (rather than being subject to a top-down imposed configuration of roles and structures) is often referred to as a 'complex adaptive system' (CAS).

Implications of Complexity Theory for organizations

According to Seel (1999) there are several far-reaching implications that Complexity Theory may potentially have for decision-making entities, be they individual or collective. These relate to the inability to predict, the inability to control, self-organisation and emergence, and the small set of simple rules, as explained below:

- ***The inability to predict*** – One of the features of complex systems is that they have what is known as 'sensitivity to initial conditions'. This means that a small difference in the initial conditions can make a huge difference as time goes on (the 'butterfly effect' - see Lorenz, 1963). Even a small perturbation could, because of the non-linear nature of a complex system, lead to a massive effect. While the chances are that it would not, the point is that it is theoretically impossible to predict whether or not it would. This has obvious major implications for planning and strategy formulation, and is an explanation, if one were needed, of why accurate prediction is often not possible. 'Here the only certainty is that the plan will be wrong'.
- ***Inability to control*** – From a planning point of view perhaps the most crucial and controversial aspect of Complexity Theory is that it is impossible to control what happens to a complex system (courtesy of Ashby's Law of Requisite Variety, 1958) A fundamental tenet of Complexity Theory is that no one element can have enough complexity to be able to comprehend the system as a whole. If it can, then the system is not complex.
- ***Self-organization and emergence*** – A key characteristic of complex systems is their ability to self-organize and for 'ordered patterns' to emerge simply as a result of the relationships and interactions of the constituent agents, without any external control or design. The characteristics of 'emergent order' are that it forms spontaneously, that it cannot be directed (but can be influenced), it resists change and maintains its boundaries.
- ***Small set of simple rules*** – Research has shown that quite simple rules, applied again and again, can lead to complex behaviour. Reynolds (1987) modelled flocking behaviour in the natural world using the following small set of rules:
  - Separation: steer to avoid crowding local flock-mates.
  - Alignment: steer towards the average heading of local flock-mates.
  - Cohesion: steer to move toward the average position of local flock-mates.

  These three simple rules can change a random assembly of agents into a cohesive group, looking just like a flock of birds or shoal of fish. Yet not all flocks or shoals are the same because each is also the product of a changing 'context' which triggers the behavioural responses, whether that is the approach of a predator or perhaps the proximity of a food source. This is a classic example of 'emergent order'.

Complex systems thus evolve from their constituent parts; they are therefore unpredictable, they manifest a myriad of bottom-up and top-down interactions. An

understanding of Complexity Theory is fundamental to learning about, the planning of, and delivery of projects of any scale, be they mega projects or smaller ones. The theory continues to generate profound changes in the way science, in its broadest sense, is conducted. The traditional paradigm of scientific enquiry has in the past tended to be top-down; now, with insights gained from research into complexity, the sciences are seeking common patterns and points of interaction to discover emergence of the unexpected.

A complex system in a state (context) where change may occur both easily and spontaneously has been described as at 'the edge of chaos' (Kaufmann, 1995). According to Chaos Theory it arises through a property of the relationships between the elements rather than the elements themselves, and *not* through any conscious design. It is something inherent in the system. When an organization is poised at the 'edge of chaos' even a small stimulus may cause major change to ripple-through with a domino effect. This 'edge of chaos' condition could equate to Gladwell's tipping point (Gladwell, 2000).

Treatment of risk and uncertainty

Risk and uncertainty have long been acknowledged as threats to desired outcomes in the context of decision-making, though that recognition has not been universal. Brown (2004) offers a taxonomy of imperfect knowledge about risk and uncertainty based on a spectrum of 'confidence' that ranges from 'certainty' through 'uncertainty' to the 'unknowable'. He further divides uncertainty into 'bounded uncertainty' in which all possible outcomes are known and 'unbounded uncertainty' in which *not* all outcomes are known. He furthermore usefully differentiates between the unknowable and 'ignorance', claiming the latter to be 'a lack of awareness of imperfect knowledge' (Brown, 2004: 374).

Identifying the 'unknowable' is important in managing uncertainty, because it may lead to a greater emphasis and reliance on contingency planning and reducing vulnerability to change, rather than vain attempts to improve prediction. In practice, specific outcomes may not be known, even if they could be known in principle, while the desire for a definitive statement about a situation may override a more realistic expression of uncertainty.

'Closure' has been identified as a behavioural response to managing uncertainty. The term refers to the process of defining and delimiting an investigation by imposing artificial boundaries (Massey, 1999). Any closure is a conscious or unconscious acceptance of the level of uncertainty, and ignorance about the environment (context) of the uncertainty and risk. 'Closure' can also encourage over-confidence. It may be introduced through an unwillingness to accept alternative views, an absence of resources to consider them, a deliberate act of ignoring a problem, or ignorance of alternative views. A study of the management of information technology (IT) projects (see Kutch and Hall, 2005) in a sector notorious for its rate of project failure, identified a common thread in the inadequate treatment of risk and uncertainty as a root cause of failure to manage expectations, and to meet project objectives. This source pinpoints a number of contributory management responses. These include the (after Kutch and Hall: 595):

- ***Denial of uncertainty*** – where this represents failure to consider or resolve risk due to apathy and lack of interest - which represents the refusal to reveal to stakeholders risk related information that may hold negative or discomforting connotations; and
- ***Delay of uncertainty*** – where there is an ignorance of uncertainty – which represents the avoidance of uncertainty reflected by the lack of attention to risk related information due to insufficient trust or belief in the efficacy of that information and the resultant complete lack of awareness of risk related information by stakeholders.

These kinds of behavioural response will be familiar across many sectors. We continue here with an examination of historical lessons in the treatment of risk and uncertainty in decision-making, and various methods, tools and techniques that have been developed and applied to address a variety of issues in a range of decision-making environments (contexts), commencing below with project management and concluding with urban and regional planning.

Project management

In project management the conventional wisdom is that if an unacceptable risk is identified, there are options for action that can be taken to render the risk acceptable. These options fall within the categories of prevention, reduction, transfer, and contingency (Elkington and Smallman, 2002: 50).

Traditional risk management methodologies in project management rely on 'bottom-up' frameworks that place emphasis on risk identification (Jones and Sutherland, 1999). This emphasis often results in lengthy risk registers, where different types of risks are grouped together and, the use of sophisticated risk management databases that keep track of the risks. Risk management approaches that are implemented in project management to ensure that a project is delivered on time, to budget and to technical requirements follow this 'bottom up' approach. Large-scale construction projects are in particular exposed to uncertain environments (contexts) because of potential changes in multiple factors such as planning, design complexity, construction aspects, multiple interfaces, various stakeholders, statutory requirements, time and money constraints (Kumar Dey, 2001: 636). The most commonly used techniques to manage uncertainty and risk in project management typically exhibit several weaknesses. They rely on quantitative data and focus on risk events, to the exclusion of risk processes. They also rely on historic data to forecast future events, and do not address the issues of unanticipated risks (Ibid.).

Crawford and Pollack (2004) advocate that the manner of risk management adopted in project management should be determined by the project paradigm (a form of acknowledged context) it employs. In the project management literature there is a debate about the categorisation of projects according to the extent to which they address 'hard' or 'soft' issues (op cit, 2004). The hard paradigm promotes an understanding of the world as an objective reality, to which all people have equal and unvarying access, and views systems as mechanistic processes, with stable, or predictably varying, relationships between the relevant variables. Examples cite of hard methods cited by Crawford and Pollack include Systems Engineering, Systems Analysis, and early Systems Dynamics. These methods have over the decades influenced the development of project management, which has inherited their 'hard assumptions' about the world. In

this we can recognise the debate about complexity and complex adaptive systems. Through our discourse on change, complexity, uncertainty and risk in the contemporary world we should not be surprised that, according to Crawford and Pollack (2004: 645), projects have often been perceived to have failed due to project managers not paying sufficient attention to 'soft criteria' and that soft issues (which include human, social, political and environmental issues) have increasingly been identified as the key success factors in other projects.

According to Simon (1986), decision-makers often act in a state of 'bounded rationality'. This leads them to confine their perception of a situation to the goals and activities of their specific and immediate domain (context). Because the perception of the world by decision-makers directly affects their ability to manage uncertainties, we would argue that the 'hard' project paradigm rooted in traditional project management (and not unfamiliar in wider planning contexts), conforms to 'bounded rationality'. This we see as a conscious or unconscious construct designed to promote manageability through an *artificially* narrow interpretation of the relevant 'universe'. It treats the project as a closed mechanistic system, and denies the influence of the wider context and the complex adaptive system model.

STRATrisk

During the time of the preparation of this Working Paper there is an important programme of on-going research and development that considers strategic risk management for the UK construction industry. This initiative to develop a comprehensive and systematic process for managing project risk, entitled 'Risk Analysis and Management for Projects' (RAMP), jointly sponsored by the UK Institution of Civil Engineers (ICE) and the Institute and Faculty of Actuaries, revealed significant shortcomings in the underlying analysis, content and format of the presentation of information, and the procedures for Board level decision-making on major construction project risks and opportunities (see http://www.ramprisk.com/riskknowledge/index.asp).

These findings led to the subsequent initiation of the STRATrisk Study (http://www.stratrisk.co.uk) in 2004, funded by the then UK Department of Trade and Industry through the ICE, supported by a dozen or so partners. The objectives of this study were:

> "*To provide guidance for prime decision-makers in construction firms and their clients to manage more systematically and effectively the most important opportunities and threats to their business with a view to its having a significant impact on improving the direction of major corporate risks and opportunities"* (STRATrisk)

Building on the insights and experiences gained in developing RAMP, the STRATrisk process sought to focus on strategic risks and opportunities in construction, rethink Board level decision-making in the face of uncertainty 'and make consideration of strategic risks and opportunities a more central feature of Board agendas'. It also aimed to develop an improved process and framework for dealing with such risks and opportunities so as to help to achieve better and more confident decisions, with aspirations to become an accepted standard of good practice.

The key findings of the STRATrisk Study of construction firms relate to:

- ***Performance***: Whilst many organisations recognise the need to improve their decision-making processes, many struggle with understanding what the first stages of this change process are.
- ***People***: Appropriate cultures need to be developed to allow integration of communication systems and organisational learning. The Board's strategic intent and purpose needs to be clearly communicated to the whole organisation.
- ***Process:*** The classic event based, probabilistic view of strategic risk in decision-making is inappropriate in complex, changing situations. Instead strategic risks need to be treated as dynamic, adaptive processes operating inside complex systems not as events.
- ***Patterns*****:** Strategic risks sometimes appear random, unpredictable and chaotic; but actually there are patterns, and the knowledge to detect them is nearly always available.
- ***Perceptions*****:** Key decision makers need a broader awareness of the dangers of 'group-think' and self bias. They need additional techniques to generate understanding and debate.

These findings were subsequently published in a report entitled *Strategic Risk: a Guide for Directors'* in 2006 and claimed to offer a new approach to strategic risk and uncertainty for top decision makers, with lessons not only for the construction industry but also applicable across all aspects of the business sector.

City and regional planning

The paradigm of 'rational comprehensive planning' as promoted by Rosenhead (1989) and subsequently employed in planning, policy formation, and decision-making for city and regional planning world-wide consists of a five stage process, as follows:

- Identifying objectives with weights.
- Identifying optional courses of action
- Predicting consequence of actions in terms of objectives.
- Evaluating the consequences on a common scale of value.
- Selecting the option expected to yield highest net benefit.

In the 1960s and early 1970s.the rational comprehensive planning approach was widely seen as the most appropriate framework for making decisions and dealing with risk and uncertainty (in so far as these concepts were explicitly recognized) in city and regional planning in the UK and North America Criticism, however, soon began to emerge from a number of quarters. A leading critic, Charles Lindblom (1959), held that this approach to planning (and the associated treatment of risk and uncertainty) to be socially undesirable because of the implicit assumption that a single agency could (and should) adopt a single set of agreed planning objectives. He furthermore argued it to be practically infeasible on three counts. Firstly, because of the lack of data needed to support such an approach, secondly because of the absence of a theory linking action and consequence, and thirdly because of the excessive intellectual demands on policy makers.

Evidence too began to accrue on the infeasibility of rational comprehensive planning (incorporating all uncertainties and associated risks). The proposition that methods capable of getting a man to the moon could, with advantage, also be employed on apparently much lesser matters as solving the problems of the inner city ghettos proved to be false. Rosenhead (1989) cites the example of the work of the RAND Corporation in New York City in the 1970s which sought to apply its cause–effect modelling and optimised modeling approach, developed for aerospace projects, to the issues of city governance. It showed positive results where the agency in question performed a well defined task which generated reliable quantitative data, and where there was a general consensus on objective priorities. It also showed positive results when applied to the fire service, *but* singularly failed with public health administration where the contextual conditions were very different. Once again highlighting the significance of context on effective decision-making and planning.

The critique of 'rational comprehensive planning' demanded that something be put in its place. In response to this call, Rosenhead (1989: 12) listed the characteristics of the 'dominant planning paradigm' and suggested that the features of a new paradigm be diametrically opposite with respect to each characteristic. This is depicted in Table 2. The dominant paradigm here is characteristic of a 'closed' mechanistic systems approach discussed in earlier parts of this section which neglects the way decisions are actually taken and the uncertainties and risks generated by the constantly changing environments (contexts) for decision-making. The 'closed system' approach, as already commented in the context of project management, excludes ambiguity, subjectivity and judgement in favour of elaborate analysis, opacity, and exclusion. The alternative paradigm advocated by Rosenhead offered greater transparency, less complicated techniques, and scope for plurality and judgement. In support of his approach he quotes De Neufville and Keeney (1972) who wrote:

> *"Typically large decisions are not made by a single group of like minded people…they are, rather, the result of extended negotiations, either implicit or explicit, between representatives of different points of view".*

This model promises more than a theoretical framework in that it offers problem structuring methods that fit those characteristics to a greater or lesser degree and which have a positive impact on the treatment of risk and uncertainty.

Table 2: Features of the dominant and a new alternative planning paradigm

	Characteristics of the dominant planning paradigm	**Characteristics of the alternative paradigm**
1	Problem formulation in terms of a single objective and optimisation; multiple objectives if recognised, are subjected to trade-off onto a common scale	Non-optimising, seeks alternative solutions which are acceptable on separate dimensions without trade-offs.
2	Overwhelming data demands with consequent problems of distortion, data availability, and data credibility.	Reduced data demands achieved by greater integration of hard and soft data with social judgements.
3	Scientisation and de-politicisation, assuming consensus.	Simplicity and transparency, aimed at clarifying the terms of conflict
4	People are treated as passive objects.	Conceptualises people as active subjects

5	Assumption of a single decision maker with abstract objectives from which concrete actions can be deduced for implementation through a hierarchical chain of command.	Facilitates planning from the bottom-up
6	Attempts to abolish future uncertainty, and pre-take future decisions.	Accepts uncertainty and aims to keep options open for later resolution

Source: After Rosenhead (1989: 12)

Treatment of uncertainty in planning

During the post-war period, up to say the mid 1970s, uncertainty as a concept and risk taking outcomes in city and regional planning in Britain (and North America) did not feature greatly (Dimitriou, 2007: 49). The current call for greater sensitivity in the treatment of uncertainty in spatial and territorial planning contexts emanates from a number of quarters. The literature (see Dimitriou, 2007: 4365) indicates that this recognition has a thirty year history in academic circles that dates back to the 1970s, and that perhaps now more than ever we are seeing a more widespread appreciation, of the need to plan and manage our future more strategically given the increasingly fast-changing world we live in, propelled as it is by many new technological and globalisation forces.

Courtney, Kirkland and Viguerie (1999: 4) identify four levels of uncertainty in strategic planning. These include:

- ***Most likely outcomes*** based on clear trends that can help define potential demand for products and services;
- ***Currently unknown outcomes*** but knowable in the future assuming that the right analysis is undertaken of performance attributes for current developments that are predictable to certain levels of confidence;
- ***Currently unknown but not entirely unknowable variables*** on the premise that there are certain performance attributes for current technologies, and trends in stable conditions that reveal these; and
- ***Residual uncertainty outcomes*** that reflect the uncertainty that remains after the best possible analysis has been conducted and/or as a result of incomplete/inconclusive developments.

The essence of the above is encapsulated in the following labyrinthine statement made at a press conference by Donald Rumsfeld, then US Secretary of State for Defence (2004):

> "*The message is that there are known knowns – there are things that we know that we know. There are known unknowns – that is to say, there are things that we now know we don't know. But there are also unknown unknowns – there are things we do not know we don't know. And each year we discover a few more of those unknown unknowns".*

If the above quote is the message, then the trick must be to understand which of the circumstances Rumsfeld cites, one is dealing with at any given time.

Scenario planning

Given the premise that in order to successfully address issues of uncertainty, risk and complexity in city and regional planning, one must employ strategic thought (see Dimitriou, 2007 and the following section in this Working Paper) and recognizing that all strategic decisions are affected by differing degrees of uncertainty, scenario planning is an invaluable additional method to the planners toolbox. The scenario planning technique was developed to manage uncertainties and educe effective decisions (see O'Brien, 2000). A scenario is here defined generally as 'a descriptive narrative, which presents a vision of the future with comments on the probability of certain events occurring' (Wack, 1985:72). It aims to connect executives and other decision-makers to ensure the accrued group learning and knowledge gained is applied to strategic decision making, rather than being a disconnected and purely theoretical activity. It can be argued that much strategic decision-making in city and regional planning occurs in an uncertain, constantly changing world (context), as opposed to a risky world, where the meaning of a quantitative risk metric is questionable.

Planners must be willing to look ahead and consider uncertainties. Rather than doing that, however, many instead react to uncertainty with denial. They take an unconsciously deterministic view of events and take it for granted that some things will or will not happen. Not having tried to foresee surprising events, they may be at a loss for ways to act when upheaval takes place. Scenario planning is a tool for helping planners and managers to take a view into the future in a world of great uncertainty. It is a method to help manage strategic risks and opportunities.

Scenario planning is the process in which planners invent and then consider, in depth, several varied alternatives (represented as scenarios) of plausible futures with the objective to bring forward surprises and unexpected leaps of understanding. These scenarios represent a tool for ordering the perceptions of a management or planning team. The point is *not* to select one preferred future and hope for it to become true, *nor* is it to find the most probable future and adapt to it. Rather, to make strategic decisions that will be sound for as many plausible futures as possible. No matter what future takes place, an organisation is much more likely to be effectively responsive to it, if it has seriously thought about scenarios.

Scenario planning is a method for appreciating the future by understanding the nature and impact(s) of the most uncertain and important driving forces affecting the future. Typically it is a group process which encourages knowledge exchange and development of mutual deeper understanding of central issues important to the future. The goal of the approach is to craft a number of diverging stories by extrapolating uncertain and heavily influencing driving forces. The stories, together with the shared journey of the participants has the dual purpose of increasing the knowledge of the decision environment (context) and widening the perception of possible future events. (Borjesson, M. at http://www.futuramb.se/)

Global Business Network (GBN) is a consulting firm specialising in developing strategies for multiple possible futures. It was founded in Berkeley in 1987 by a group of leading scenario experts. According to GBN (2006) scenarios are seen by their proponents as powerful strategic planning tools precisely because the future is unpredictable. Unlike traditional forecasting or market research, scenarios present alternative futures instead of extrapolating current trends from the present. Scenarios

also embrace qualitative perspectives and the potential for sharp discontinuities that econometric models exclude. Consequently, creating scenarios requires decision-makers to question their broadest assumptions about the way the world works so they can foresee decisions that might be missed or denied. GBN argue that within an organisation, scenarios provide a common vocabulary and an effective basis for communicating complex conditions and options. 'Using scenarios is rehearsing the future'

Global Business Network maintains that by recognising warning signs (of the future) and by understanding the drama that is unfolding, one can avoid surprises, adapt, and act effectively. Decisions that have been pre-tested against a range of what fate may offer are more likely to stand the test of time, produce robust and resilient strategies, and create distinct competitive advantage. Ultimately, the result of scenario planning is then not a more accurate picture of tomorrow but better thinking and an on-going strategic conversation about the future (Global Business Network, 2006).

No particular scenario is regarded as any more likely than any other in scenario planning. However, by revealing situations that are both possible and uncomfortable, it can help policy-makers anticipate hidden weaknesses and inflexibilities in organisations and methods. When exposed years in advance, the weaknesses can be remedied more easily than if a similar real-life problem should present as an emergency. The challenge of scenario planning is to find out the 'real needs' of policy-makers and planners, when they may not themselves know what they need to know, or may not know how to describe the information that they really want. The chief value of scenario planning is then that it allows policy-makers and planners to rehearse their decisions without risking important failures in real life.

Scenarios are seen as best deployed in strategic decision-making, with a longer term time horizon (say 5 to 10-years), rather than short-term developments. Virtually any strategic decision situation in which external factors are complex, changing, and uncertain is a suitable target for the scenario process. Three applications of scenario planning techniques are described below (after Wilson, 2006):

- ***Risk assessment*** – This approach can be used to evaluate a specific strategic decision such as a major infrastructure investment. The decision is known beforehand: the question, therefore, is simply whether or not to proceed after assessing the resilience or vulnerability of the strategy in different conditions.
- ***Strategy evaluation*** – Another relatively straightforward role for scenarios is to act as 'test beds' to evaluate the viability of an existing strategy, usually one that derives from traditional single-point forecasting. By playing a strategy against the scenarios it is possible to gain some insight into the strategy's effectiveness in a range of conditions, and so to identify the need for amendments, and identify important outcomes that require immediate attention.
- ***Strategy development*** – In this approach, decision-makers take all scenarios at face value without judging probabilities. Probability has more to do with forecasts than with scenarios; and scenarios are not forecasts. A complete strategy is not developed for each of the scenarios. The real aim is to devise a resilient strategy within the framework of alternative futures provided by the scenarios. The strategy is tested against a variety of scenarios so that the decision-maker is forewarned of potential vulnerabilities. Resilience can then be built into the strategy, not by reducing its force or boldness, but rather by 'hedging' or contingency planning. Scenarios, as a

collection of futures, are intended to establish the boundaries of uncertainty and the limits to plausible futures. Strategy development is the most ambitious and demanding application of scenarios. It seeks to provide decision makers with the maximum feasible range of choice, and to force evaluation of these options against differing assumptions about the future.

Scenario planning differs markedly from contingency planning and sensitivity analysis. Contingency planning is a 'What if' tool, that typically takes into account only one uncertainty; however, scenario planning considers combinations of uncertainties in each scenario. Planners also try to select especially plausible but uncomfortable combinations of social developments. Sensitivity analysis analyses changes in one variable only, which is useful for simple changes, while scenario planning tries to expose policy makers to significant interactions of major variables (ScenarioThinking.org, 2006).

Moving from the scenarios themselves to strategy development and to action is, according to Wilson (2006), perhaps the most critical phase of the scenario process. More scenario projects fail because they have no impact on strategy and management decisions rather than because they were unimaginative or poorly constructed. The major cultural barrier to scenario implementation stems from the way managerial competence is typically defined. It is equated with 'knowing', and the assumption that decisions depend on facts about the present and about the future. The reality is, of course, that decision-makers have no facts about the future. Scenarios confront this dilemma, with the need to acknowledge that the future is unknown and unknowable. But, in doing so, scenarios also may seem to challenge the definition of managerial competence. Managers thus have a vested interest in not acknowledging their ignorance, and so in resisting the intrusion of scenario planning into traditional forms of executive decision-making .

Strategic Choice Approach (SCA)

A planning approach that embeds scenario planning into its framework is the Strategic Choice Approach (SCA) developed by John Friend as a result of experiences gained as a consultant in UK local government in the 1960s (Yewlett, 2007). Friend came to realise that 'hard' systems approaches were not a fruitful avenue to decision-making for planning in climates of high uncertainty, and that a more behavioural and qualitative perspective was a more realistic approach. He therefore shifted from a 'system-centred' approach to a 'decision-centred' view (Friend and Hickling, 1997: 325–326) which rejected decision-making methods that assumed that consequences could be predicted with certainty. The 'strategic choice' approach was thus devised as an answer to pervasive uncertainty. Faludi (2004: 226) claims:

> *"The value of this approach derives from the whole-hearted acceptance of, and its manner of, dealing with, 'uncertainty' as part of the human condition .... 'In dealing with uncertainty, strategic choice puts essential aspects of planning such as engaging in research, political choice, and co-ordination into a unified perspective".*

Whilst the approach typified by Courtney *et al* (1999) fully acknowledges the existence of varying degrees of uncertainty in planning that was advocated by Friend and Hickling (1987, 2005), SCA has uncertainty at its very core. This is because the latter authors view planning as a continuous process of choosing strategically through time – a process they term 'strategic choice'. While their procedural approach has its origins in the 1960s (Friend and Jessop, 1969), yet evermore complexity and uncertainty in today's world continue to heighten its relevance.

SCA comprises a procedural method to tackle complex problems (including 'wicked problems') through a coherent series of steps and actions by which to generate the best substantive solution. It has evolved into a coherent methodology that has been applied in a wide range of contexts (Friend and Hickling, 2005: 295–360). The approach identifies three types of uncertainty in any decision situation (context), and specific types of response to those uncertainties (as shown in Table 3). The key characteristics of SCA are as follows:

- A focus on decisions to be made in a particular planning situation.
- The judgments involved in handling the technical, political and procedural uncertainties surrounding a decision.
- Its incremental approach, rather than one which looks towards an end product of a comprehensive strategy at some point in the future.
- Its 'commitment package' which expresses a balance between decisions to be made immediately, and those to be postponed until a specified future time horizon.
- Its promotion of interaction as a framework for communication and collaboration between stakeholders with different backgrounds and skills.

A decision-maker may respond to uncertainty by accepting the current level of uncertainty, or by taking an 'exploratory action' conceived as a means of reducing current feelings of uncertainty. In judging whether to invest in exploratory efforts towards the reduction of uncertainty, the decision-maker must therefore weigh the expected gain in confidence from the exploratory exercise, against the resources (money, skills, energy, goodwill etc.) consumed in pursuing the action and the delay to the decision introduced by undertaking the action.

Table 3:Types of uncertainty in planning situations

Type of Uncertainty	Response to Uncertainty	Typical Methods	Outcomes
UE working Environment	More information	Research, survey, analysis	Confidence gained Resources used
UV guiding Values	Clearer objectives	Policy guidance, clarify aims.	Decision and action delayed
UR Related decisions	More coordination	Liaison, negotiation.	

Source: After Friend and Hickling, 2005: 11.

Friend's work embodies particular notions about decision-making which act as underlying assumptions or principles on which SCA has been constructed. Burns (2004: 218) highlights several of them as follows:

- ***Group decisions seldom occur as a result of a linear problem-solving process;*** instead they follow a more 'naturalistic', non-linear course, in which problem-solving and decision-making activities are co-mingled.
- ***Policies are seldom made explicitly***; rather they evolve from an incremental sequence of purposeful decisions taken with reference to both history and future options: the policies that result are not irrational, but rather their rationality becomes evident when the sequences of choices made over time are viewed as responses to changing situations.
- ***Decisions cannot be understood apart from the differing stakeholder perspectives and motivations*** that are a source of complexity within a decision process; decisions and plans result from the negotiations of interested parties with different stakes and different perspectives on the situation.
- ***The creative, 'problem-setting' part of a decision-making process is different from the more analytic part*** that is usually associated with choosing among alternatives. Problem setting and problem shaping are distinct parts of the process; they are seldom linear and more often circular, and may take several iterations among them to arrive at a decision.
- ***Decisions are seldom made by thinking comprehensively of whole systems;*** more often they are responses to particular issues or areas of focus, which are selected from larger areas of potential focus.

The claim that SCA embodies a shift in emphasis from simple choice to strategic choice represents an overt response to managing uncertainty as opposed to a reliance on consistent policy. It also represents a shift in management emphasis from regulating to selecting and adapting, and from the pursuit of optimality to achieving effectiveness. It rejects 'black box' expert techniques in favour of its more transparent and accessible methods. SCA promotes interactive participation instead of individual working and replaces routine procedures with a learning process; and it pursues incremental progress rather than discrete problem solving (Burns, 2004:220).

There have been two strands of further development of SCA as follows (after Faludi, 2004: 231):

- ***The increasing attention given to the 'context' of decision-making,*** including mobilising ideas and organisational modes of expression;
- ***The revision of the role of plans in decision-making*** from one of directing decisions (according to preconceived ideas), to one of providing intelligence for decision-makers on the likely ramifications of their intended action.

Friend has himself described the gradual evolution of SCA from a set of practical techniques for decision-making in governmental settings into a more general planning theory that he prefers to call 'connective planning'. SCA is distinctive in the creative way in which it combines the following five emphases:

- enriching communication rather than reinforcing expertise,

- supporting decisions rather than investigating systems,
- managing uncertainty rather than organising information,
- sustaining progress rather than producing plans, and
- developing connections rather than maintaining control.

It offers an alternative model to the rational comprehensive paradigm which has continued to dominate the planning field despite now decades of criticism of its utility, feasibility and appropriateness (see for example Mintzberg, 1994). SCA contrasts with Lindblom's 'disjointed incrementalist model' of decision-making (see Braybrooke and Lindblom, 1970) in that it recognises the value of pursuing an idealised end state, but through sequences of incremental steps also continually redefines and adjusts the vision(s) through an appreciative process. This perspective of planning has profound implications for the role and skills required of the planner as a facilitator of social learning within a process of collaborative problem framing and joint decision-making (Schon, 1980). Burns (2004: 220) argues that '…far from being irrational, the planning process as viewed from within this paradigm is a purposeful, disciplined and rational response to the levels of uncertainty that characterise much of public (and corporate) decision-making'.

Conclusions

The research undertaken for this review has revealed that issues of risk and uncertainty in the context of decision-making and planning are of interest and concern across a wide spectrum of academics and practitioners in a variety of fields, sectors and disciplines (see Working Papers #2 and 3 in this series). In the fields of economics and sociology, in particular, research and debate have been sustained over many years.

While risk has come to be regarded by some as a special sub-set of uncertainty in which the probabilities and/or magnitude of outcomes of an event are quantifiable, as commentators we have observed in applications outside the physical sciences, such quantification is rarely practicable. This has not necessarily inhibited the application of techniques relying on quantification; it simply means that assumptions are made to mask the use of inappropriate methods and dubious results.

Away from the physical sciences, classic models of rationality are being abandoned in favour of more sophisticated models which embody a multifaceted perspective of decision-making behavior, in which context is identified as the key factor. Furthermore, while uncertainty has primarily been studied with regard to future events it is increasingly recognised that it also applies equally to the present.

We also found that as we move into the realms of natural science, so theories based on mechanistic closed systems cease to have any real applicability and relevance. Uncertainty relating to the future within the behavioural domain is, and will continue to be, largely intractable. This is the territory of CAS that are unbounded and inherently unpredictable in outcomes. Even from positions of ignorance of outcomes and likelihoods, decisions still have to be made. In such cases individuals rely on contextual factors for guidance – culture, experience, beliefs, and heuristics.

We conclude that an appreciation of the characteristics of complex adaptive systems is essential for any interventionist in order to understand the limits over control of outcomes, and to recognise that emergence over time can transform them in positive or negative directions. Impacts are not static phenomena. Complexity and chaos

theories tell us that changes continue to reverberate around the system in unpredictable ways. The measurement of outcomes and consequences are therefore only valid for the time in which they are measured. Emergent properties of complex systems mean that subsequent changes are unpredictable.

Complexity generates uncertainties in the decision environment (context), which may in turn impose other risks in the form of threats (or opportunities) upon the achievement of objectives. Planned interventions, such as planned infrastructure projects, for example, can act as a disturbance that triggers myriad responses as the elements seek to adjust to new circumstances and interactions generate feedback. Decision-makers need to appreciate that actions designed to achieve 'directed order' will also, through the operation of 'complexity', lead to unanticipated 'emergent order'.

From our examination of the nature of risk, uncertainty and complexity (and the emerging clear importance of the context in which they arise), together with a selection of methods tools and techniques that are deployed to handle them, we note that each approach explicitly acknowledges uncertainty as an *obstacle* in achieving desired outcomes of concerted action(s). We see that these methods operate with varying degrees of success, none is universally applicable, and there is certainly no *panacea*. We have a sense that each approach is at best appropriate to particular circumstances (contexts), and yet at this stage it is by no means clear what those circumstances are or how best to categorise these circumstances/contexts. What we therefore need is a better way(s) of recognising and categorising contexts, and signposting appropriate ways of handling uncertainty for different circumstances.

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