Beyond predictability

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Abstract

This essay deals with the interrelationship between climate change, the flood, the Brent Spar, one hundred years of discussion about sewerage systems, the weather, the Anazasi Indians, Pim Fortuyn (a Dutch right-wing politician assassinated on May 6, 2002), soccer fans, ecosystems, and innovation.

1 Unpredictability

History is a succession of quiet and turbulent times. Developments that have been emerging gradually over the years may suddenly and apparently without warning start accelerating, assuming a dramatic or revolutionary character. It is of vital importance for any society to be able to counteract these changes by alertness and preparedness.

The biblical Noah was no fool when he obeyed God's command and built an Ark. His actions seemed absurd: who would be so foolish as to build an ark in the middle of a desert, miles away from the coast? Noah, however, built his ark with hazardous times in mind. He prepared himself for an event that no person in his right mind would ever consider to happen. Unlike so many others, he was determined not to be taken by surprise. The dinosaurs did not give a toss about comets, did they? The world could not imagine that the assassination of Franz Ferdinand in 1914 would lead to the death of hundreds of thousands of soldiers in muddy trenches a couple of years later.

In order to be able to understand how an event in a remote place can cruelly disrupt our peaceful little lives, it is necessary to study unstable dynamic systems. These are systems whose long term state of quietness and equilibrium suddenly changes due to seemingly minor marginal changes and turbulently transform into a new and unexpected state of equilibrium.

First, however, I will dilate upon the issue of the predictability of the future. Is it possible for us to know everything, anticipate everything, and prepare

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ourselves for everything? In the following sections, a series of unpredictable and dramatic revolutionary events will be discussed. The systems and their developments will be investigated by means of theories in the field of complex unstable dynamic systems. The results of the investigation will form the basis for a discussion about the existence or non-existence of a universal principle.

2 Is the future predictable?

Intoxicated by the rapid development of mathematics, people have lived for a long time under the impression that everything in nature could be defined with exactness. Ever since the seventeenth century, the conviction has prevailed that a given initial state of a system determines its entire future development. Science is based on this fundamental principle, and to some extent present-day science still is. Natural phenomena are carefully observed and theoretically explained. The explanations are tested experimentally, accepted, adjusted, or rejected.

Newton developed the mathematical laws describing the orbital paths of two heavenly bodies in relation to one another. There seems to be a seamless explanation for everything. Voltaire saw the world as a mechanism, a timepiece. However, the state of euphoria was shattered when Poincaré, in an attempt to solve the mathematical three-body problem, concluded that it was mathematically impossible to predict the motion of three heavenly bodies in relation to one another on the basis of the initial conditions. As this is an all too complex problem for us, we have to conclude that the future development of a random complex system ranks highly among the issues that cannot be reduced or solved. Let us illustrate the matter of unpredictability by means of a number of examples.

3 The Lorenz Butterfly

Mathematician and meteorologist Lorenz carried out computerized simulations to predict weather conditions. One day, he wanted to continue a run he had done earlier so he put in the end variables from the day before. The new simulation yielded radically different weather results. He discovered that internally the computer worked with six decimal places but in the presentation with three decimal places, which caused a rounding error in the start of the simulation of less than 0.001%. This marginal difference in the values of one of Lorenz' variables resulted in an entirely different weather forecast.

This experiment gained fame as the metaphor of Lorenz' butterfly. A butterfly flapping its wings in one place on the earth could cause a hurricane in another. A minimal deviation in the initial variables caused by an unforeseen perturbation leads in a short time to completely different weather conditions. Within this context, a campfire on the Suburban Ark could affect the weather in the whole of the Netherlands in, for instance, a period of two weeks. This seems more spectacular than it is. The flapping of the butterfly's wing does not essentially change the weather and the climate will remain as it is now. All over the world, small perturbations are taking place continuously: countries are teeming with butterflies; campfires are burning everywhere, and in many places, buildings are erected influencing turbulence.

In short, weather conditions are continually affected by all kinds of natural and anthropogenic interventions. The majority of disruptions do not affect the weather structurally. The weather conditions in Western Europe, for instance, will continue being determined by the low-pressure areas from Iceland. The system seems stable, yet there are indications that dramatic climate changes in the past were indeed caused by sudden unusual circumstances.

4 Ecosystem dynamics

A sudden event can also radically change an ecosystem. A system that looks very stable on a superficial level may turn out to be unexpectedly vulnerable. A striking example of such a rapid shift is the Sahara desert. Between ten to five thousand years ago, the area was a wetter place than it is now, with lush vegetation, lakes, and marshes. The transition from this area into the current desert took place very suddenly approximately five thousand years ago. The Dutch ecologist Scheffer has identified similar changes in lakes, coral reefs, forests, deserts, and oceans (Scheffer et al, [10]).

Figure 1: Fractal (frost-flower).

The shift takes place as follows. The environmental conditions in a system that at a given moment is in (an state of equilibrium) can change gradually. Increased pressure from the outside causes the environmental conditions of the system to change very slowly. As, inside the system, a large number of biological, physical, or chemical feedback mechanisms are still in action, the situation remains as it is, i.e. stable. However, the resilience of the system undergoes a gradual deterioration. At a given moment, an impulse from the outside can lead to a catastrophic change. Such an impulse, which could be anything from a sudden drought to a flood, acts like the proverbial last straw. A catastrophic change always takes place unexpectedly and cannot be predicted with the current *early warning systems*. Restoring the fundamental necessary conditions of the system at issue will not reverse the change. In order to reach this, far greater efforts are necessary.

A small and simple system will change relatively rapidly. A large and particularly a complex system will offer more and longer-lasting resistance. Even so, the change will be sudden and unpredictable and the degree of irreversibility many times higher. Moreover, a system such as a lake seems to have two or more stable equilibrium states, which enable it to jump from one state to another. According to Scheffer, the changes are unpredictable because they are not linear in character.

5 Collapse of civilizations

In his book *Guns, Germs, and Steel: The Fates of Human Societies* [1], Jared Diamond lists a large number of crises that have led to the near-collapse of entire civilizations.

After Christopher Columbus had discovered America, Spanish armies comprising of no more than a few dozen soldiers managed to defeat tens of thousands of Indians. The deciding factor here was the fact that the Spaniards had horses, guns, and steel swords, objects with which the Indians were entirely unfamiliar. In the centuries following the 'discovery of America' and the first conquests, diseases that they lacked immunity to more than decimated many peoples of the new world.

Thus, a marginal development, i.e. the arrival of a small number of white people, led to a massive crisis in the existence of the Indians. In his book *Collapse: How Societies Choose to Fail or Succeed* [1], Jared Diamond answers the question why societies can collapse.

In his vision, the collapse of entire societies can be attributed to the combination and interrelation of factors such as environmental damage through human interventions, climate change, hostile neighbours, enemies of befriended societies, and the way in which a society's elite responses to its problems.

Janssen et al [4] have done research into the civilization of the Anazasi Indians. In the '*collapse literature*', they came across three factors that may lead to the collapse of a civilization: a) sudden negative events, b) the impressive size of the collapsed settlements at issue, and c) evidence of overexploitation. The researchers added a fourth element, based on psychosocial expertise: d) large investments in a certain area or in a certain way of living make it virtually impossible for a population to abandon the area or adopt another lifestyle in less favorable conditions. If the situation gets too unstable in terms of surroundings, circumstances or environmental conditions, a sudden event, a drought or a war, can lead to the collapse or fall of the civilization at issue.

6 Complexity theory

Since the seventies of the last century, science has adopted the view that the world is composed of systems sharing a number of qualities. These systems often seem to be in a seemingly stable situation. This stable equilibrium state is called an 'attractor'. The processes of development within a system continue in a linear way for a long time, remaining within the stability of the given attractor. Certain developments at the periphery of the system can lead to instability in the system, causing it to move into the sphere of influence of another attractor. This change can be extreme and often pass off chaotically: it is unpredictable what the new stable equilibrium state will be. Generally, the addition of extra energy or matter to a stable system will eventually lead to a phase jump.

Following Geldof [2] and others, the following characteristics play a role in the description of an unstable dynamic or complex system:

- Attractors. Complex systems are often experienced as stable. They usually are in a preference state. A lake, for instance, has an ecological equilibrium state. VINEX housing estates are generally developed according to largely the same procedures.
- Crisis. A crisis causes a complex system to jump from one system to another: the metaphorical flapping of the wings of Lorenz' butterfly or a sudden and unexpected drought can be the last straw.
- The border area between order and chaos (*the edge of chaos*). Intellectual, societal, and/or biotic processes in a system have changed to the extent that the existing equilibrium state is under pressure, but is not yet undergoing changes. The system is 'far from equilibrium'. In this state, a crisis, or a marginal event in the periphery of the system is likely to arise, forcing the system to move into the sphere of influence of another attractor.

Figure 2: World EXPO Hannover.

Gleick describes the gradual evolution of new insights in the work of scientists engaged in various fields of specialization such as philosophy, chemistry, ecology, communication science, management sciences, and archaeology (Prigogine en Stengers, [8]; Gleick, [3]; Lewin, [5]; Waldrop, [12], Janssen et al, [4]; Scheffer et al, [10]).

7 Back to the first question

What is the interrelationship between the flood, the Brent Spar, one hundred years of discussion about sewerage systems, the weather, the Anazasi Indians, Pim Fortuyn, soccer fans, eco-systems, and innovation?

A flood happens suddenly, unexpectedly, like a raid. In 1995, Shell Oil decided that from an environmental point of view, dumping the Brent Spar, a heavily contaminated oil installation, into the North Atlantic was the best solution. This decision met with well-founded global resistance, which Shell initially considered irrelevant and marginal. The installation of sewerage systems in the Netherlands has led to a heated debate about usefulness and necessity resulting in a plethora of systems. In the end, one specific system was applied in the greater part of the Netherlands. The Dutch 'purple' cabinet (a coalition of the labor party (PvdA), right-wing liberals (VVD), and liberal democrats (D66), which ruled from 1994 to 2002, thought to have matters under control when out of the blue former sociology professor and right-wing politician Pim Fortuyn raised a number of politically sensitive issues. Soccer fans massively started the wave or indulged in worse activities without incitement or stage direction. These examples are all indicative of a system, be it a group of people or a planning process, suddenly changing from one into another equilibrium state under the influence of a marginal or remote phenomenon.

8 Makeability

This approach has far-reaching consequences for our western way of thinking, which is strongly based on the concept of makeability. In his book *The End of Certainty* [6], Prigogine introduces the physics of non-equilibrium processes, a science that affects our way of thinking in two ways. Firstly, it proposes the fundamentally constructive role of 'the arrow of time', which expresses Prigogine's vision of the irreversibility of time. Even with limitless knowledge, it is fundamentally impossible to reverse time, which means that any process is irreversible.

Secondly, it proposes the principle of uncertainty. Traditional science relates limitless knowledge to certainty; however, limitless knowledge of a system or of its initial conditions does not imply that its development can be predicted. Prigogine claims that the laws of nature do not express certainties but possibilities. This vision is of major importance to systems innovations, which after all do not arise from thinking in terms of linearity and cognizance or the invention of a new system. System innovations come into being by developing the right idea, or new thing, at the right time in the right context. To attain that, one has to allow oneself to be lazy from time to time...

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