Santi di Tito

Portrait of Niccolò Machiavelli (1469-1527).

TO WIN OR NOT TO WIN: THAT IS THE QUESTION

Victor M. Ponce

Professor Emeritus of Civil and Environmental Engineering

San Diego State University, San Diego, California

29 August 2023

ABSTRACT. This article dwells on Niccolò Machiavelli, the famed Italian writer, and his very timely thoughts about winning and losing in regard to the human experience (Machiavelli, 1517). Three broad real-world examples are discussed: (1) The role of sediment in hydraulic engineering; (2) the role of salinity in irrigation management; and (3) the existential issue of global climate change. The article closes by elaborating on the appropriateness of environmental impact analysis and on the path toward sustainability through the endorsement of interdisciplinary knowledge.

1. TO WIN OR NOT TO WIN

In his seminal work "Discourses on Livy", written circa 1517, Niccolò Machiavelli, the famed Italian writer, saw fit to mention the *singular human predicament* twice, just in case his readers missed it the first time. He said: "So in all human affairs one notices, if one examines them closely, that it is impossible to remove one inconvenience without another emerging." Later in the book, he reiterated: "In human affairs there is, in addition to others, this difficulty: When one wants to bring things up to perfection, one always finds that, bound up with what is good, there is some evil... and it would seem impossible to have one without the other." We note the two elements that distinctly show up in Machiavelli's dicta: (1) human affairs, and (2) the good/bad duality. If these two are not effectively tied to each other by destiny, indeed Machiavelli may have been among the first to make sure that they were at least placed on the record.

Accomplishing good, and winning something from it, material or inmaterial, invariably requires some action. Nobody ever won anything by sitting still. Action requires a change in the status quo, typically a development that brings a new idea to fruition. It is hoped that this development will result in an increase in the *quality of life*, as defined by contemporary standards. Societies around the world employ various types of professionals to assist in materializing the developments into commercial products and services. Yet, the crucial question remains: Is it possible for humankind to develop a product or service that will deliver only good, to the exclusion of bad? Was Machiavelli correct in pointing out that we have no choice but to accept this dichotomy as part of the workings of Nature, which, ostensibly, we are only able to manage, but not to circumvent?

In the remainder of this article, we describe three cases that will endeavor to show that if Machiavelli was not totally right, at least he was pointing in the right direction. This is the true predicament of human society: How to win without losing. To the extent that, so far, we have been largely unable to resolve the issue in a satisfactory manner, the matter remains a thorn in our side.

2. HYDRAULIC ENGINEERING

Contemporary human societies like to wrestle with the weather: It is too cold, or too hot; too dry or too wet. We recognize the importance of water in all facets of the human experience but, when choices are made as to where to live, we run from it (the water). We prefer an arid climate to a humid climate. Is this were not the case, Southern California would not have been developed, starting more than 100 years ago. The situation is certainly not unique to the United States; all we need to do is to look around to find a similar situation elsewhere. Humid climates bring bugs, which humans find it hard to coexist with; arid climates bring sun, which provides a much healthier, and admittedly nicer, environment. However, the settlement of arid lands has a practical limit: The need to provide for the timely delivery of enough water to urban and rural populations that not only need it, but demand it, for a diversity of uses.

The availability of local water varies markedly with weather. A sure indicator is the duration of the rainy season, measured in number of months per year. In very arid climates, this number may be as low as two months, while in very humid climates it may last twelve months, i.e., all year! When contemporary development started in earnest, around the turn of the 20th century, hydraulic engineers were tasked with moving the water from where it occurred to where it was needed. In due time, water reservoirs began to multiply across the landscape, first in developed, and later in developing countries. Current online information reports that there are an estimated 84,000 dams/ reservoirs in the United States (**Wikipedia:** *List of dams and reservoirs in the United States*, consulted on August 26, 2023).

Here is where Machiavelli's dicta begin to haunt us. The reservoirs are built ostensibly to store water, but water *never* occurs alone, i.e., in its pure state (H_2O). While flowing on the Earth's surface as it is driven by gravity in the direction of the (nearest) ocean, water has the tendency to pick up solid materials such as sand, silt, and clay. These are the so-called *sediments*, because they can, and eventually will, settle out of the flow and become sediment deposits. Thus, reservoir design has to contend with the question of how to best manage the sediments, which will be there, whether we like it or not!

Removing the sediments by mechanical means does not solve the problem either, because flowing water will always have the capacity to entrain sediments from the surrounding environment to satisfy its transport capacity, i.e., the quantity, or amount of sediment that Nature has determined that it will carry. Thus, it is an established fact, well accepted by hydraulic engineers, that *all water reservoirs* will eventually fill up with sediments (Fig. 1). The timing will depend on the weather and the prevailing local conditions: In arid climates, the filling could take a year or less, while in humid climates it could take up to hundreds of years!

Fig. 1 Sedimentation at Gallito Ciego reservoir, La Libertad, Peru.

Thus, **the good:** The storage of precious water to meet societal needs. **The bad:** The deposit of sediments in the reservoirs intented to store water. And here we run into Machiavelli's dicta again! There is no practical way known to humans to get rid of the sediment problem altogether. The sediment comes with the territory: If we store water, we store sediments. We note that Nature intended for the sediments to serve the useful purpose of eventually settling in the valleys, where they would constitute a reservoir of nutrients, the basic constituents of life. This reminds us, once more, of the good/bad duality, or dichotomy, which we cannot seem to get rid of. The total control, or effective management, of sediments, is usually so expensive and so cumbersome that societies end up shying away from the undertaking.

3. IRRIGATION MANAGEMENT

Most people would regard irrigation as a lofty undertaking. The avowed objective is to increase the amount of food and fiber available to a growing world population, which has reached 8,045,000,000 by the middle of 2023. On the surface, the subject appears clean enough, but there is a problem. Plants use water (H_2O), but the water delivered to the plants by irrigation is not pure. There is a certain amount of salt in all irrigation water, and plants strive not to use it, so it is left behind to accumulate in the soil profile. Predictably, the Machiavelli dicta show up, this time with a vengeance.

To understand irrigated agriculture as opposed to dryland agriculture, where farmers do not use irrigation, we must describe the differences between them, exactly as they occur. In dryland agriculture, crops get their physiological needs for water satisfied from the immediate vicinity, most likely by local rain. In regions with annual precipitation close to the mean annual value (800 mm), it is likely that there is enough moisture in the environment to satisfy the water needs of most plants (**Ponce, 2000**). In this case, irrigation may not be absolutely necessary, although it may be often implemented in order to increase productivity. As mean annual precipitation decreases to 400 mm, the limit between semiarid (≥ 400 mm) and arid (< 400 mm) regions, the need for irrigation becomes more pressing. For values of 200 mm, or less, irrigation is almost an absolute necessity if the agricultural enterprise is to continue to flourish. Thus, the drier the environment, the greater the perceived need for imported water to supplement the deficiency.

Irrigation may require the transport of water over long distances, and here is where the plot thickens (Fig. 2). Water has an innate tendency to pick up solids, both of molecular and particulate size from coming in contact with the Earth's soil surface. The water molecule's *dipole moment* guarantees the effective entrainment of various chemical components, among them, typically, the alkali metal cations (sodium Na^+ and potassium K^+) and the alkaline earth metal cations (magnesium Mg^+ and calcium Ca^+) (**Ponce, 2019**).

Fig. 2 Water supply canal (L) and drainage canal (R), Wellton-Mohawk irrigation and drainage district, Wellton, Arizona.
[Note that these canals flow in opposite directions!].

These four cations are the most common salt cations, together amounting to about 11% of all the cations present in the litosphere (**Ponce, 2015**). Thus, by the time irrigation water actually reaches the proximity of the plants, it is already loaded with salts! These salts are gradually left behind in the process of evapotranspiration, because the physiological needs of most agricultural crops do not include salts, particularly in the amounts in which they are usually present. The net result is the increased presence of salts in the soil profile, which acts to limit the normal vegetative growth of the crops, amounting to a reduction in net productivity. Thus, once again, the Machiavelli dicta rules: Irrigation increases the production and availability of food and fiber, a **good thing**; but at the expense of increasing the concentration of salts in the soil profile, a **bad thing**.

Over the years, irrigation engineers have devised a way of coping with the salt problem. They add a certain amount of water, the *leaching fraction*, to the potential evapotranspiration needs of the crop in question, to remove the salt out of the root zone and to send it on its way in a downstream direction, by way of drainage. But this only ends up increasing the salt content of the receiving waters, be they surface or groundwater. Effectively, we have "robbed from Peter, to pay Paul..." to paraphrase the popular saying.

The anthropogenic salt resulting from the irrigation enterprise adds to the total salt load of the stream. Now, granted, all rivers have a natural salt concentration, which increases as the streams flow downstream from headwaters to ocean (**Pillsbury, 1981**). But, with the additional salt from irrigation, the concentration becomes larger, taxing the receiving stream and its other uses. If the decision is made not to drain the extra salts produced by irrigation, the only recourse is to collect and store the additional salt in evaporation ponds (Fig, 3). But eventually, these end up contaminating the underlying aquifers and even the neighboring streams receiving the local baseflow (**Pillsbury, Extract, 1981**). Carting away the salts and dumping them into the nearest ocean proves to be too costly for the typical case. Invariably, the salt comes back to haunt us, no matter how hard we try to solve the problem, confirming once again Machiavelli's dicta.

Fig. 3 South evaporation basin, Tulake Lake Drainage District, Kings County, California.

The case of the Salton Sea, in Imperial and Riverside counties, in California, is a lesson to be learned. When subjected to irrigation, we note that arid lands such as those neighboring the Salton Sea generate a greater amount of anthropogenic salt than comparable subhumid lands (Rhoades and others, 1968). This is because the soils are relatively new and, therefore, still relatively unleached. Yet, for the past 100 years, agricultural drainage from the irrigation of the Imperial and Coachella valleys, adjacent to the Salton Sea (Fig. 4), have been dutifully collected and deposited in the Sea, with its salinity increasing from about 3000 ppm in the 1920's, to 60,000 ppm at the present time (2020s) (**California Department of Fish and Wildlife, undated**).

Google Earth®

Fig. 4 The Salton Sea, and Imperial and Coachella valleys, Imperial and Riverside counties, California.

The existence of the Imperial and Coachella valleys has effectively increased the amount of food and fiber, and made quite a number of people wealthy in the process, but this has been at the expense of the creation of the Sea. There appears to be no solution to this veritable dilemma: In the absence of the Salton Sea (**a good thing**), the Imperial and Coachella valleys would not exist! (**a bad thing**). Many similar examples may be construed to confirm the pervasiveness of Machiavelli's dicta.

4. GLOBAL CLIMATE CHANGE

The original concept of what we now refer to as *global climate change* is attributed to the Swedish scientist **Arrhenius (1896)**. He was the first to quantify the contribution of carbon dioxide (CO_2) to the greenhouse effect in the Earth's atmosphere. While he did not explicitly suggest that the burning of fossil fuels would cause global warming, it is clear that he was aware that it would constitute a potentially significant source of carbon dioxide.

Global climate change remains a crucial, existential issue that the world is currently faced with. To better describe it, we divide the issue into three parts: (1) inception, (2) growth, and (3) maturity.

Inception. The beginning of global climate change may be linked to the accomplishments of one person, the American industrialist Henry Ford. In 1913, Ford finalized the implementation of his *moving assembly line*, enabling the mass production of motorized vehicles, while substantially increasing the automobile industry's output. Eventually, this bold development caused a reduction in the cost of automobiles to such an extent that many more people were able to afford it. Effectively, the moving assembly line brought the automobile within reach of many more individuals than prior to Henry Ford's invention. We note that at the present time (2023) there are about 1.446 billion cars in the world, 110 years after their sales took off, propelled by Henry Ford's invention.

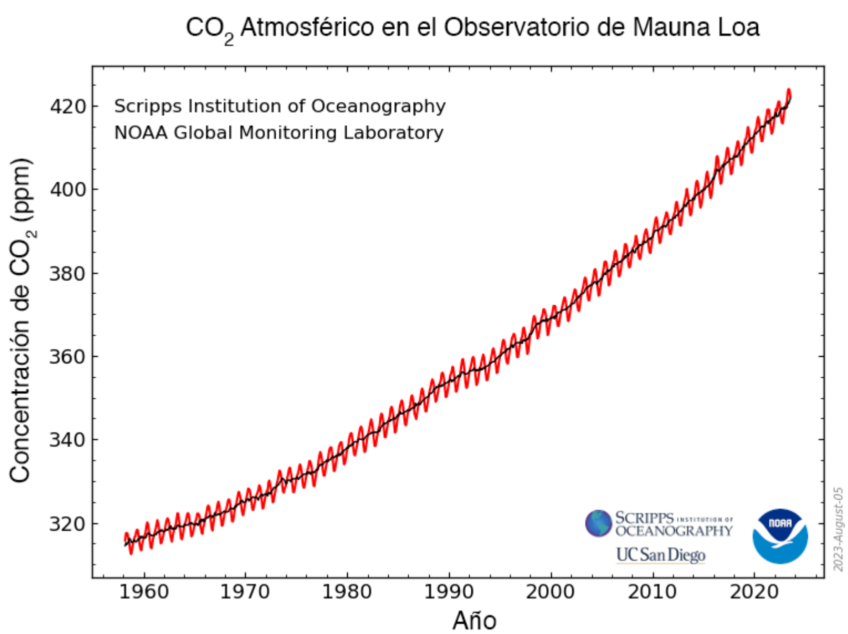
The record shows that Ford never attended high school. However, at the age of 28, his proficiency with mechanics helped him get a job as an engineer with Edison Illuminating Company of Detroit. And the rest is history... (**Wikipedia: Henry Ford**; consulted on August 28, 2023). With his limited scientific background, Ford was unable to grasp the consequences of the geological and atmospheric adventure that he, unknowingly, ushered the world into.

Growth. Intrinsic to fossil fuels is the issue of time, i.e., *geologic time*. It took Nature a considerable amount of time, about 360 million years to state current geological knowledge, to put away the surplus organic matter accumulated on the Earth's surface so that our atmosphere could retain a semblance of balance. Too much (contemporary) burning would cause the *diatomic molecules* in the atmosphere, among them, significantly, carbon dioxide, to increase and lead to warming. Conversely, too little burning would cause the said molecules to decrease and lead to cooling.

Like everyone else, Ford could not have correctly guessed the future. The world population in the year 1900 was 1.6 billion; it is now (2023) close to 8.0 billion, a fivefold increase in the past 123 years!

It is now widely recognized that the sustained warming of the Earth's atmosphere of the past two to three generations is due to the combustion of fossil fuels, which have been consistently taken out of the ground and ignited, surely against Nature's design!

Maturity. The sustained increase of atmospheric carbon dioxide in contemporary times has been documented by Charles D. Keeling (1928-2005), who, starting in 1959, undertook the measurement of atmospheric CO_2 concentration in Mauna Loa, Hawaii (Fig. 5). The Keeling curve, which continues to be plotted to this date (2023) by his son, Ralph F. Keeling, clearly shows the direct relation between the atmospheric content of CO_2 and the contemporary burning of fossil fuels. Ostensibly, the latter is largely for the purpose of powering the mechanical devices that have been referred to, since their inception in the early 1900s, as "cars," or "automobiles".



Scripps Institution of Oceanography

Fig. 5 The Keeling curve.

We surmise here that if Machiavelli (1469-1527) had been around at this time, he would have said, admonishingly: "I told you so." In fact, the use of fossil fuels to power our automobiles (**a good thing**) has resulted in the sustained warming of the Earth's atmosphere (**a bad thing**). Alas, we are back to where we started! Unmistakably, looking into the future, the resolution of this conflict will take all the ingenuity and political will that the human race is able to muster.

5. ENVIRONMENTAL IMPACT ASSESSMENT

The beginning of the concept of environmental impact assessment goes back to the year 1969, when the United States passed the National Environmental Policy Act (NEPA). It was officially realized at that time, that development projects produced certain unintended impacts on the surrounding environment. Thus, the need arose to evaluate projects carefully, using rational, reproducible methods of analysis, so that the professionals in-charge could determine whether the project was worth pursuing, once the advantages and disadvantages had been clearly identified and compared on a similar basis (Leopold and others, 1971; Dee and others, 1972; 1973).

This change in outlook regarding development projects has all but institutionalized the sense of Machiavelli's dicta, bringing into law what had previously been regarded at best as a keen observation. More than 50 years after the passage of NEPA, it is now widely established that the **positive** and **negative** features of development projects should be carefully evaluated and compared on a systematic basis, in order to decide whether or not to pursue the projects to their successful completion.

6. EPILOGUE

With the need for an environmental impact assessment firmly established in practice, the obvious solution is to broaden the outlook of scientific and professional inquiries to encompass *nearly all* fields of study. This pursuit entails the *interdisciplinary* collection of all fields of human endeavor into one distinctly seamless body of knowledge. Here again, **Machiavelli's** genius reappears to set the record straight. He elaborates: "Men make quite a number of mistakes about things in general, but not so many about particulars." In other words, it is easy for a person to solve a specific problem, but not one exhibiting many angles.

To close, it is clear that humanity would be keen to employ a group of its best minds to examine and decide on the much needed *sustainable solutions*, unarguably those that naturally cover a gamut of fields of human endeavor.

REFERENCES

Arrhenius, S. 1896. **On the influence of csrbonic acid in the air upon the temperature of the ground**. *Philosophic Magazine and Journal of Science*, Series 5, Vol. 41, April 1896, 237-276.

Machiavelli, N. ca. 1517. *Discourses on Livy* (Original title: Discourses on the First Decade of Titus Livy), Mockingbird Classics Publishing, 2015. **(Extract)**.

Rhoades, J. D., D. B. Krueger, and M. J. Reed, 1968. The effect of soil-mineral weathering on the sodium hazard of irrigation waters. *Soil Science Society of America Proceedings*, Vol. 32, 643-647.

Leopold, L. B., F. E. Clarke, B. B. Hanshaw, and J. E. Balsley. 1971. A procedure for evaluating environmental impact. *U.S. Geological Survey Circular 645*, Washington, D.C.

Dee, N., J. Baker, N. Drobny, K. Duke, and D. Fahringer. 1972. Environmental evaluation system for water resource planning, *Report to Bureau of Reclamation, U.S. Department of Interior*, Battelle Columbus Laboratory, Columbus, Ohio, January, 188 pages.

Dee, N., J. Baker, N. Drobny, K. Duke, I. Whitman, and D. Fahringer. 1973. An environmental evaluation system for water resource planning. *Water Resources Research*, Vol. 9, No. 3, June, 523-535.

Pillsbury, 1981. **The salinity of rivers**. *Scientific American*, Vol. 45, Number 1, July, 55-65. **Extract**.

Ponce, V. M. 2000. **Characterization of drought across climatic spectrum**. *Journal of Hydraulic Engineering, ASCE*, Vol. 5, No. 2, April.

Ponce, V. M. 2015. **The right of Nature to dispose of its salt waste**. Online publication.

Ponce, V. M. 2019. **The properties of water**. Online publication.

California Department of Fish and Wildlife, undated. **Background information on the Salton Sea**. Consulted on August 27, 2023.

Wikipedia: **List of dams and reservoirs in the United States**, undated. Consulted on August 26, 2023.

Wikipedia: **Henry Ford**, undated. Consulted on August 28, 2023.

230829 18:00 PDT