A Social Study of the Technologies Composing the Green Revolution

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Abstract

Strictly speaking, the term 'Green Revolution' is used to indicate the introduction of improved crop seeds into the agricultural systems of Less Developed Countries (LDCs), starting after WWII and still going on today, but with its major breakthrough during the sixties. It was believed that modern science and technologies —improved crop seeds in particular— would be able to eradicate famine. In this article the metaphor of *script*, taken from Madeleine Akrich and Bruno Latour, is used to analyse the relation between designers (plant researchers) and users (LDC-farmers) in the Green Revolution. First, it is shown that the new Green Revolution seeds contained a *script* that drastically reconfigured the farmers' relation with each other, with their seeds, with their government and with the West. Next, the author analyses how the *script* was embedded into the seeds. Finally, the ideologies that underpinned the *script* are briefly discussed.

1 Introduction

The 'Green Revolution' is a term commonly used to refer to a 'technologification' and commercialisation wave of the agriculture in Less Developed Countries (LDCs hereafter) during the sixties and seventies. More specifically, however, it refers to the introduction of high-yielding crop

seeds —wheat and rice were the first— designed by international research institutes, into the agricultural systems of the LDCs, not only during the sixties when it was most visible, but already modestly starting in the forties and still going on today. Especially plant researcher Norman Borlaug, by some called 'the founder of the Green Revolution', had a triggering role in the Green Revolution for developing high yielding semi-dwarf wheat varieties during the fifties in a Mexican research institute and exporting them to other LDCs in the sixties[1]. Borlaug was awarded the Nobel Peace Prize in 1970 for his achievements. Indeed, at that time the world community was convinced that the application of modern science and technology to the global agricultural system would be able to eradicate famine.

Hybrid seeds are obtained by cross-breeding repetitively existing varieties in order to select or reinforce desired characteristics. They are, thus, the result of simple plant breeding and not (yet) the result of genetic engineering. By the end of WWII hybrid seeds were already widely used in US agriculture[2]. The first significant steps to apply western technology and science to the agricultural system of a *developing* country were taken in Mexico during the forties. The Mexican government set up, with the collaboration of the Rockefeller Foundation, a research centre dedicated to develop high yielding wheat and maize varieties. In 1963 the centre was given its current name *Centro Internacional para el Mejoramiento del Maiz y del Trigo* (CIMMYT). In 1966 it became a centre on its own, independent from the Mexican government. A similar centre dedicated to the improvement of rice (IRRI) was set up in the Philippines. In 1971, under the impulse of the World Bank, these

1. H. M. J. Cleaver, *Some contradictions of capitalism. the contradictions of the green revolution*, in "The American Economic Review", 62 (1972), pp. 177–186 ; V. Shiva, *The Violence of the Green Revolution*, Zed Books, London, 1993. ; G. Conway and G. Toenniessen, *Feeding the world in the twenty-first century*, in "Nature", 402 (1999), pp. C55–C58 ; E. B. Ross, *Malthusianism, capitalist agriculture, and the fate of peasants in the making of the modern world food system*, in "Review of Radical Political Economy", 35 (2003), pp. 437–461 ; R. Evenson and D. Gollin, *Assessing the impact of the green revolution, 1960 to 2000*, in "Science", 300 (2 May 2003), pp. 758–762.

2. V. Shiva, *The Violence of the Green Revolution,* cit.

agricultural research centres were grouped under a new international umbrella organisation: the Consultative Group on International Agricultural Research (CGIAR). Today CGIAR includes 15 international, mostly publicly funded research centres that up till now have produced over 8000 new hybrid crop varieties, most of them designed for specific climates[3].

The food production rates in LDCs have risen considerably. During the Early Green Revolution (1961-1980) the crop production in the entire Developing World grew on average 3.2% per year and during the Late Green Revolution (1981-2000) still 2.2% per year. This growth is a result of various factors, including an increase in the cultivated area and the growing use of chemical fertilisers, but Evenson and Gollin[4] estimate that the share of growth *exclusively due to the use of new seeds* was 0.52% and 0.86% per year during the Early and Late Green Revolution respectively.

Interestingly enough, these seeds, once they left the laboratory, could not just straightforwardly be adopted by the LDC-farmers. The seeds —although tiny and apparently simple objects— forced a reconfiguration of the farmers' relations with each other, with their seeds, with their government and with the West. In this article the metaphor of *script*, taken from Madeleine Akrich and Bruno Latour[5], is used to analyse the interaction between the designers of the seeds (laboratory researchers) and the users of the seeds (LDC-farmers).

In fact, this article does not have the scope to analyse whether the Green Revolution was effective or not in eradicating famine. Nor is it the aim of this article to evaluate the environmental costs of

3. R. Evenson and D. Gollin, *Assessing the impact of the green revolution*, cit.

4. ibid.

5 M. Akrich, *The de-scription of technical objects*, in *Shaping Technology - Building Society: Studies in Sociotechnical Change*, edited by W. E. Bijker and J. Law, Cambridge, MA: MIT Press, 1992, pp. 205–224 ; M. Akrich and B. Latour, *A summary of a convenietn vocabulary for the semiotics of human and nonhuman assemblies*, in *Shaping Technology - Building Society: Studies in Sociotechnical Change*, edited by W. E. Bijker and J. Law, Cambridge, MA: MIT Press, 1992, pp. 259–64.

the Green Revolution. As Wyatt writes[6], sociologists of science and technology should not 'care' whether a technology works or not. Instead, this article tries to analyse how a tiny technological object can contain a *script*, consciously or unconsciously written by the designers of the object, that has the power to establish, reconfigure and naturalise the social, political and economical relations that surround the object.

Most data for this article refer to India and Mexico, since these countries were the first LDC-countries to undergo large changes due to the Green Revolution and they are both considered 'successful' examples.

2 Methodology of analysis

Actor-Network Theory (ANT) sustains that knowledge and technologies are produced by a heterogeneous network of 'actants', that can be humans, non-humans (objects), technologies and even concepts. Certain knowledge or technologies can become preponderant and functional only if they manage to configure the relations between actants in a favourable way. In other words, actants try to build long chains of associates or allies —whether these allies are scientists, stakeholders, statistical data, concepts, equipment or laboratory rabbits— in order to make certain knowledge or technologies working. In this negotiation process interests and knowledge reciprocally produce and reshape each other. Akrich and Oudshoorn[7] emphasise that non-human objects, which are equally considered actants in the network, have the agency to establish, maintain and naturalise the links between diverse actants in the network.

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6. S. Wyatt, *Technological determinism is dead; long live technological determinism*, in *The Handbook of Science and Technology Studies*, edited by E. J. Hackett, O. Amsterdamska, M. Lynch, and J. Wajcman, MIT press, 2008, pp. 165–180.

7. M. Akrich, *The de-scription of technical objects*, cit. ; N. Oudshoorn and T. Pinch, *User-technology relationships: Some recent developments*, in *The Handbook of Science and Technology Studies*, edited by E. J. Hackett, O. Amsterdamska, M. Lynch, and J. Wajcman, MIT press, 2008.

Akrich argues that an ANT-analysis of the social network surrounding technical objects is capable to avoid, on the one hand, *technological determinism*, by emphasising that objects are surrounded by a *network* of actants that are able to reshape the object, and, on the other hand, *social constructivism*, by insisting in the obduracy of objects and by denying that only humans can be actants.

The concept of *script* should be situated in the ANT-tradition. It assumes that designers, at the time of shaping technical objects, have specific characteristics in mind for the future users, and embed in that way a certain *script* that configures the relations of the actants in the network that will surround the object. Akrich defines *script* as follows[8]:

> [W]hen technologists define the characteristics of their objects, they necessarily make hypotheses about the entities that make up the world into which the object is to be inserted. Designers thus *define* actors with specific tastes, competences, motives, aspirations, political prejudices, and the rest, and they *assume* that morality, technology, science, and economy *will evolve* in particular ways. A large part of the work of innovators is that of 'inscribing' this vision of (or prediction about) the world in the technical content of the new object. I will call the end product of this work a 'script' or a 'scenario'.

This means that a technological object is the realisation of the designer's beliefs and projections of the future user. If the user does not encompass these projections, the technological object will remain a chimera. It is through the user and his adaptation to the *script* that an object is rendered real or unreal, and considered to work or not to work[9].

8. M. Akrich, *The de-scription of technical objects*, cit., emphases are mine

9. ibid.

3 The *script* in the Green Revolution seeds

3.1 How the *script* instructed the user

The seeds are designed to generate plants that give higher yields per hectare. In the case of wheat (the variant designed by Norman Borlaug) this is obtained by increasing the ratio of the 'useful' bio-mass to the total bio-mass that is produced by each individual plant. According to this logic, the 'useful' bio-mass is composed by the edible grains, while the straw forms the 'useless' bio-mass. The new wheat or rice varieties can reach a ratio of 50% while indigenous varieties have a typical ratio of 25-30% , although the total amount of produced bio-mass is more or less the same[10]. The hybrid varieties are characterised by a short stem (few straw) and are called (semi-)dwarf varieties.

But how were these seeds able to alter the relations in the network of actants? In the scientific literature, the hybrid Green Revolution seeds are called 'High Yield Varieties' (HYVS), but some scholars prefer to call them 'High Response Varieties'. This is due to the fact that the Green Revolution varieties are designed to give high yields only when the environmental conditions are optimal, i.e. they require large amounts of chemical fertiliser and water in order to produce the 'promised' high yields. Without irrigation or chemical fertilisers, these seeds do not produce more than an average indigenous variety.

Moreover, the Green Revolution seeds reduce genetic diversity in the agricultural system of LDCS. In Latin-America, thousands of maize varieties are present, many of them the result of thousands of years of selection by the local farmers and each of them adapted to a specific micro-climate. The same is true for rice in Asia. The large genetic diversity in indigenous varieties has been replaced by uniformity, under the form of a few modern hybrid varieties. The new varieties are not as well adapted to specific micro-climates as indigenous varieties, yet they require optimal conditions that can be created artificially, as explained in the paragraph above. This lower genetic diversity means

10. V. Shiva, *The Violence of the Green Revolution,* cit.

also that the modern hybrid seeds are less resistant to local diseases or pests, while indigenous varieties were better adapted. This loss in resistance, together with the increased danger of plagues due to monoculture, augments the need for pesticides. In fact, the Green Revolution seeds cannot be adopted without accepting as well the use of pesticides, fertilisers and irrigation. In this way we have detected a first level of the *script* that is embedded in the seeds: the seeds do not come alone but rather they are one element of a larger 'technological package'.

The seedlings of hybrid varieties loose, due to a game of nature, part of the characteristics that their parents carried. This means that optimal yields can only be obtained if the farmers buy new seeds every year. In this way the hybrid seeds break down the millennia old agricultural cycle that assures that the grains of well-performing plants will give good yield the next year. There is no sense any more in collecting seeds and exchange them with colleague farmers. Also the natural cycle of fertilising is broken down: the (semi-)dwarf varieties produce less straw, which used to be a natural fertiliser. The farmer is now *obliged* to add chemical fertiliser.

The *script* in the hybrid seeds is becoming clearer: the seeds promise high yields but in exchange the farmer needs to buy new seeds every year, needs to buy chemical fertiliser, needs to buy pesticides and needs to irrigate his field. These investments require capital, which an average LDC-farmer does not have, thus he needs credits. In order to keep up with the cycle of credit and investment, he dedicates as much area as possible to the cultivation of cash crops since only these have a market value and can be converted into capital for future investments (or to pay off debts). This focus on cash crops provokes an even higher reduction of crop diversity. During the Early Green Revolution, the fertile Indian region Punjab was destined to become the 'bread basket' of India. In the season 1985-6 the cultivated area of Punjab dedicated to rice was 24% of the total cultivated area, while 20 years earlier this was only 5.5%. In those 20 years the area dedicated to cereal crops had risen from 51% to 73% of the total cultivated area, provoking a decrease in pulses, nuts and other components of the traditional diet[11]. The move towards cash crops also means that the farmers are more and more depending on the food prices on the (inter)national markets and on

11. V. Shiva, *The Violence of the Green Revolution,* cit.

the amount of governmental subsidies that is given to acquire fertilisers or to keep prices stable. Conway and Toenniessen[12] mention that between 1970 and 1999 food prices on the world markets have declined 70% in real terms.

Through the *script* in the Green Revolution seeds, capital has become a new factor in the household economy of LDC-farmers. Not surprisingly, larger farms have more chances to be profitable than smaller farms. Shiva[13] mentions a study carried out in Punjab in the year 1974. Small farms (less than 5 acres) suffered an average loss of 125 Rupees that year. Medium farms (5-10 acres) had an average profit of Rs50, while large farms (more than 20 acres) had an average profit of Rs1500. The inclusion of small farmers into the world capitalist system has created additional class tensions in LDCS. Shiva argues that these tensions are often presented as ethnic or religious problems. For instance, the majority of small farmers in Punjab are Sikhs. The new class tensions due to the Green Revolution, however, are presented by the central government as a 'Sikhs'-problem rather than a 'poor farmers'-problem.

Apart from fertilisers, pesticides and capital, the seeds also need water. Traditional irrigation systems have existed for centuries. The Green Revolution, however, has increased drastically the need for irrigation. The irrigation water can have two sources: (i) the water of rivers that is deviated by dams, or (ii) groundwater that is pumped up. Large irrigation infrastructures, such as dams, have proliferated throughout the LDCS at the same speed as the Green Revolution did. In Mexico, from 1940 to 1970, the investments in irrigation works rose from 70% to 99.2% of the total governmental investment in agriculture[14]. In just 5 years, from 1970 until 1975, during the 'boom' of large dams, 5000 new large dams appeared in the world[15]. In 2002, China had 22.000 large dams, the US 6390 and India 4000[16]. Thanks to large irrigation infrastructures more water can be used for irrigation

12. G. Conway and G. Toenniessen, *Feeding the world in the twenty-first century*, cit.

13. V. Shiva, *The Violence of the Green Revolution,* cit.

14. E. B. Ross, *Malthusianism, capitalist agriculture,* cit.

15. V. Shiva, *Le guerre dell'acqua*, Milano: Feltrinelli, 2003.

16. ibid.

before it runs off to the sea, but the negative (social) consequences are also obvious: dislocation of people and concentration of power in the hands of a few decision-makers. In the case of India, for example, the large river dams are controlled by the central government who also decides the distribution of the water among the different federal states. While traditional irrigation systems were controlled and managed at community level, now the Indian government *alone* controls the water distribution for hundreds of millions of farmers. This loss of self-control of the farmers has also contributed to increase the earlier mentioned tensions between classes, communities or federal states in India[17]. In the case that water is pumped up from bore-wells, the social costs are similar: water that is subtracted from the sub-soil at a certain point is not available elsewhere. Moreover, the pumps need gas oil or electricity, which requires capital and creates again new dependencies.

The *script* has many far-reaching effects that are not described in this article. Just to mention a last one, the *script* also changed the dietary habits of farmers in LDCs. Due to the tendency to grow cash crops and the use of pesticides, plants that traditionally were part of the diet have disappeared from the table, while extensively cultivated ergo cheap cereals like rice or wheat have increased in importance. This has created new dietary imbalances[18], which some researchers try to resolve with new hybrid or genetically engineered varieties, such as 'golden rice' that contains higher quantities of vitamin A.

The first important consequence of the *script* embedded in the seeds is the break-down of a natural cycle in agriculture: (i) 'useless' bio-mass does not suffice any more to fertilise in a natural way the farm lands, (ii) seedlings of well-performing plants cannot be kept any more to be planted the next year, (iii) crops do not yield the expected food volumes without chemicals, (iv) farmers depend on external electricity supply or external water supply for irrigation, etc. In brief, a process that used to be circular and completely independent has become linear, with a constant need for external input if a certain level of production should to be maintained. Autonomy has been converted into dependency.

17. V. Shiva, *The Violence of the Green Revolution*, cit. ; V. Shiva, *Le guerre dell'acqua*, cit.

18. V. Shiva, *The Violence of the Green Revolution*, cit.

Secondly, the new seeds forced farmers of the LDCs to enter the global capitalist market, in which they cannot perform without capital. Capital is needed if they want to adopt the entire technological package of the Green Revolution.

3.2 How the *script* got written

Now, we can wonder if the *script* described above is merely a result of contingency, or if we can detect a certain alliance of actants on the design side that influenced the shaping of the *script*.

The north-American philanthropic foundations *Rockefeller Foundation* and *Ford Foundation* have had a decisive role in the setting-up of international research centres dedicated to the improvement of crop seeds for the LDCs. Gemelli and MacLeod sustain that, throughout the twentieth century, philanthropic foundations have had a very important role in societal change *tout court*, through their role in research and in activism[19]:

> Since their beginnings in the early twentieth century, American foundations have operated in the world of public policy, mobilizing expertise to solve emerging problems along a spectrum of disciplines ranging from industrial relations and urban planning, to public health and social welfare. While maintaining the status of private institutions, they have blurred historical boundaries between public responsibility and private initiative, and have played an important role in shaping scientific, social and economic policies throughout the world.

As their names indicate, the assets of the Ford Foundation and Rockefeller Foundation are fruit of the commercial activities of the Ford family and the Rockefeller family. The former is founder of the automotive company *Ford*, the latter was owner of *Standard Oil* that up till today forms the core of *Exxon Mobil*. Given the leading role that these foundations had in US foreign policy and research[20], some radical authors sustain that these foundations had an active role in shaping the

19. G. Gemelli and R. MacLeod, *Introduction*, in "Minerva", 41 (2003), pp. 95–99.

20. ibid.

script in such a way that the LDCs would be included in the global capitalist market. Ross writes[21] :

> From the onset, the Green Revolution represented an implicit commitment to capitalist relations of production that in turn reflected the fact that the Ford and Rockefeller (and to a lesser degree the Kellogg) foundations, which played a leading role in its emergence and expansion, were an intimate and influential part of the U.S. capitalist economy. Despite their carefully crafted philanthropic image, they were profoundly influential in the design and implementation of U.S. development policy from the end of the Second World War. Not unexpectedly, therefore, the global agricultural transformation that they promoted became a part of that policy. In that role, it was less about enhancing the food security of the poor in developing countries than about securing the economic prosperity of the U.S. power elite with which they were so closely associated.

Whether these accusations are true or false, history clearly shows that the foundations and related research institutes have always chosen the path of technological solutions (that require capital) rather than considering a redistribution of land in LDCs, which also could have been a path to resolve the world food problem[22].

The case of Mexico is exemplary. Before the Mexican Revolution started in 1910, a mere 800 haciendas owned 90% of the land, and a large proportion of those 800 haciendas was in hands of US citizens. Of all rural families in Mexico, 97% was landless[23]. A first tentative for land reform in Mexico was started by Emiliano Zapata. It was, however, only during the global depression of the 1930s that a vast land reform could be started by 'leftist' general Lázaro Cárdenas. He broke up land into communal units called *ejidos*, which, by 1940, had received nearly half of all cultivable land in Mexico. Andre Gunder Frank described the Mexican land reform of Cárdenas as "the most

21. E. B. Ross, *Malthusianism, capitalist agriculture,* cit.

22. ibid. ; G. Esteva, *Detener la ayuda y el desarrollo: una respuesta al hambre*, in *Carencia alimentaria. Una perspectiva antropolgica.*, Serbal/UNESCO, Barcelona, 1988

far reaching in Latin America before Cuba's and one which really did incorporate the peasants into national life" [24]. Moreover, in 1938 Cárdenas nationalised Mexican oil exploitation. Although compensation for the expropriation was foreseen, it caused great animosity, since the US oil company Standard Oil played a dominant role in Mexico's oil exploitation[25]. The US together with Great Britain started to boycott Mexican oil and other goods. Decreasing exports, shortage of foreign exchange and increasing dependence on US imports forced Cárdenas not to present for the elections in 1940. He was succeeded by Avila Camacho, who had the support of the US. The *ejidos* program and oil nationalisation were cancelled.

It is the Camacho government that founded in 1943, with support from the Rockefeller Foundation, a research centre for crop improvement. A major figure in US agriculture was Henry A. Wallace, who in 1932 became the US secretary of agriculture and in 1940-44 vice president. Wallace was the founder of Pioneer Hi-Bred, the company that produced the hybrid wheat seeds that were largely used in US agriculture. As a liberal advocate of a modern style of agricultural management, he was also a close associate and friend of Nelson Rockefeller. According to Ross[26], both regarded the Rockefeller Foundation as the proper vehicle for transferring an American style of agriculture to Mexico. In the Mexican laboratory that consequently was founded by the Rockefeller Foundation, Norman Borlaug created in the fifties a high-yielding variety of *wheat* —a cash crop that was

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23. J. Davids, *American political and economic penetration of Mexico, 1877-1920*, New York: Arno, 1976 ; D. Massey, R. Alarcon, J. Durand, and H. Gonzalez, *Return to Aztlan: The social process of international migration from Western Mexico.*, Berkeley: University of California Press, 1987 ; B. De Walt and D. Barkin, *Mexico's two green revolutions: Feed for food*, in *Anthropology and food policy: Human dimensions of food policy in Africa and Latin America*, edited by D. McMillan, Athens: University of Georgia Press, 1991, pp. 12–39

24. A. G. Frank, *Latin America: Underdevelopment or revolution. Essays in the development of underdevelopment and the immediate enemy.*, New York: Monthly Review Press, 1969.

25. J. Davids, *American political and economic penetration of Mexico,* cit.

26. E. B. Ross, *Malthusianism, capitalist agriculture*, cit.

already extensively cultivated in US farms— rather than creating a variety of *maize* —which was consumed much more by Mexicans but much less present on international markets.

Borlaug's seeds contained already the *script* that obliged the user to use chemicals and to irrigate if he wanted to obtain the promised yields. The seeds were simply *designed* to be highly responsive to fertilisers and large amounts of water. In this way the users of the new seeds were forced to copy the American style agriculture that had boomed in the first decades of the twentieth century in the US.

When in 1966, due to drought, India was hit by severe famine, US president Lyndon Johnson was unwilling to advance more food than the amount that was needed to feed the Indians for one month, unless the Indian government would sign an agreement to adopt the Green Revolution seeds[27], … precisely the seeds that included the *script* that was written in and around Borlaug's laboratory. Not by coincidence the 'field had already been levelled' for American style agriculture in India, by research institutes and various Rockefeller-trained scientists present in the Indian territory. The year 1966 is considered the year in which the Green Revolution started in India. Fertilisers were widely available through a well-established network of Standard Oil subsidiaries in Asia.

Generally speaking, the Ford and Rockefeller foundations had already a long history of overtly missionary and commercial presence in ex-colonies[28]. Especially after the communist revolution in China in 1949, American philanthropic organisations were increasingly present in Asia[29].

This section has focussed on Mexico and the foundation of CIMMYT, and to a lesser extent on India. The context in which CIMMYT created high-yielding seeds is not value-free. Rather, the seeds needed a network of allied actants surrounding them to make them work. The network was very heterogeneous and included both humans as non-humans: humans like Nelson Rockefeller, Henry

27. V. Shiva, *The Violence of the Green Revolution*, cit.

28. E. B. Ross, *Malthusianism, capitalist agriculture,* cit.

29. ibid. ; N. Shrestha, *Becoming a development category*, in *Power of Development*, edited by J. Crush, chap. 14, Routledge, London, 1995, pp. 266–277.

Wallace, Avila Camacho, Norman Borlaug; institutions such as Rockefeller Foundation, Ford Foundation, Standard Oil, USAID, CIMMYT, IRRI, CGIAR, the Indian government, the Mexican government, LDC farmer movements; and finally also non-human technical objects such as fertilizers, pesticides, dams, pumps, etc.

The author does not sustain that the *script* included in the seeds was written *consciously* by the designer actants, but he certainly is convinced that due to the background of the principal actants, their ideas and convictions, and the type of relation they had with the seeds, the *script* has been programmed in the specific way as it turned out to be.

3.3 The ideologies of the actants that shaped the *script*

From the previous paragraph we can identify some ideologies that laid the basis for the *script*. I discuss them briefly.

Capitalism vs communism. By the philanthropic foundations and the US government, modern American style agriculture and secure food production were *explicitly* seen as an antidote for eminent communism, since it would keep the peasant population of the LDCS happy[30]. Rowan Gaither, who became president of the Ford Foundation in 1953, had written years earlier[31]:

> As the tide of communism mounts in Asia and Europe the position of the United States is crucial. We are striving at great cost to strengthen free peoples everywhere. The needs of such peoples, particularly in underdeveloped areas, are vast and seemingly endless, yet their eventual well-being may prove essential to our security.

Malthusianism. Malthusian thinking prevails in the agro-business, plant science, and some international organisations such as the World Bank and FAO, and is invoked to defend the

30. H. M. J. Cleaver, *Some contradictions of capitalism*, cit. ; E. B. Ross, *Malthusianism, capitalist agriculture*, cit.

31. Gaither quoted by E. B. Ross, *Malthusianism, capitalist agriculture,* cit.

commercialisation and 'technologification' of global agriculture. Population growth is compared to food production data and the pressure of the first on the latter is used to justify the (past) Green Revolution and (current) genetic engineering. The scientific literature is rife with Malthusian discourse[32]. For instance Mann writes[33]:

> Since the early 1980s, says the United Nations Food and Agricultural Organization (FAO), global cereals harvests have been rising at a rate of about 1.3% per year — just enough to meet the projected increase in demand. But this rate of increase is half what it was in the 1970s, suggesting the possibility of a long-term falloff. […] To many agronomists, the slackening is a sign that the now-familiar tools of the Green Revolution are facing diminishing returns. The burgeoning harvests the world will need tomorrow will have to come, they say, from radically new, completely untried innovations in genetic engineering.

Although the Malthusian discourse prevails, it is far from demonstrated that hunger in the world is really —or solely— a result of population pressure on food production. Alternative explanations, such as unequal land distribution[34] or a lack of capabilities to have access to food[35] are marginalised.

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32. see for instance: C. C. Mann, *Reseeding the green revolution*, in "Science", 277 (1997), pp. 1038–1043 ; G. Conway and G. Toenniessen, *Feeding the world in the twenty-first century*, cit. ; C. C. Mann, *Crop scientists seek a new revolution*, in "Science", 283 (1999), pp. 310–314 ; B. Wollenweber, J. R. Porter, and T. Lubberstedt, *Need for multidisciplinary research towards a second green revolution. commentary*, in "Current Opinion in Plant Biology", 8 (2005), pp. 337–341 ; E. Marris, *More crop per drop*, in "Nature", 452 (20 March 2008), pp. 273–77; Q. Schiermeier, *A long dry summer*, in Nature, 452 (20 March 2008), pp. 270–73

33. C. C. Mann, *Crop scientists seek a new revolution*, cit.

34. G. Esteva, *Detener la ayuda y el desarrollo,* cit. ; E. B. Ross, *Malthusianism, capitalist agriculture,* cit.

Technological determinism. The development policies that induced the Green Revolution in the LDCs are based on a faith in technological determinism, which supposes that the introduction of a technology into society will induce societal change. According to Wyatt[36] technological determinism includes two ideas: (i) it denies the agency of the user or the society in general, and (ii) it supposes that the introduction of certain technologies into a society will lead to 'progress', i.e., technological progress equals social progress. Wyatt sustains that scholars of sociology of science and technology should *combat* the ideology of technological determinism, since it denies the agency of the people and it absolves society from responsibility for the technologies it makes and uses.

4 Conclusions

The Green Revolution, that took off after WWII in Mexico and had its major breakthrough in the sixties and seventies in Latin-America and Asia, has in the present paper been studied from the sociology of science and technology. There has been focused on the central technological object: the seeds. The paper has assumed that —consciously or unconsciously— a specific *script* was programmed into the seeds and that it has reconfigured the relations of actants in the network: the relation of the users amongst them, with the seeds and with other actants. In section 3.1 it was shown how the *script* reconfigured the relations while in section 3.2 the process of shaping the *script* has been described, mainly for the Mexican case.

The concept of *script* was taken from Akrich[37], who applied it to the electrification of Ivory Coast. Akrich describes how the electrification process contained a *script* that reshaped the socio-politico-

35. L. Yapa, *The poverty discourse and the poor in sri lanka*, in "Transactions of the Institute of British Geographers", 23 (1998), pp. 95–115 ; A. Sen, *Development as Freedom*, Oxford University Press, 1999 ; M. Baro and T. F. Deubel, *Persistent hunger: Perspectives on vulnerability, famine, and food security in sub-saharan africa*, in "Annual Review of Anthropology", 35 (2006), pp. 521–38

36. S. Wyatt, *Technological determinism is dead,* cit.

37. M. Akrich, *The de-scription of technical objects*, cit.

economical relations of the villagers. If they wanted a connection to the electricity net, they had to give up nomadism, give up communal management of resources and thus accept the transfer of a part of their freedom to the central authority. Just like the Green Revolution in Mexico or India, the electrification in Ivory Coast did not come alone. It was part of a 'pre-negotiated package for modernisation' of the country. The *script* written onto this package transformed users into good citizens and increased the power of the central authority over their lives[38]. The similarities with the Green Revolution are striking.

Although technological determinism has been indicated by the author of this article as one of the founding ideologies for the Green Revolution, that does not mean that the author sustains that the Green Revolution *in se* would be an example of technological determinism. The *script* concept is no synonym for technological determinism. First, the users of technological objects have a reciprocal relation with the technologies and with each other, and are able to negotiate these relations. As Actor-Network Theory explains, the technology needs the alliance of the users in order to function. And second, the designer side should not be separated from the user side as if it were two distinct worlds. Actants can pertain to both worlds. For instance, a large part of the researchers working in CGIAR laboratories come from LDCS. The parent seeds that are used for cross-breeding are often indigenous seeds from LDCS. In some cases scientists have joined farmers in their efforts to negotiate the Green Revolution conditions. The examples of the conflation of the two worlds are many.

The LDC-farmer, although he might not have such a prominent role in the design of the *script* as the actants in the North, has enough agency to decide whether to accept, reject or renegotiate the script. Akrich and Latour define these actions as 'de-inscription' (resistance) and 'subscription' (acceptance). The numerous grass-rooted movements that emerge from the civil society in LDCS are the utmost expression of the intensification of these negotiation processes.

38. ibid.