# Laboratories and Landscapes: the Fascist New State and the Colonization of Portugal and Mozambique

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In recent years, by shifting attention from antiscientific practices to interactions between scientific research and the building of a fascist society, historians of science have given new relevance to the role of laboratories in fascist regimes, namely in Nazi Germany.[1] As scientists and engineers adapted their practices to the opening up of opportunities by the new rule, as well as to the imposition of restrictions, political dreams were also enlarged by technological innovations and laboratory work. The Kaiser Wilhelm institutes, for example, are now commonly perceived as crucial sites for understanding autarky policies and the eastern ambitions of the Third Reich in its quest for Lebensraum.[2] In spite of the many differences between the regimes of Hitler and Salazar, this paper contends that the stories of the Third Reich laboratories may help to shed new light into the research undertaken at Portuguese laboratories during the years of the fascist New State (Estado Novo).

The present paper deals with the creation of three Portuguese scientific institutions: the National Agriculture Experiment Station (Estação Agronómica Nacional), the National Laboratory of Civil Engineering (Laboratório Nacional de Engenharia Civil), and the Center for Cotton Research (Centro de Investigação Científica Algodoeira). The narrative delves into the relations between research undertaken at those laboratories and the colonization efforts of the New State both at home and in the colonies. The use of the concept "resources for each other", developed by Mitchell Ash to deal with science and Nazism, seems very useful to explore the ways science and politics interacted in the Portuguese experience with fascism.[3] By following the importance of scientific artifacts such as new strains of wheat or models of dams for changing landscapes according to the regime's colonization policies, it is possible to grasp how science contributed with its resources for the institutionalization of the New State. In the opposite direction, it would be hard to understand the kind of science undertaken inside those institutions' walls without referring to State support and the political economy of the New State.

## The Colonization of the Portuguese Far-West

The frontier narrative is not an American exclusive and there are many examples of the significance of settlement of new territories in the history of the Twentieth Century. The Amazon Jungle in Brazil, the Soviets' Siberia or the Jewish Colonization of Palestine, are well known historical cases.[4] But maybe no one would expect to find similar tales in a country like Portugal for which the rhetoric of conquest and colonization is normally associated with the imperial saga of the navigators of the fifteenth century. Nevertheless, at the beginning of the twentieth century, Portuguese elites were not looking only for Africa or Asia when designing civilizing missions. The very same national territory was to be transformed into an object of internal colonization.[5]

Ezequiel de Campos (1874-1965) is probably the best example of those engineers that started to look obsessively to the map of Portugal in order to produce a scientific plan for the development of the country as a coherent whole.[6] Not being able to find an attractive job after finishing his training as Mining Engineer, he joined the colonial administration of the African island of São Tomé, located in the Gulf of Guinea, where he stayed from 1899 to 1911.[7] Relegated to such a faraway post he was soon confronted with the conservation problems faced by the tropical island, where the clearing of the rain forest by cacao growers was having profound effects in the landscape. Following the direct correlations established by desiccation theory between deforestation and rainfall decrease, he urged the creation of forest reservation areas to moderate severe droughts so the island could keep its rank as first world producer of cacao.[8]

Campos' arguments for the merits of forest reservations were directly taken from his readings of North-American conservationist literature which he abundantly quotes in his books. And if one recalls the large ambitions of American conservation movement of transforming every natural resource into a manageable unit, it can come as no surprise that it didn't take long for São Tomé to become too small for Campos plans.[9] He had no problems in shifting Africa for Europe for, as he stated, the "biggest problem of Portugal… is the colonization of Portugal itself".[10] The overthrow of the Portuguese Monarchy by the Republican coup of 1910 was the perfect moment to present his project of refunding the nation on a scientific basis. His return from Africa as national deputy was followed by intense political activity combining the American conservationist proposals of Gifford Pinchot and Theodore Roosevelt with the Portuguese tradition of internal colonization projects such as those of Oliveira Martins.[11]

In 1911 he proposed to the new National Assembly a law on unreclaimed land which explicitly recognized as guiding principles the conclusions approved in the National Conservation Congresses of 1909 in Seattle (Washington) and of 1910 in Saint Paul (Minnesota).[12] The wealth of the Nation was a direct consequence of the proper conservation of natural resources: to properly manage soil, water, forests and minerals was to properly manage Portuguese society. In his widely quoted The Conservation of National Wealth (A Conservação da Riqueza Nacional), a thick volume of more than 700 pages published in 1913, Campos presented his program to save Portugal from the path of decadence.[13] Social problems were depicted as a series of maps of Portugal accounting for the density of population, the numbers of emigration and rainfall distribution.[14] The maps measured the deficit of national resources and showed the irrationality of Portuguese population distribution. People were emigrating mainly from the highly dense regions of the rainy northwest to Brazil and the United States, while the dry lands of the South, the Alentejo region, could be considered as a no man's land. The central issue of Campos program was almost self-evident: to colonize the south with people from the north.

Such a gigantic move would only be possible through a drastic change of the landscape. The semiarid southern lands were to be irrigated by major hydraulic structures that would allow settlers from the north to practice a profitable agriculture. American reclamation heroes like Powell, Mead or Newell would be proud of the Portuguese engineer who clearly stated that "the problem of the national destiny is intrinsically dependent of the farming of our land, and this is only possible by large scale irrigation of our semiarid region."[15] The large and unproductive properties of the South should be divided in order to sustain a virtuous community of small farmers: "The Republic was born for every Portuguese, offering a homestead to anyone willing to cooperate with the strengthening of the Nation. There is no Republic while a single large landowner subsists." Campos considered that "there is almost no difference between the social condition of the Far West and our Alentejo: both are lands to colonize, the only difference being that the free lands from the Rockies… to the Pacific shores are mainly Public Domain while among us the Alentejo is private property".[16] The analogy went even further: "May tomorrow the Alentejo be a promise land, a new California."[17]

The greening of Alentejo by hydraulic works would be complemented by other typical conservation measures. Forestation by pine trees, eucalyptus, oaks or nut trees would transform unfarmed land into profitable properties providing also a defense against erosion, protecting river banks and, more ambitiously, changing the Portuguese climate. The concluding data that Campos claimed to have gathered from São Tomé were translated to the Portuguese experience,

with the entire climate of the country registering a steady increase in precipitation by the effect of planted forests.[18] The technological garden dreamt by Campos also included the exploration of coal, iron and copper mines and an expanded transportation network. But, above all, it would be crossed by an electrical grid transporting the energy produced by Portuguese rivers.[19]

The historical interest of Campos rests as much on his role as distinguished conservation ideologue and politician, as on the fact that his writings and laws were in direct relation to his engineering activities. His claims for a national electrical grid presented in conferences, newspapers and parliamentary sessions, went hand in hand with explorations of the main Portuguese rivers. He traveled along the Douro, Cávado, Mondego, Guadiana and Tagus rivers in search for the hydroelectric power to support the industrialization of the country. And although his narratives are not as exciting as John Wesley Powell's exploration of the Colorado, he confessed nevertheless to have suffered more than in his African experience in São Tomé.[20] After six years of wandering through indigenous Portuguese territory, sleeping among local villagers and carrying his own surveying instruments, Campos' efforts were recognized by the central government who appointed him head of the Hydraulic Studies Brigade created in 1918.

For the country to thrive national resources were to be scientifically managed. This was the answer Campos offered to the Portuguese crisis in the aftermath of First World War and the break of international commercial fluxes. The riots and lootings in the capital city in search for provisions and the unwillingness of the countryside to contribute to Lisbon's hungry relief seemed to confirm Campos' diagnosis of a poorly organized country, excessively dependent of foreign trade with little knowledge of its own potential resources. Soon he would join all those other intellectuals willing to replace traditional liberal politics by the rule of the learned elite. Together with his left leaning companions of the Seara Nova (New Harvest) movement, he claimed for a national government of experts immune to parties' rivalries, a revolution from above to save Portugal from chaos and decadence.[21] For order to be restored the ignorant mobs that dominated the streets of Lisbon just had to trust New Harvest clerks who in the pages of their journal demonstrated their proficiency in economics, hydroelectricity, aviation, literature, irrigation and philosophy. Soon, the illusions of the first years of the Republic were definitely lost and in 1923 Campos overtly embraced an authoritarian solution to "heal the sick body of Portugal". Making no case of the republican constitution, he pleaded for a "national ministry of public salvation… invested with exceptional powers… to launch the bases of the national reorganization."[22]

Campos and his friends were not alone in their distrust of democratic values and they didn't feel uncomfortable to share reform projects with all different sorts of allies. In the Revista dos Homens Livres (Free Men Magazine) they joined forces with anarchists, conservative monarchists and even with radical right wing integralists (the Portuguese version of the French Action Française of Charles Maurras). All that mattered was to gather forces against traditional party politics, for the only authentic dividing line was not "between left and right… but between men of the XXth century and men of the XIXth century."[23] So it is no surprise to find the name of our engineer in the list of ministers of the first government formed after the military coup d'état of May 1926 that overthrew the Republic and inaugurated the authoritarian regime that would last till April 1974. A dictatorship seemed the fastest and the only feasible way to accomplish the task of reorganizing national life through conservationist reforms. Nevertheless, Campos would decline his nomination as Minister of Agriculture, considering the situation too unstable to present his proposals.[24]

His fears revealed unsound and in the following years engineers would become crucial players of the fascist Estado Novo (New State).[25] In 1933 the New Corporatist State was to be officially institutionalized trough the approval of the new Constitution. The new regime replaced any form of liberal mechanisms of representation by ideological nationalism, the one-party state, systematic repression and a social and economic corporatism formed by organic social unities, a combination that definitely placed it among other European fascist regimes.[26] In an ironic resemblance to communist ideology, Portuguese society was considered not yet ready for pure corporatism, the State having to assume the responsibility to build a new social structure based on the harmony of its different organs.[27]

The task of empowering the State to actively intervene in the coordination of national economy demanded an active support from engineers. The prevailing image of Portuguese fascism dominated by a traditionalist establishment, reduced to the trinity "God, Fatherland and Family", doesn't pay justice to the relevance of technoscientific elites in the building of the New State. The very same dictator, Oliveira Salazar, seems to support the traditionalist interpretation with his proverbial suspicion of urban life and praise of pastoral modest virtues. But if Salazar doesn't bring to mind the futurist visions of other dictators, namely those of Mussolini, it is also true that his public image was cautiously designed around the myth of the University Full Professor of Financial Sciences that finally put an order to Portuguese state finances. In 1933, the year of the new constitution, he proudly declared: "When everyone thought that the Dictatorship would crash everything in an adventure of military violence, one sees the

government from, almost exclusively, superior professors; strength serving justice; improvisation giving its way to scientific training".[28]

## The National Agriculture Experiment Station and the Wheat Campaign

In 1929, three years after the coup d'état, the dictatorship launched a national mobilization for bread self-sufficiency justified by the enormous weight of wheat in Portugal's commercial deficit.[29] The campaign was the final result of several initiatives since the mid 1920s to promote wheat production and support wheat protectionism against the menaces of cheap foreign grain. As for many other western countries, the years of autarky had arrived. The Wheat Campaign came to epitomize the new trend with its motto "Our land's wheat is the border that best defends us". Based on the example of fascist Italy and the Battaglia del Grano, this mobilization for the production of the most basic need – bread - brought together big landowners of the south selling cereal at prices guaranteed by the State; agriculture machine builders; chemical industries producing fertilizers; masses of reapers reclaiming land. There was no contradiction between modernizers looking forward to convert the Portuguese territory into a productive machine and traditionalists relying on the cultivation of the land as the source of national virtue. The Wheat Campaign worked as the first material basis of the new organic social formation dreamt by the corporatist New State. After the campaign a new set of corporatist institutions was created around wheat production with the National Federation of Wheat Producers controlling production and commercialization, the Houses of the People gathering farm laborers or the Farmers' Gilds bringing together landowners. All these institutions were promoted by the State trying to bring his new order to the Portuguese fields through idealized organic unities.

Agriculture engineers and scientists were no secondary actors in this battle for production. The Secretary of Agriculture and future president of the National Federation of Wheat Producers stated that the outcome of the campaign went way beyond the record productions of the years 1934 and 1935, for it settled a new union between farmers and the State technical services.[30] The best proof that his words were not empty rhetoric was the fact that the Army colonel responsible for launching the campaign appointed the young and promising professor of the Agriculture Institute, António Sousa da Câmara, as its field Marshall. The campaign, in tune with the militarist tone, was divided in six divisions - Propaganda; Technical Assistance; Financial Assistance; Transportation; Fertilizers; Seeds –

which were under the control of a triangular command formed by a politician named by the Minister of Agriculture, a large landowner and an agriculture scientist. Technical brigades were launched to the fields of the South of Portugal to promote selected seeds, proper fertilization and mechanized farming. In three years the Alentejo wheat fields had an increment of area of 50% occupying a total of one million and a half acres. Maybe it now resembled more the Great Plains than the desired California, but the old problem of the abandoned fields of the South had finally come to an end. In the following decades all sorts of problems would surface deriving from a monocrop system extended over the thin soils of Alentejo. [31] But by then the Wheat campaign had already put agriculture scientists at the heart of the State administration, and they would be the ones called to solve the problems they had helped to create in the beginning of the 1930s.

For Câmara, the young agriculture scientist head of the campaign, there was no doubt about the importance of this first mobilization of scientists for the fascist new state. Let us follow some of his emphatic words when remembering those glorious days: "The wheat campaign had come. The dawn had arrived! Happy those like us, who started our professional lives under the light of the dawn and were able from the very first moment to follow a Great Leader and the flame of a new Mystique."[32]

In 1936 new legislation would reorganize the Agriculture Department with research being granted a central role. The law founded both the Board for Internal Colonization, created to plan the settlement of the southern lands with people from overpopulated areas of the Northwest, and the National Agriculture Experiment Station (EAN), the scientific arm of the Department. Câmara was selected as the head of this new laboratory, for he was not only a distinguished participant of the wheat campaign, and of all other production battles that followed, but he also had previous experience in renowned international institutions such as the Plant Breeding Institute in Cambridge or the Kaiser Wilhelm Institut for Breeding Research in Berlin.[33]

When he returned to Portugal, Câmara organized his EAN around Genetics which after his international experience he considered to be "the central science of an institute of agriculture research."[34] But besides Genetics, and following the example of most experiment stations that spread all over the world on the first half of the twentieth century, each economically relevant species was scrutinized by a battery of techniques.[35] The departments just sprawled, with wheat, corn, rice or apples put under the scrutiny of genetics, physiology, botany, phytopathology, entomology, chemistry, soil science, economics or sociology. If the

botanical gardens of the previous centuries were able to bring together thousands of species under one unique discipline – botany - , the experiment stations limited the number of species but multiplied the number of approaches. One of the distinctive features of experiment stations is this accumulation of departments sometimes organized around their object, like the rice department, others around their discipline, like the phytopathology department.

In 1943, only seven years after its foundation, the EAN counted already 62 researchers. There was no previous case of a research institution in Portugal with so much manpower, and Câmara believed that Taylorism was the tool he needed to organize it: "the organizer of a company tries to elaborate its rules as precisely as he can, by establishing the number of organs needed, the way they relate to each other, the hierarchies between them, the performance expected from each of them... The modern leader is the one who knows how to distribute his power by a system of intelligently divided responsibilities."[36] Câmara's obsession with the organization of scientific work was the main subject of his book On the Way. Guiding a Scientific Enterprise, published in 1943, the XVIIth year of the national revolution as stated in the cover. The book had a preface by Marcelo Caetano, commissioner from 1940 to 1944 of the Portuguese Youth—the regime youth organization tightly connected with the experiences of the Opera Nazionale Balilla in Italy and the Hitlerjugend in Germany -, and future prime minister of the authoritarian regime after Salazar's death. Caetano recommended the book to all Portuguese who have been called "for a mission of leadership, of orientating, of directing national life".[37] Câmara intended to offer a guide to the researcher serving the New State, with science as the best weapon to defend the Fatherland. Every young man mobilized to the EAN should have "faith, patriotism, character, intelligence, knowledge and working capacities. The lack of faith leads to the sad petit bourgeois mentality of some supposedly said scientists... petit bourgeois lack the needed enthusiasm... The religion of the fatherland is the eternal source of energies from where the researcher will get the courage to overcome all difficulties."[38]

Câmara's intentions were translated into stone in the new facilities of the EAN built in 1941 in the Lisbon outskirts. The design of the building and the adjacent experimental fields followed the rules of the Portuguese House movement as established by the regime architects. Câmara bluntly asserted that he wanted to avoid "the modern style and its juxtaposition of containers, with no character, poorly adapted to our climate and being in all its manifestations an outrage to the beauty of the Portuguese landscape."[39] And the fact is that the historicist outcome was singled out as one of the best examples of the public buildings that were remaking the Portuguese landscape following the rules of Portuguese good taste.[40] In the pages of

Panorama, the official magazine of the National Propaganda Board responsible for making Portugal Portuguese, the EAN building was considered to be one of the best expressions of the revival of national architecture.[41]

More practical considerations were of course also taken into account such as the dimensions of the laboratories, their location and illumination. And once again one understands better Câmara's intentions by noting his decision of having only one building instead of several isolated pavilions as was for example the case of the Beltsville Research Center of the American Department of Agriculture near Washington. Câmara made his case by stating that one building "not only promotes a more intimate collaboration between the different departments, but the role of the director also becomes easier and more efficient. In such an establishment the authority of a director can't be dismissed, and it should be felt at every moment and in each activity."[42]

The architecture of the National Agriculture Experiment Station was undoubtedly appropriated for a state laboratory conceived as a tool for colonizing the national soil. Much of the research conducted at the Station had the direct support of the corporate organs of the New State which were trying to penetrate into the Portuguese fields. The National Board of Olive Oil, for example, directly supported in 1939 the research undertaken at the phytopatology department on the Daccus oleae fly, a major plague in Portuguese olive trees, hiring scientists for the study of its biology, ecological relations, natural enemies and ways of controlling it. The National Federation of Wheat Producers built the greenhouses of the plant breeding department, while at the same time and on the opposite direction the Station delivered to the Federation 22 new wheats distributed mainly among Alentejo farmers.

## The National Laboratory of Civil Engineering and hydroelectricity

The 1930s, as already stated, were golden years for engineers willing to collaborate in the autarky policies of the regime.[43] Salazar himself sustained that for the State to drive national economy towards corporatism, "the constitution should provide the building of great works such as communications, sources of power, transportation networks and electrical grids…whose plans ought to be designed and enforced by the State."[44] In 1935 the Law for Economical Reconstitution materialized the visions of the development of the economy on a nationalist basis under the direction of the State. Its main investments went to roads, harbors, irrigation dams, public buildings and defense.[45] The combination of defense and

infrastructures, typical for many state policies of the Depression years, would materialize the presence of the New State in the territory. Once again, the dictator sermon offers little doubt: "The dominant thought in the Administration is to do nothing without a plan."[46] That same year, 1935, a Plan for Agriculture Hydraulics was set in motion. In 1936 the government launched the Board for National Electrification and the Board for Internal Colonization, founded the National Agriculture Experimental Station and inaugurated the monumental premises of the Superior Technical Institute in Lisbon, the main engineering school of the country. Two years later, in 1938, a new ambitious plan was set in motion: the Forestation Plan. The paradox is striking. Big state plans and big technology were fundamental to materialize Salazar's visions of Portugal as a well kept garden planted by modest catholic farmers.

Of course such paradox is not a Portuguese exclusive. It is good to remind that the program for the rationalization of the national territory through Forests, Internal Colonization, Irrigation and Electricity owed a lot to the American experience with the West. And it is now commonplace for historiography to denounce the distance between the rhetoric of independent yeoman farmers reclaiming the West and the reality of a powerful State bureaucracy - the Bureau of Reclamation – colonizing the western landscape through large dams.[47] If to propose a national electric grid Ezequiel de Campos just had to combine his conservationist readings with expeditions around the country with his unsophisticated topographical and hydrographical instruments, to design and build large dams a totally different kind of instruments was needed.

In 1939 it was started the building of the first Portuguese concrete arch dam, the Santa Luzia dam which inaugurated a new era for the rivers of the country.[48] The irregular behavior of Portuguese rivers with its torrential flows during the rainy winter reduced to scant streams in the dry summer, demanded high structures damming big artificial lakes.[49] By using only conservative heavy and expensive gravity structures most watercourses would remain unexplored. Thinner and cheaper concrete arch dams were needed to materialize the visions of Portuguese rivers supplying energy for an industrial surge based on the country's own resources. And for national resources to support national development, for rivers to support industry, engineering researchers were to be mobilized to study arch dam behavior. This was the rationale sustaining the collaboration between the State hydraulic services and the Center for Studies of Civil Engineering (Centro de Estudos de Engenharia Civil).[50]

The Center, operating in the premises of the Superior Technical Institute, was directed by Manuel Rocha, a young engineer recently returned from the Massachusetts Institute of

Technology (MIT) who was interested in materials resistance.[51] His American experience was made possible through a scholarship of the Institute for High Culture, a government department created to support the formation of a new scientific elite.[52] In addition to offering to young talented scientists the opportunity of attending renowned international universities, the Institute also funded local centers of excellence. The Center for Studies of Civil Engineering, one of the Institute's centers, was founded in 1942. No more than two years later it was already building the first model of the Santa Luzia dam, inspired by the American Bureau of Reclamation work on models for the world famous Hoover dam on the Colorado River. In a tiny laboratory six young and enthusiastic engineers were starting a research program that would become the most successful Portuguese experience with Big Science.

The shortage of coal supplies experienced by Portugal during the Second World War was the ultimate argument for hydroelectric production to free the country from external sources.[53] In 1944 a National Electrification Law was passed relying on large dams as the first energy source of the country and in 1945 the State promoted the creation of two large companies to develop the basins of the Cávado and Zêzere rivers.[54] The big investments of the companies were justified with the creation of new key industries such as electrochemical plants and steel mills, in a typical import substitution industrialization policy.[55] Electrification and the reorganization of Portuguese industry were, not surprisingly, two interwoven topics. Cheap large arch dams, designed following laboratory recommendations, were key elements of the postwar ambitious plans of industrializing the country through the use of the territory's own resources. In 1946 construction started for the large dams of Castelo de Bode and Venda Nova, and one year after the small Center for Studies of Civil Engineering was converted into the flamboyant National Laboratory of Civil Engineering (LNEC).

Contrary to the practice of most countries, the laboratory centralized all experimental activity connected with civil engineering problems, responsible not only for the study of structures and materials, but also for defining standards and developing construction methods.[56] But Manuel Rocha himself was the first to recognize that the impressive growth of LNEC and its relevance on the national scale were first and foremost connected to the research carried in arch dams' behavior. From the beginning most of its researchers were involved with dams, testing different qualities of concrete; observing deformations, stresses and temperatures during and after construction; examining rock foundations; or carrying model studies of the shapes of the structures to be adopted.[57] In fact, model studies became the most distinguishing

feature of the research undertaken at LNEC, proving to be an effective tool both to actively participate in the national electrification effort as well as to its international recognition.

Starting from the United States Bureau of Reclamation experience with models of Hoover Dam a research program was launched to systematically use small models in arch dam design.[58] The aim was to overcome the high manpower and time requirements of numerical methods by developing techniques of model building that would at the same time improve accuracy in establishing the stress state of the dam.[59] To reproduce the dam and its foundations at a laboratory scale different model materials were tested, several methods of reproducing the load on the structure were tried, and new instruments for the measurement of deflections were developed. In those model tests the accurate measurement of small deformations was a crucial issue which explains why Manuel Rocha insisted on the importance of counting with an active Instrumentation Section in the laboratory. Electrical extensometers were developed to replace traditional vibrating chords which demanded improved facilities to control experiments' conditions. The measurements made inside LNEC's walls in Lisbon were then compared with field data from the real dams which were equipped with a set of instruments following an observation plan also designed by LNEC in tight collaboration with the building companies.[60]

The engineers of the Structures department of LNEC, directed by Manuel Rocha himself, claimed in several papers presented to the International Congresses of Large Dams and published, for example, in the Proceedings of the American Society of Civil Engineers to have demonstrated the superiority of models when compared to analytic tools in offering a fairer account of the complexities inherent to arch dam structures.[61] The use of models was mandatory if safe thin structures were to be built, especially in sites of irregular profile, in dams with singularities (such as spillway openings) or in the case of heterogeneous foundations. Or, more bluntly, models were mandatory for any important structure. All Portuguese large dams then started to be previously tested in LNEC premises before laying the first stone. In contrast to the U. S Bureau of Reclamation practice which only used models to confirm the designs coming out of numerical methods' computations, the Lisbon laboratory put all its efforts in developing cheap and flexible model techniques that earned its international reputation. In the beginning of the 1960s the very same U. S Bureau of Reclamation was hiring LNEC to make the model studies of the complex Morrow Point Dam structure in the Gunnison River in the Colorado basin.

In 1955, only eleven years after the beginning of the first model of the Santa Luzia dam, Manuel Rocha could already argue that the experimental technique developed in the lab, through its direct savings in structure costs, had already compensated for the entire investment made by the State in the National Laboratory.[62] Such cost-benefit analysis was not an innocent claim for we are dealing with a laboratory that started in the 1940s with six young engineers and improvised research facilities, and that grew up in the 1950s to an institution with 279 people. Four years later the total number of employees was already 490 from which 90 were research engineers. The workforce numbers, as in the case of the Agriculture Experiment Station, demanded a new organization of research. Let us follow Rocha's account of his own institution: "the laboratory has an industrial type organization which enables it to determine the real cost of each service after its conclusion. Each member of the staff has a card in which he records daily the time spent in the different jobs, discriminating even the time spent in studies, in consultations, in receiving visitors, …"[63] These bureaucratic procedures were in agreement with the cautious planning of research activities, avoiding "doing research for the sake of research. The criterion for the choice of a problem is the service it renders to the country."[64]

The building of the laboratory, inaugurated in 1952, reveals Rocha´s idea of what a national research institution ought to be. Its monumental character was in no contradiction with the simplicity of the concrete façade, an obvious homage to the work being carried behind the gray walls. A quick look is enough to realize the modular nature of the building, with no differentiation of the several sections of the laboratory.[65] Each modulus of 7*3.5m was limited by glass walls easily removable in case of necessity. The laboratory was perceived as a research machine easily adoptable to new objects of inquiry requiring different space distributions for teams and instruments. Nevertheless the clear hierarchy of the institution was not forgotten in this egalitarian modular structure. Each section was distributed in a single zone of the building in a cascade occupying its three floors, in order for the engineer director of the section to supervise the subordinates' work.

It is evident that Rocha worked closely with the architect Pardal Monteiro who designed a building to be located in the northern outskirts of the city, between Lisbon new neighborhoods and the recently planned ring road and airport. The building may be seen as part of a coherent whole that was changing Lisbon image. Monteiro's Lisbon was not Speer's Berlin, but it included several monumental buildings, among them those of the High Technical Institute and the National Laboratory of Civil Engineering, new urban landmarks of the fascist New State Capital. Once again, LNEC is not only a fundamental site to understand how

during the second half of the twentieth century Portuguese rivers had been dammed according to the internal colonization dreams first expressed by Ezequiel de Campos. The very same laboratory building is an important part of the new urban landscape of Lisbon.

## The Center for Cotton Research and the Nationalization of the Empire

The characters we have been following suggest different possible relations between science and fascist regimes. Câmara was a full enthusiast of the New State and he didn't shy in urging the researchers at the EAN to directly contribute to the building of the new regime. Campos, a former minister in the Republican period, was happy to actively participate as deputy in the New State's Corporatist Chamber, as long as the regime implemented his proposals for the rationalization of the territory through conservationist policies. Rocha kept his technocratic pose without apparently mingling with politics until he became minister of Public Works in the first government formed after the overthrow of the dictatorship in 1974. Nevertheless, as we just saw, it is hard to isolate the work undertaken at LNEC from the political economy of the Portuguese authoritarian regime in the postwar years. Actually, as celebrated by the regime's propaganda, there was no stronger material presence of the New State in the landscape than those massive concrete dams tested and calculated at Rocha's laboratory.

In contrast, the biography of Aurélio Quintanilha (1892-1987) seems to confirm the traditional narrative about the difficulties of conducting scientific research under authoritarian fascist type regimes. His dismissal and compulsive retirement in 1935 from his position as Full Professor of the Botanical Institute of the University of Coimbra, when his scientific reputation in the field of cytology and genetics was indisputable,[66] is in accordance with the well known purges of scientists under the dictatorial regime that ruled Portugal from 1926 till 1974. Although the numbers of scientists which fled Portuguese fascism are less impressive than those of Nazi Germany or even Franco's Spain, historians have already explored in detail the research lines, namely in Physics, that were abandoned due to political repression.[67] The decision by the Minister of Education, a physical anthropologist at the same University of Coimbra and local leader of the radical right wind movement – the blue shirts –, to shut down Quintanilha's laboratory, not even allowing him to finish a paper to be presented at the 1935 Congress of Botany in Amsterdam, has been perceived as proof of the antiscientific nature of Salazar's dictatorship. By denying Quintanilha access to his laboratory, the results of seven years of research on cytology and genetics of fungi were totally lost.

Salazar, who was also a professor of financial sciences at the University of Coimbra, felt strong personal reluctance towards Quintanilha, a renowned anarcho-syndicalist who embodied all he stood against. In the years they coincided in Coimbra, the would-be dictator would not even shake hands with Quintanilha. Salazar, always in his severe black suit, felt insulted by a figure who dared to show up in public wearing tennis sportswear and exhibited the cosmopolitan character earned in his Berlin and Paris years.

It was to escape the regime's repression that in 1936 Quintanilha left Portugal for Paris to work in the Natural History Museum where he temporarily had to abandon his research on genetics. But fascism, once again, stood on his way. After voluntarily joining the French Army to fight the Nazi invasion of France, he returned to Portugal where his previous scientific connections promised him a warm welcome. Namely, his fellow geneticist Antonio Câmara, assured Quintanilha a position at the EAN. Although Câmara was one of the main figures of the scientific Portuguese fascist establishment and was responsible to develop a new breviary of the scientist serving Salazar's New State, the dictator himself interceded personally to prevent Quintanilha to be hired by the Experiment Station. In the following years Quintanilha could only count with a part-time job at the laboratory canteen to maintain himself and his family.

In 1943 he was finally recruited by the Board of Export of Colonial Cotton Board (Junta de Exportacao do Algodao Colonial – JEAC) which was willing to create a Center for Cotton Research (Centro de Investigacao Cientifica Algodoeira – CICA) in Mozambique, the Portuguese colony in Eastern Africa. Quintanilha was thus sent to a far-away post, isolated from the political intrigues of the metropolis, following the regime's policy of sending opposition members to the African Colonies. He would remain in Mozambique till 1982. The trajectory of Quintanilha doesn't bring any special problem to historians. Nevertheless, I intend to suggest that his Mozambique years shouldn't be seen just through the lens of forced exile.

Despite the formal annexation of Mozambique after the Berlin Conference in 1885 that officially launched the Scramble for Africa, Portugal was never able to really take possession of the territory, ceding large plots of land to chartered companies formed by international capitals that had total control over their concessionary areas. Most of the income of these companies was derived from extracting taxes from African populations living under their domain and exporting conscripted labor to the South African gold mines or the Katanga copper mines. The economy of Mozambique was totally dependent on its neighbors, with railways transporting ores from South Africa and Southern Rhodesia mines to be shipped at the ports of Lourenço Marques and Beira, and returning in the opposite direction carrying conscripted laborers to work at the

same mines. Autarky policies demanded more from a territory that was supposed to provide raw materials and markets for metropolitan industries. The fast growing Portuguese textile industry in particular was getting in 1931 only 1% of its ginned cotton from the African colonies, buying huge amounts of North American and Egyptian cotton in the world market and decisively contributing to the negative balance of payments of the State.[68] Charted companies were repeatedly denounced in Portuguese press, not only because of their foreign capital, but mainly because of their inability to transform the Mozambican landscape into a productive territory.

Already in 1926, as first Minister of the Colonies of the dictatorial government, João Belo launched new legislation to bring to an end the domain of the chartered companies which in some areas were to be replaced by cotton zones. The zones should materialize the "nationalization of the Empire", the motto guiding Belo's policies and much of the imperial initiatives of the New State.[69] In such zones concession holders had purchasing exclusivity over native production at prices fixed by the Government. The holders were not only compelled to buy, gin and export to Portugal all the cotton produced in their zones, but they were also entitled to force natives to plant cotton, mobilizing them to the nationalized colonial economy. Through the new labor legislation of 1928, the previous system of forced labor of rounding up natives and displacing them to plantations was now to be replaced by forced crop cultivation requiring workers to remain in their own village and tile their own land. In spite of the joint efforts of concessions' overseers and colonial agents, the main objective of incorporating native population into capitalist production of commodities was hard to achieve, with only 80.000 peasants, out of a total population of more than 4 million, incorporated into the cotton system by 1937.[70]

The colonial authorities were especially concerned with the provinces of Northern Mozambique with its population of two and a half million people occupying an area 4 times the size of the Metropolis and with no visible contribution to the economical welfare of the Portuguese empire. In 1938 the New State created the Board of Export of Colonial Cotton, another economic coordinating organ, part of the corporatist structure institutionalized by the constitution of 1933. The Board not only organized cotton exports from the colonies as it intervened directly in the process of capturing the peasantry for cotton production. Board officials had the power to designate the areas for growing cotton as well as to fix mandatory dates by which peasant communities planted, reseeded, and harvested their cotton crop. In accordance with the standardization tasks of many of the corporatist organisms of economic coordination, the Board also defined the various qualities of cotton and helped to set the price

paid to the peasants by concessionary companies and to the concessionary companies by the Portuguese textile industry. In 1940, two years after the Board started its action, there were already, and only for the Northern provinces, about half a million natives incorporated in the cotton regime. For the entire country the numbers reached some 800.000 people. From 1942 to 1946 from a total of 28 million tons of cotton imported by Portugal, 24 million were produced in the African colonies. Cotton had become in a few years the first Mozambican export, with the northern region producing around 60% of all colonial cotton.[71]

These numbers that made the joy of Salazar and strengthened his imperial vision of Portugal were directly related to one of the darkest pages of Portuguese colonialism. Historiography has convincingly documented the brutal character of the Portuguese cotton regime and its systematic use of violence. Allen Isaacman offers a detailed survey of the grim stories, rumors, gossips, and songs depicting the colonial state sanctioned violence spread out through the Mozambican countryside.[72] And it's good to remind that the guerrilla war for independence led by FRELIMO started exactly in those northern cotton districts in 1961 when several thousand cotton growers demonstrated. There are many different versions of what happened in the village of Mueda, but Eduardo Mondlane, the founder of FRELIMO, had no doubts about making the killing of unarmed protesters by the colonial police a founding myth of the would-be postcolonial country, converting the cotton regime into one of the main symbols of Portuguese oppression.[73] In his book Struggle for the Independence of Mozambique, published in 1969, the same year he was murdered by the Portuguese secret police, he recollected various statements of poverty, violence and hunger associated with the cotton regime.[74]

It was in the brutal context of the cotton regime that the anarcho-syndicalist Aurélio Quintanilha was supposed to lead the Center for Cotton Scientific Research. The Center created in 1943 was to be the scientific branch of the Colonial Cotton Board. Following the organization of the National Agriculture Experiment Station, a multiplicity of disciplines was to be gathered around one unique object: cotton. To cover the multiplicity of issues related to cotton were created the departments of genetics, entomology, soil, botany, phytopathology, fiber technology, agriculture engineering and regional experiment stations.[75]

The establishment of a network of experimental fields distributed through the entire Mozambican territory was the first task of the Center. Essays on 39 experimentation sites were to offer basic results about proper sowing timing, strains employed and planting rotations.[76]

These first essays covering the different regions should produce enough information on the fundamental issue of where to plant cotton. The policy of just enrolling through coercion a growing number of natives led to the cultivation of cotton in improper areas with fast erosion of soils in vast areas.[77] Textile factory owners in Portugal also complained about the lack of reliability of colonial cotton with large annual variations of quantity and quality. In 1945 the number of cotton producers started to decrease and would stabilize around some 500.000 for the next two decades, with some of the previous cultivated areas even being interdicted for cotton production. In the opposite direction, cultivation was to be intensified in the most suitable ones.

Together with the scientists responsible for the network of experimental fields, other researchers of the Center were dedicated to translate the landscape of Mozambique in laboratory terms. During the rainy season botanists and soil scientists collected and analyzed data available on climate, geology, vegetation and demography of the colonial province. When dry season arrived brigades of scientists crossed the country collecting samples of soils and plants, making socio-economical inquires to local populations and marking areas for cotton cultivation in the topographical maps. In 1955 all this work would be brought together in the thick volumes of the "Ecological-Agricultural Survey of Mozambique", the first of such surveys to be completed in the Portuguese colonies.[78] The research center was thus able to produce an invaluable tool in the form of maps detailing the areas more suitable for planting cotton.

The Portuguese scientists, led by Quintanilha, were following the example of experiment stations in neighbor regions whose experience they were aware of by constant trips to Egypt, Congo, Sudan, Uganda, Nigeria, Rhodesia or South Africa. Detailed reports of research facilities of the British Empire Cotton Growing Corporation, like the Uganda one were published by Portuguese scientists.[79] The Empire Cotton Growing Corporation (ECGC) and its network of experiment stations in the British colonies was in fact the main international model for the Portuguese Center. But maybe the most direct influence of the ECGC was the import of strains developed by its Barberton station, in the Union of South Africa, which accounted for the vast majority of cultivated cotton in Mozambique. The great advantage of the strains developed at Barberton by F. Parnell in the 1920s, namely the famous U4, was their resistance to Jassid, an insect pest that constituted one of the main obstacles to the success of cotton in Africa, and that in the twenties it was even thought to inhibit any cultivation in the Southern region of the continent.[80]

Much of the initial breeding work held in the Mozambican Center for Cotton Research was thus to adapt the Barberton varieties to local ecological conditions, namely by selections of the U4 strain, aiming to enhance productivity and the technological properties of the fiber. A constant selection effort was also necessary to avoid the degeneration of the cultivated species resulting from crossings with previously planted varieties by insect pollination or poor seed isolation, in order to keep the good properties of yielding, fiber quality and resistance to diseases or plagues. Each of the regional experiment stations, controlled by the Research Center, performed essays testing different selected seeds under different conditions of fertilization, pest control, sowing timing or rotation of cultures. Only after were the cotton seeds ready to be multiplied and distributed among the cultivators. The local experiment station was supposed to work as a model farm whose order was to be transplanted to the entire landscape of cotton fields.

As cotton zones were delimited by the officers of the Board of Export of Colonial Cotton, local people inside those areas were registered by local state and cotton companies' officers as cotton producers. Each grower received a card which he should always carry with, documenting age, residence, size of cotton field, type and qualities of seeds received, number of times the field had been weeded, quantity and quality of the produced crop…[81] Thus, as in many other examples of designed agriculture schemes throughout the African continent, indigenous individual identity was indistinguishable of the condition of crop-grower.[82] Actually, this was the core of the Portuguese civilizing mission, transforming lazy indigenous into proud hardworking farmers, even if for that, as the board officials dully observed, physical coercion had to be employed.[83]

U4 Cotton seeds looked like the perfect tool to attain such objective. In spite of the disadvantages of producing short cotton fibers and small capsules, which meant low productivity levels, the U4 was not only resistant to Jassid (its main characteristic) as it also proliferated under very different climatic and soil conditions.[84] If it were not for the qualities of the U4 it would be hard to explain how Mozambican cultivators, growing the crop entirely manually, in small plots of scarcely more than 2.5 acres, without the aid of any farming implements, and dealing with an unstable climate, were able to produce those quantities of cotton in the 1940s that made the joy of Salazar and the Board technicians.

As it is usually the case in such schemes, its success was also the first cause of problems.[85] To protect cotton from having to compete with other crops for moisture, sunlight and soil, the

Board engineers imposed a system of monocrop in contrast to traditional practices of growing different crops in the same plot of land, mixing maize, sorghum, beans or peas.[86] The concessions' surveyors only had to take a quick look at the field to realize if natives were complying or not to their obligation of growing cotton. The dismissal of the chaotic model of intermixing crops in favor of monothematic fields of cotton caused all sorts of environmental problems, namely soil erosion and the spread of new plant diseases like the red bollworm. Already in 1947 a report to the president of the Board of Export of Colonial Cotton supported the increasing evidence linking plant diseases and pests associated with the monoculture of cotton to the decline in food crops.[87] Nevertheless, such decline was also associated to the short periods of time natives were allowed to dedicate to their own households, occupied as they were with demanding cotton fields. More than that, the quick visual method of surveillance required the demarcation of cotton fields along the few roads crossing the Northern Mozambique landscape, most of the times a long-way from natives villages. Soon, the diet basis of the local population was based on manioc, a less demanding crop but also a less nutritive one. Famines stared to show up in the cotton regions and in 1951 in the Mogovolas some two to three thousand people died from starvation.[88]

Not only such events were denounced by the catholic church as well as the very same General Governor of Mozambique asserted that the obsession with cotton production, separating it from the general issue of food security, was responsible for the spread out of famines in the northern regions.[89] It is no surprise than to find out that already in 1947 the Cotton Board, under the advice of the Center for Cotton Research[90] started promoting the construction of a network of planned cotton communities throughout the north of Mozambique, the so called "cotton concentrations", multi crop agriculture units organized around scientific principles of rotation and crop management and located on the best available land. For native people the main advantage of belonging to such communities was the opportunity to plant other crops along with cotton. In the carefully planned cotton concentrations, land rotation, access to tractors, better seeds and lands, and the opportunity to grow other crops were intended to overcome all previous problems. Each household received a plot with an area between five and seven hectares, half of which would be allowed to lie fallow at any time. On the remainder, peasants would cultivate a hectare of cotton, a hectare of corn or sorghum, and a hectare of manioc. The concentrations contemplated also an integral social structure with a primary school, a sanitary post, a fountain, and houses for the professor, nurse and overseer of the concession holder. [91]

By the end of the 1950s more than 30.000 families had been relocated into the cotton concentrations. Nevertheless, the majority of cotton planters didn't adhere. Women, namely, were very resistant to a new scheme where the transmission of property was now in the hand of men, the family's head in the colonial social model.[92] More, soil quality was now the overarching factor determining the location of concentrations. Soil scientists didn't make much case about complains associated with abandoning the protection of ancestor spirits, guardians of fertility. Also contributing to the unwillingness of natives to resettle was the fact that the translation of the experimental station model into the fields demanded harder and longer work than before. The very same overseers recognized that "within the concentrations we had more or less perfect control over the work of each peasant every day. We could never have exercised such power when their cotton fields were dispersed."[93]

It may be argued that 30.000 families were just a tiny proportion of the total number of cotton planters in Mozambique, roughly 10% of the total number. But the fact is that in spite of the majority of natives not being under the scientific rule of the cotton concentrations the scientists of the Center for Cotton Research still kept a large array of responsibilities: distribution of selected and disinfested seeds produced at the experimental stations; decision about the areas for growing cotton, taking into consideration soil and climate conditions; election of best strains for each region; instructions on how to prepare soil and defend them against erosion and loss of fertility, when and how to seed, when and how to weed, when and how to pick... The connection between the recommendations made in the colony's capital, Lourenço Marques, and the field was assured by a vast corps of agriculture extension distributed by 4 delegations, 22 sectors and 195 agencies. By the mid 1960s, short after the coercive labor system was abolished, 2700 officials of the Cotton Institute, the new name of the Board, were responsible for managing less than half a million cotton growers planting some 350.000 ha of cotton.[94]

But maybe the best example of the tight connections between laboratory work and the changing landscape is the breeding effort undertaken by the center geneticists and phytopatologists. In the 1940s the requisite of selecting strains resistant to Jassid attacks was considered as a necessary condition to the very same future of cotton in Africa. Twenty years later, breeders' aims would change radically. In the 1960s plants resistant to Jassid were perceived as a hindrance to achieve higher productivity. For cotton to be picked up mechanically it is necessary to employ a chemical defoliant, so that leafs won't be picked together with the cotton fiber. Now, Jassid resistance is due to pubescent leafs that after the

application of a defoliant stick to the cotton fiber, reducing drastically its value. Jassid resistance is thus a property tightly connected with manual workers, planting in their small plots much less productive strains. In the beginning of the 1970s the new strains that the breeders of the Center were proud to announce presented a poor resistance to Jassid, but were highly recommended for farmers relying on machines and making use of big inputs of insecticides.[95]

The new strains were thus crucial for the new white settlers that started to dominate cotton growing in Northern Mozambique, and that in 1974, just before independence, were responsible for 80% of the region production. The new settlers, with the support of local authorities, occupied the best lands and even took over the previous areas of cotton concentrations. If the new rise in international markets in cotton prices attracted many to the cotton business, the colonial government also contributed to this new strategy of changing the color of cotton from black to white in order to create buffer zones against guerrilla actions in one of the most disputed landscapes of Mozambique.[96]

It is hard to distinguish what allows for what. Was it the policy of the last European empire that offered the resources for the breeders work? Or were the breeders the ones that offered colonial authorities the resources for keeping their policies in spite of the international pressure to put an end to Portuguese imperial ambitions?[97] Better than understanding the history of colonial science as a simple tool of empire, the cotton case suggests instead that we should start considering it simply as colonial history.

## Conclusion

The aim of the present paper was to make a similar case for the other two laboratories, the National Agriculture Experiment Station and the National Laboratory of Civil Engineering. Better than just understanding them in the context of internal colonization of Portugal, I suggest that one should take their history as internal colonization history. The argument is that delving into the relation between laboratories and landscapes helps to make history of science narratives more relevant for general history. In this paper I present at least three forms of understanding such relation. First, laboratories can grow up from landscapes, with people and instruments mobilized around the translation of landscapes into laboratory language. The EAN was tightly connected with the new wheat fields of Alentejo; LNEC's main feature was its ability to put rivers and dams at laboratory scale; the Cotton Research

Institute first task was to translate the entire territory of Mozambique into soil and vegetation charts while building an entire regional network of experimental cotton fields.

Second, it pays off to explore how laboratory facilities interact with their surroundings, as suggested by the treatment of LNEC as new urban landmark of fascist Lisbon. But maybe the EAN example was even clearer with its building taken as the best example of the kind of architecture that should make Portugal Portuguese. Actually, paying attention to architecture and the sprawling departments occupied with the same object helps to understand how big state laboratories work, mobilizing instruments and people for the purpose of scrutinizing individual objects, be it dams or wheat.

Finally, and this is the third and more obvious point, landscapes are changed by the work done inside laboratories walls. The way cotton fields are organized or rivers are put in service of electrical production is only understandable passing through interior spaces. Also, landscapes are constantly changing and one need lots of laboratory work to keep them producing good yields of wheat or cotton, to keep dams producing electricity without falling apart or to keep natives working the land for autarky policies. A useful way for historians of science to question a landscape is to ask for the laboratories that produced it. And so it seems proper to end by slightly changing Bruno Latour's famous motto into "Give me a laboratory and I will raise you a landscape".[98]

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[1] See namely the edited volumes, Susanne Heim, Carola Sachse and Mark Walker, eds., The Kaiser Wilhelm Society under National Socialism (Cambridge University press, 2009); Monika Renneberg and Mark Walker, eds., Science, Technology and National Socialism (Cambridge University Press, 1994); Margit Szöllösi-Janze, ed., Science in the Third Reich (Oxford. Berg, 2001); Carola Sachse and Mark Walker, eds., Politics and Science in Wartime: Comparative International Perspectives on the Kaiser Wilhelm Institutes, Osiris 20 (2005).

[2] Susanne Heim, ed., Autarkie und Ostexpansion. Pflanzenzucht und Agrarforschung in Nationalsozialismus (Göttingen: Wallstein, 2002)

[3] Mitchell Ash, "Wissenschaft und Politik als Ressourcen für einander", in Wissenschaften und Wissenschaftspolitik: Bestandsaufnahmen zu Formationen, Brüchen und Kontinuitäten im Deutschland des 20. Jahrhunderts , eds. Rüdiger vom Bruch and Brigitte Kaderas (Stuttgart: Franz Steiner Verlag, 2002), 32-51.

[4] For a general overview see, Caroline Elkins and Susan Pedersen (eds.), Settler Colonialism in the Twentieth Century: Projects, Practices, Legacies (New York: Routledge, 2005). For an informed discussion between the relation of American and Australian frontier myths see, Sarah Franklin, Dolly mixtures: the Remaking of Genealogy (Durham: Duke University Press, 2007), 118-157. For Brazil and the Soviet Union see, for example, Marianne Schmink and Charles H. Wood, Contested Frontiers in Amazonia (New York: Columbia University Press, 1992); Paul Josephson, Industrialized Nature: Brute Force Technology and the Transformation of the Natural World (Washington DC: Shearwater Press, 2002), 172-192.

[5] For the role of science and technology in the efforts of the Portuguese state to control the national territory in the second half of the nineteenth century see, Tiago Saraiva, Antonio Lafuente, Ana Cardoso de Matos, "Tecnología y Frontera: La Invención Fracasada de Iberia", in Maquinismo Ibérico, eds. Antonio Lafuente, Ana Cardoso de Matos and Tiago Saraiva (Aranjuez: Doce Calles, 2007), 15-32.

[6] For a general overview of Campos' trajectory see Fernando Rosas, "Ezequiel de Campos e a solução neofisiocrática da «crise Portuguesa»", introduction to Textos de Economia e Política Agrária, Ezequiel de Campos (Lisbon: Banco de Portugal, 1998).

[7] Ezequiel de Campos, Pregação no deserto (Porto: Lello & Irmão, 1948).

[8] Ezequiel de Campos, "Modificação do Ambiente das Ilhas de S. Tomé e Príncipe", Boletim da Sociedade de Geografia de Lisboa, 74 (1956): 141-150.

On the formation of an international desiccation discourse see Richard H. Grove, Green Imperialism. Colonial expansion, tropical island Edens and the origins of environmentalism, 1600-1800, (Cambridge University Press, 1995).

[9] David E. Nye, America as Second Creation. Technology and Narratives of New Beginnings (Cambridge, Mass: MIT Press, 2003); Donald J. Pisani, Water and American Government. The Reclamation Bureau, National Water Policy, and the West, 1902-1935 (Berkeley: University of California Press, 2002), 272.

[10] Campos, Pregação no Deserto, 12.

[11] For Martins' proposals see Oliveira Martins, Fomento Rural e Emigração (Lisbon: Guimarães, 3rd ed., 1994). For the Portuguese tradition of internal colonization projects, Fernando Oliveira Baptista, A Política Agrária do Estado Novo (Oporto: Afrontamento, 1993), 19-35.

[12] Ibid., 20-22. For a description of the conservation movement see, Samuel Hays, Conservation and the Gospel of Efficiency. The Progressive Conservation Movement, 1890-1920 (Cambridge, Mass: Harvard University Press, 1959); Donald Worster, Rivers of Empire: Water, Aridity, and the Growth of the American West (Oxford University Press, 1985).

[13] Ezequiel de Campos, A Conservação da Riqueza Nacional: a grei, os minerais, a terra, as matas, os rios (Porto: 1913)

[14] From 16.000 emigrants for the year 1900, the number rose to 31.700 in 1910. From 1900 to 1930 the total flux of emigrants was of some 900.000 people. The total Portuguese population was 5.446.760 in 1900 and 6.802.429 in 1930.

[15] Campos, Pregação no deserto, 17.

[16] Campos, Conservação da Riqueza Nacional, 460.

[17] Campos, Pregação no deserto, 18. Ezequiel de Campos conducted his own colonising test in Alentejo by buying some 42 hectares of land and occupying it with settlers from the northern region. In his memories he narrates all the difficulties that would finally put an end to the experiment. Ibid., 33-36.

[18] The correction of the rain pattern of Portugal by forestation was one of Campos' favourite issues, on which we presented several papers. For example, Ezequiel de Campos, Problemas Fundamentais Portugueses (Lisbon: Edições Ocidente, 1946), 77-81.

[19] On Campos proposals for a national electrical grid see, Campos, Problemas Fundamentais, 150-151.

[20] Campos, Pregação no deserto, 61-63; Campos, Problemas Fundamentais, 151-152.

[21] Manuel Villaverde Cabral, "The Seara Nova group (1921-1926) and the ambiguities of Portuguese liberal elitism", Portuguese Studies, 4 (1988): 181-95.

[22] Fernando Rosas, Salazarismo e Fomento Económico. O primado do político na história económica do Estado Novo (Lisbon: Editorial Notícias, 2000), 179.

[23] Rui Ramos, A Segunda Fundação, in História de Portugal, vol. VI, ed. José Mattoso (Lisbon: Círculo de Leitores, 1994), 552.

[24] Campos, Pregação no Deserto, 136-138.

[25] For an overview of the relation between engineers and the New State see, José M. Brandão de Brito, "Os Engenheiros e o Pensamento Económico do Estado Novo", in Contribuições para a História do Pensamento Económico em Portugal, ed. José Luís Cardoso (Lisbon: Dom Quixote, 1988): 211-234; Nuno Luís Madureira, "Visionários e dirigentes: os engenheiros portugueses na primeira metade do século XX", paper presented at the XXth Annual Meeting of the Associação Portuguesa de História Económica e Social, Oporto, 2000.

[26] This short list of characteristics of Salazar's regime is taken from Manuel Villaverde Cabral, "Portuguese Fascism in Comparative Perspective", working paper presented at the International Political Science Association, XIIth World Congress Rio de Janeiro, 1982. For an informed discussion on the place of the Portuguese authoritarian New State among fascist regimes see, António Costa Pinto, Salazar's Dictatorship and European Fascism. Problems of Interpretation (New York: Columbia University Press, 1995). For a contrasting position see Luís Reis Torgal, Estados Novos, Estado Novo: Ensaios de História Política e Cultural, 2 vols., Vol. I (Coimbra: Imprensa da Universidade de Coimbra, 2009), 289-367; Manuel de Lucena, "Interpretações do Salazarismo" (I), Análise Social 20 (1984): 423-451; Villaverde Cabral, "Portuguese Fascism in Comparative Perspective". These three texts are convincingly critical about the exclusion of the Portuguese regime from the category of Fascism. The historian Fernando Rosas goes a step further and includes it in the family of totalitarian regimes: Fernando Rosas, "O salazarismo e o homem novo: ensaio sobre o Estado Novo e a questão do totalitarismo", Análise Social, 35 (2001): 1031-54. On the deep relation between Portuguese fascism and its European counterparts see also, Manuel Loff, "O nosso século é fascista!" O Mundo visto por Salazar e Franco (1936-1945) (Oporto: Campo das Letras, 2008).

[27] Manuel de Lucena, "Interpretações do Salazarismo: notas de leitura crítica" (I), Análise Social 20 (1984): 423-451

[28] Luís Reis Torgal, A Universidade e o Estado Novo (Coimbra: Minerva, 1999), 46.

[29] In 1928 wheat alone represented 12% of the total Portuguese imports, being responsible for 22% of the external deficit. The best source for the Portuguese Wheat Campaign is still, José Machado Pais, Aida Maria Valadas de Lima, José Ferreira Baptista, Maria Fernanda Marques de Jesus, Maria Margarida Gameiro, "Elementos para a história do fascismo nos campos: A «Campanha do Trigo»: 1928-38 (I)", Análise Social 12(1976): 400-74; and José Machado Pais, Aida Maria Valadas de Lima, José Ferreira Baptista, Maria Fernanda Marques de Jesus, Maria Margarida Gameiro, "Elementos para a história do fascismo nos campos: A "Campanha do Trigo": 1928-38 (II)", Análise Social 14 (1978): 321-89.

[30] António Sousa da Câmara, Os objectivos da Campanha do Trigo (Lisbon: Editorial Império, 1955), 42-43.

[31] Mário de Azevedo Gomes, Henrique de Barros e Eugénio de Castro Caldas, "Traços principais da evolução da agricultura portuguesa entre as duas guerras mundiais", Revista do Centro de Estudos Económicos, 1 (1945): 21-203; Mariano Feio, Le Bas Alentejo et l'Algarve (Lisbon: Congrès International de Gèographie, 1949), 82-87.

[32] Câmara, Os Objectivos da Campanha doTtrigo, 31. This is a quotation by Câmara of the words spoken by Homem de Melo.

[33] For a description of Câmara's experience in berlin see Tiago Saraiva, "Fascist Labscapes: Genetics, Wheat and the Landscapes of Fascism in Italy and Portugal", Historical Studies in the Natural Sciences, 40 (2010), forthcoming.

[34] António Câmara, "Programa de Trabalhos do Departamento de Citologia e Genética", in Planos de Trabalho da Estação Agronómica Nacional, ed. António Câmara (Lisbon: Estação Agronómica Nacional, 1939) 79-89, on 79.

[35] António Câmara, "Horizontes da Estação Agronómica", in Planos de Trabalho da Estação Agronómica Nacional, ed. António Câmara (Lisbon: Estação Agronómica Nacional, 1939), 7-41.

[36] António Câmara, No Caminho. Guiando uma empresa científica. (Alcobaça: Tip. Alcobacense, 1943), 47-48.

[37] Marcelo Caetano , preface to Câmara, No Caminho, X.

[38] Câmara, No Caminho, 68-72.

[39] António Câmara, "Instalações da Estação Agronómica Nacional", in Câmara, Planos de Trabalho da Estação Agronómica Nacional, 42-70, on 54.

[40] On the new old good taste see Margarida Acciaioli, Exposições do Estado Novo, 1934-1940 (Lisbon: Livros Horizonte, 1998).

[41] "Campanha do bom gosto", Panorama, 1941. On the role of the National Propaganda Board see for example, Daniel Melo, Salazarismo e Cultura Popular (1933-1958) (Lisbon: Imprensa de Ciências Sociais, 2001); Luís Trindade, O Estranho Caso do Nacionalismo Português. O salazarismo entre a literatura e a política (Lisbon: Imprensa de Ciências Sociais, 2008).

[42] Câmara, "Instalações da Estação Agronómica Nacional", 54.

[43] The First National Congress of Engineering in 1931, the Great Exhibition of Portuguese Industry in 1932, and the First Congress of the Portuguese Industry in 1933, were historical landmarks expressing the new social role of engineers. See, Brandão de Brito, "Os engenheiros e o pensamento económico…"; Rosas, Salazarismo e fomento económico; Madureira, Visionários e Dirigentes, 8.

[44] Quoted in Rosas, Salazarismo e Fomento Económico, 58.

[45] Fernando Rosas, O Estado Novo nos Anos 30 (Lisbon: Estampa, 1986).

[46] Ministério de Obras Públicas, Quinze anos de obras públicas: livro de ouro (Lisbon: Comissão Executiva da Exposição de obras Públicas, 1948), 122.

[47] Worster, Rivers of Empire; Marc Reisner, Cadillac Desert: the American West and its Disappearing Water (New York: Viking, 1986)

[48] For a general overview of dam building in Portugal see, Rui Candeias Jacinto, "As barragens em Portugal: de finais de Oitocentos ao limiar do Século XXI", in Momentos de Inovação e Engenharia, eds. Manuel Heitor, J. M. Brandão de Brito, M. Fernanda Rollo, Vol. II (Lisboa: Dom Quixote, 2004), 800-819.

[49] Carvalho Xerez, "Aproveitamento hidroeléctrico dos nossos rios. Estudos realizados pela Direcção Geral dos Serviços Hidráulicos", Paper presented at the Ordem dos Engenheiros, Lisbon, May 1945.

[50] O Laboratório de Engenharia Civil. Organização e Funcionamento (Lisbon: Ministério de Obras Públicas, 1949); Manuel Rocha and J. Laginha Serafim, "Model Tests of Santa Luzia Dam", Third Congress of Large Dams, Stockholm, 1948.

[51] For a biographical account of Manuel Rocha see, Armando Gibert, Manuel Rocha, O Pensamento e a Obra (Lisbon: Imprensa Nacional Casa da Moeda), 1986.

[52] On the activities of the Institute of High Culture see in this same issue the article by Júlia Gaspar, Maria do Mar Gago, Ana Isabel Simões, "Scientific Life under the Portuguese dictatorial regime (1929-1954): the communities of geneticists and physicists."

[53] António José Telo, Portugal na Segunda Grande Guerra (1941-1945) (Lisbon: Vega, 1991).

[54] Direcção Geral dos Serviços Eléctricos, Concessão do aproveitamento hidroeléctrico da energia das águas dos rios Cávado e Rabagão (Lisbon: Imprensa Nacional, 1964); Ilídio Mariz Simões, Pioneiros da electricidade em Portugal e outros estudos (Lisbon: EDP, 1997); Maria Fernanda Rollo and J. M. Brandão de Brito, "Ferreira Dias e a constituição da Companhia Nacional de Electricidade", Análise Social, 31 (1996): 343-354.

[55] Brandão de Brito, "Os Engenheiros e o Pensamento Económico do Estado Novo", 223-225; Madureira, "Visionários e Dirigentes", 16-17.

[56] Manuel Rocha, The Laboratório Nacional de Engenharia Civil. Organization Mangement, and Activity (Lisbon: Laboratório Nacional de Engenharia Civil, 1955), 1-2.

[57] Ibid, 17-21.

[58] See for example, Manuel Rocha et al, "Model tests, Analytical Computation and Observation of an Arch Dam", Proceedings of the American Society of Civil Engineers, 81 (1955), Separate No. 696.

[59] Manuel Rocha and J. Laginha Serafim, "Analysis of Concrete Dams by Model Tests", Fifth Congress of Large Dams, Paris, 1955.

[60] Manuel Rocha, J. Laginha Serafim, A. Ferreira da Silveira, and O. V. Rodrigues, "The Observation of the Behaviour of the Portuguese Concrete Dams", Fifth Congress of Large Dams, Paris, 1955.

[61] Rocha et al, "Model tests…".

[62] Rocha, The Laboratório Nacional de Engenharia Civil, 2.

[63] Ibid., 3.

[64] Ibid., 2.

[65] I follow here the unpublished architecture project for the laboratory building, Pardal Monteiro, Laboratório Nacional de Engenharia Civil. Programa e Memória Descritiva. Ante-Projecto (Lisbon: Ministerio de Obras Públicas, 1948).

[66] For biographical data on Quintanilha see, A. Fernandes, "Prof. Dr. Aurélio Quintanilha", separata do Boletim da Sociedade Broteriana, Vol. XXXVI, 1962; Maria L. A. Neves, Homenagem a Aurélio Quintanilha (Lisbon: Câmara Municipal de Lisboa, 1992); João Medina, "Entrevista com Aurélio Quintanilha", CLIO, 4 (1982): 121-132.

[67] The most well documented case is the expulsion of 21 University professors in 1947. The expulsions were justified with the involvement of scientists in a plot to overthrow Salazar's government.

[68] On the importance of cotton for the Portuguese economy, see M. Anne Pitcher, Politics in the Portuguese Empire. State, Industry and Cotton, 1926-1974 (Oxford: Clarendon Press, 1993); Carlos Fortuna, O Algodão de Moçambique, Portugal e a Economia-Mundo (1860-1960) (Porto: Afrontamento, 1993); Joana Pereira Leite, La formation de l'économie coloniale au Mozambique (Paris: EHESS, 1989).

[69] Valentim Alexandre, Velho Brasil, Novas Áfricas: Portugal e o Império (1808-1975) (Oporto: Afrontamento, 2000), 208-215.

[70] Nelson Saraiva Bravo, A Cultura Algodoeira na Economia do Norte de Mocambique (Lisbon: Junta de Investigações do Ultramar, 1963); Allen Isaacman, Cotton is the Mother of Poverty. Peasants, Work, and Rural Struggle in Colonial Mozambique, 1938-1961 (Porstmouth, NH: Heinemann, 1996).

[71] Pitcher, Politics in the Third Portuguese Empire, 114-136;

[72] Isaacman, Cotton is the Mother of Poverty.

[73] Pitcher, Politics in the Third Portuguese Empire, 252-53.

[74] Eduardo Mondlane, The Struggle for Mozambique (Harmondsworth: Penguin, 1969).

[75] For the first phase of the center see, A. Quintanilha, 'Introdução", in Trabalhos do Centro de Investigação Científica Algodoeira (Lourenço Marques: Minerva, 1948) 3-10.

[76] Mário de Carvalho, "Resultados de Experimentação Algodoeira em Moçambique", Agronomia Lusitana, XI (1949): 249-375.

[77] For an early account of soil erosion problems related to cotton, Domingos H. Godinho Gouveia "A cultura do algodão nas suas relações com o problema da erosão do solo na Colónia de Moçambique", Trabalhos do Centro de Investigação Científica Algodoeira, (Lourenço Marques: Minerva, 1948).

[78] Soon the scientists of the Cotton Center were making surveys for the rest of Portuguese colonial territories like Guinea or the Cape Vert islands. See, Centro de Investigação Científica Algodoeira, Esboço do Reconhecimento Ecológico-Agrícola de Moçambique (Lourenço Marques: Imprensa nacional de Moçambique, 1955).

[79] António Jose da Silva Teixeira, "A Estação Experimental Algodoeira de Namulonge, Uganda", Separata Gazeta do Agricultor, 1955: 1-31.

[80] Aurélio Quintanilha, Manuel Guerreiro Beatriz, Luiz Salazar d'Eça, "Variedades de Algodão Cultivadas em Mocambique", in Trabalhos do Centro de Investigação Cientifica Algodoeira, (Lourenço Marques: Minerva, 1948); P. Pereira Carvalho, 25 anos de melhoramento algodoeiro em Moçambique -1952/1976 (Maputo: Instituto de Investigaçãoo Agronómica de Moçambique, 1976).

[81] Isaacman, Cotton is the mother of poverty, 44.

[82] Cristophe Bonneuil, Osiris

[83] Saraiva Bravo, A Cultura Algodoeira, 233-34,

[84] On the qualities of the U4, see Quintanilha et al, "Variedades de algodão cultivadas", 21.

[85] For a general discussion of State schemes failures with some examples taken out from agriculture projects, see James C. Scott, Seeing like a State: how certain schemes to improve the human condition have failed (New Haven: Yale University Press, 1998).

[86] Isaacman, Cotton is the mother of poverty, 43.

[87] Secrete correspondence between Gabriel Teixeira, Governor of Mozambique, and the Minister of Overseas (Ministro do Ultramar) for the year 1951: Arquivo Nacional Torre do Tombo (ANTT), Arquivo Salazar (U/7-a).

[88] The authorities recognized the problem, but only acknowledged the death of 200 Mozambicans. See Fortuna, O Algodão de Moçambique, 152-154.

[89] Secrete correspondence between Gabriel Teixeira, Governor of Mozambique, and the Minister of Overseas (Ministro do Ultramar) for the year 1951: Torre do Tombo, Arquivo Salazar (U/7-a).

[90] J. Fonseca George, "Concentrações Algodoeiras", in Trabalhos do Centro de Investigação Científica algodoeira (Lourenço Marques: Minerva, 1948).

[91] Fonseca George, "concentrações algodoeiras", 7-9.

[92] M. Anne Pitcher, "Conflict and Cooperation: Gendered Roles and Responsibilities within Cotton Households in Northern Mozambique", African Studies Review, 39 (1996): 81-112.

[93] Nelson Saraiva Bravo, op. cit., 114-115

[94] Instituto do Algodão de Moçambique, Relatórios. Actividade do Instituto do Algodão de Moçambique nos anos de 1962 a 1967, (Lourenço Marques: IAM, 1968), Arquivo do Instituto de Apoio ao Desenvolvimento (AIPAD).

[95] P. Pereira de Carvalho, 25 anos de melhoramento do algodoeiro em Moçambique – 1952-1976. (Maputo: Instituto de Investigação Agronómica de Moçambique, 1976).

[96] Pitcher, "Conflict and Cooperation"; Centro de Estudos Africanos, A transformação da Agricultura familiar na província de Nampula (Maputo: Universidade Eduardo Mondlane, 1980).

[97] See namely, the UN reports on massacres in Mozambique committed by the Portuguese: UN General Assembly, Report of the Commission of Inquiry on the Reported Massacres in Mozambique, New York: United Nations, 1974.

[98] Bruno Latour, "The Force and the Reason of Experiment", in Experimental Inquiries: Historical, Philosophical and Social Studies of Experimentation in Science, ed. H. E. Le Grand (Dordrecht: Kluwer, 1990), 49-80, on 76.