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Maize and socio-technical regimes

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Introduction

This chapter explores the practices and dynamics of the development of technologies in the field of agriculture. The theoretical entry point is heterogeneity and knowledge encounters, which are important themes that run through Norman Long's long academic career. Long understands heterogeneity as the co-existence of various social forms at any one point in time. This is apparent in the conceptualisation of agricultural development as being:

> '*many sided, complex and often contradictory in nature. It involves different sets of social forces originating from international, national and local arenas. The interplay of these forces generates specific forms, directions and rhythms of agricultural change*' (Long and van der Ploeg, 1988: 37).

Heterogeneity is thus '*a structural feature of agrarian development. It does not emerge casually nor can it be easily engineered*' (Long, 2001: 39). Scientific and local bodies of knowledge constitute an important and dynamic driving force that continuously produces and reproduces heterogeneity, particularly in situations when these two bodies encounter each other, for example in planned technology interventions. This positions Long's work vis-à-vis the belief that agriculture can be moulded through processes of planned intervention that are firmly rooted in development agencies (see also Hebinck and van der Ploeg, 1997). Unpacking planned intervention has been one of his favourite pastimes given the number of publications on this topic, either alone or together with others. The inability of externally designed interventions that work with standardised (technological) solutions to build upon local knowledge is intrinsic to planned interventions. Long concludes that they possess very little mastery over highly diversified local situations. Clashes and friction between scientific knowledge and various local bodies of knowledge are logical outcomes of planned interventions.

This chapter explores these issues and will do so with reference to a recently developed framework to analyse the dynamics of technology development and design: socio-technical regimes (Rip and Kemp, 1998). This concept evolved from the work of academics at technical universities in their attempt to understand technological change from a social science perspective. The

[1] I wish to acknowledge comments on earlier drafts by Han Wiskerke and Nelson Mango.

usefulness of this concept will be probed with reference to maize and maize breeding. Empirically, the analysis is more specifically situated in Kenya, as are the political, technical and cultural choices actors make concerning which varieties to breed and produce.

Technology-related issues have attracted my interest for a long time (Hebinck, 1990, 1995, 1997; 1999; Hebinck and van der Ploeg, 1997; Hebinck and Mango, forthcoming), but this interest has so far only focused on issues of the redesigning of technologies that have been disseminated through research and extension. This chapter will attempt to move beyond this narrow focus and incorporate the 'meso' or 'landscape' level for which the concept of socio-technical regimes seems appropriate.

Towards socio-technical regimes

Technology has been studied from a variety of disciplines and perspectives ranging from technological determinism and the (neo-classical) economic view on technology development to the social-constructivist school and actor network theory. I will not attempt to present a complete overview of the merits and critical issues of these perspectives[2] here, but I will explore the intellectual roots of the concept of socio-technical regime. The point of entry for this part of the chapter is the quest for a perspective that is capable of handling, at the same time, the artefacts, the designers as well as the so-called 'end users' of technology, as well as the social interactions between them. I argue that this perspective fits the actor oriented approach as elaborated by Long in his recent book (Long, 2001). Understanding the dynamics of technological change requires a notion of agency. Agency, in the final analysis, can not only be attributed to the experts designing technologies, but also to policymakers and farmers who use but also design and redesign technologies. Technology experts, techno-scientists, politicians, state institutions and farmers are network builders that shape, through processes of enrolment, the dynamics and directions of technological change.

Technological determinism and the neo-classical economic view on technology development

In the past, technology was considered as an exogenous factor and perceived to develop autonomously - implying that it is self-generating – and to be universally applicable – which means that it is culturally neutral. Implied in this view is a strong faith in progress (i.e. modernisation) and the normative wish that people will eventually adapt to new technologies designed outside their relevant action-context. This position can be regarded as the backbone of the early modernisation theories that emerged in the social sciences after the Second World War. These views were fiercely criticised by many academics. Long, being one of them, argued strongly against the assumption of the cultural

[2] Van Lente (1993) and Wiskerke (1997) provide an excellent overview of most of the perspectives elaborated in this chapter. An unpublished manuscript of Henk van den Belt from the Philosophy Group at Wageningen University also inspired this section. We discuss these issues with students in the course 'Social Science, Knowledge and Practice' that we (partly) give together.

neutrality of technology with reference to the huge variation in cultural repertoires and localised processes of social and technological transformations. Furthermore, he argued that technology was being treated as something exogenous that denies farmers' agency and makes them invisible.

Hayami and Ruttan (1985) refined this exogenous view of technology within the parameters of neo-classical economy. They considered technology as an endogenous factor that was 'induced' by agricultural society or the sector itself. Hence their paradigm is referred to as induced technological change. Within their framework, technology development is not perceived as homogenous, but rather as heterogeneous, as different technological trajectories emerge over time. Hayami and Ruttan explain these trajectories by the relative factor prices of capital, land and labour (i.e. the most import production factors in agriculture in the many strands of economics). Labour-saving technology development, they argued, occurred in countries where labour is scarce (e.g. the United States, Australia, hence the 'American model'), while land-saving technology development took place in regions were land is a scarce production factor (e.g. Japan, the Netherlands, hence the 'Japanese model'). In the first case, mechanical technology was developed. In the latter, conditions that stimulated technology development centred on bio-chemical innovations thus increasing the productivity of land and labour were developed. The model maintained that in regions where land and labour were not really scarce, technological change took a direction characterised by a mix of both trends. Europe, in the eyes of Hayami and Ruttan, was an example of such a case and stood for the 'European model'. The so-called 'Third World model', in contrast, was considered to have a 'low' level of technology development.

The neo-classical paradigm of technological change presented by Hayami and Ruttan has been criticised for its economic determinism – equating economic growth with development - and for not taking into account issues of power and diverging interests (Beckford, 1984). Their position that technological change is endogenous and progresses in different ways is indeed a step forward but the explanatory model remains rather narrow. Van der Ploeg (1990, 1999), argues that differences or variations within, for example, the 'European model' cannot be explained with reference to relative price factors only. Cultural repertoires play an equally important role in shaping farming technology (see also Hebinck and van der Ploeg 1997). Likewise, the analysis of my own data on maize farming in Nandi district, Kenya, collected during the mid 1980s, shows quite a variety of development patterns if the scale and intensity of farming are taken into account. The region was characterised at that time by fixed, state-controlled prices for produce and physical inputs such as seed, fertiliser and pesticides. Labour was sufficiently available for work on the farmer's own fields or on others and wages were found to be fairly similar within the region. Although land had a price, a land market did not really exist at the time. Yet within the context of rather homogenous price factors, an enormous diversity in maize farming was found - ranging from land and labour intensive to land and labour extensive – something that could not be explained by the relative price factors only. These two extreme but different patterns are closely associated with strategies based on '*protecting the means of production and consumption*' and with the '*expansion of production and accumulation of capital*' (Hebinck, 1990, 1995). Other factors, then, are obviously at play, such as social identities and

livelihood trajectories that also shape the choices people make with regard to farming and the use of new technologies.

Social constructivist perspective

The social constructivist perspective on technology emerged in the 1980's as a response to such deterministic interpretations. This perspective postulates that technology development is a reflection of society and its different interests. Hence technologies are not neutral artefacts, but social constructs. For example, interests of corporate groups such as seed companies, combined with advances in agrarian science (notably Mendelian plant breeding), have shaped the outcome of plant-breeding technologies (Kloppenburg, 1980). Hybrid maize is a paradigm case. It has the characteristic of higher yields because of its hybrid vigour arrived at through the selection of 4 grandparents and 2 parents. Breeding continues with the successful inbred lines. The outcome of this kind of breeding, however, is a product that is sterile in economic terms: the early hybrid maize plant breeders and their contemporaries constructed the maize seed in such a way that farmers needed to buy fresh seed every year. If farmers would adopt such 'induced' innovation, it would render the seed companies with a huge market and profits for years to come. Kloppenburg argues that this economic sterility was not an unintended side effect but that the early maize breeders purposefully built economic sterility into the seed. This decision was taken in the early 20th century, when maize breeders stood at the crossroads between two distinct ways of breeding. Apart from hybrid selection and breeding, there existed another way of improving landraces or local varieties of maize that naturally occurred in the environment (the so-called Vavilov centres, which for maize is Central America) or that had been introduced in regions where maize was not indigenous (such as Africa) through a variety of networks (Hebinck and Mango, forthcoming). This is referred to as *recurrent selection* which is a breeding process based on the crossbreeding of 10 or more different parents and thus based on capturing (and maintaining) genetic diversity rather than homogeneity as with the hybrid varieties. Nowadays these are called *Open Pollinated Varieties* (OPVs), which have as a major advantage the fact that farmers can recycle or reproduce seed from the previous harvest for at least four to five years. Kloppenburg argues that the hybrid maize breeders sympathised with the seed companies whose interests are not served by producing and supplying farmers with OPVs. With reference to guaranteeing the profitability of the private seed sector, Kloppenburg argues that the publicly funded breeders choose for the 'hybrid school'. Wiskerke (1997) underpins a social constructivist perspective when he explains the difference between The Netherlands and the United States in wheat breeding. The choice to hybridise wheat in the United States is made in the context of relatively limited protection of breeder's rights. This is in contrast with the Netherlands where these have been well protected by law since 1941.

While Kloppenburg and Wiskerke situate their examples in the early and mid 1900s in Europe and the United States, the argument of choice is still relevant today and for Africa. The government of Zimbabwe prohibited Seed Company of Zimbabwe and other companies to multiply OPVs (the date is not exactly given but is must have been between 1983 and the early 1990's; see Rusike, 1998: 311-312). Another example comes from Kenya, where the former parastatal Kenya

Seed Company (KSC) was privatised in 1997 and multiplication of OPV was immediately abolished. KSC today produces only hybrids (Managing Director KSC, June 1998, *pers. comm.*).

The 'hybrid school' is still predominant in maize breeding, although the beacons are slowly being reset and giving rise to the emergence of new or other socio-technological regimes, as we will see later in the chapter. The hybrid maize school expanded into international centres for agricultural research, with Norman Borlaug as the founding father of the publicly and donor funded International Centre for the Improvement of Maize and Wheat (CIMMYT), subsequently leading to the 'Green Revolution' of the 1960's. From that time onwards, the 'hybrid school' progressively spread to South Africa, Zimbabwe and Kenya and resulted in the establishment of seed companies producing hybrid seed '*for the nation*' and '*to feed Africa*'. These seed companies were initially parastatals or co-operatives, but after the waves of deregulation and privatisation they have now become private companies that have to satisfy their shareholders. Breeding and multiplying hybrids is apparently good business, and these companies have since sold maize in neighbouring countries, successfully competing with multinational companies such as Pioneer Hi-Bred and Cargill.

Actor networks

A more recent entry in the field of technology studies is the so-called actor-network theory. Latour, Callon and others criticise the social-constructionist perspective because of its propensity to predict and explain technology with reference to the way society is constituted, as Kloppenburg and others do. In addition, they argue that the end-users and their influence on technological changes are not apparent in the social constructivists' explanatory scheme. Instead, Latour *c.s.* argues that events such as the ones described above cannot be predicted or explained with reference to a particular pattern of social relationships. They propose to reject *a priori* distinctions, such as nature-society, micro-macro, global-local, nature-culture, and more importantly the distinction between humans and non-humans (Latour, 1994). It is argued that such distinctions are not pre-given, but can only be the outcome of interactions between actors involved in the construction of technology and knowledge. This is an interesting element of the actor network theory, as it would imply that a specific maize variety could be attributed with the capacity to act - just as the breeder or the farmer (*actant* is the word used in Latour's terminology).

This position has met severe criticism from social constructionists whom in their response to Latour c.s. defend the special place of human actors as well as their agency and knowledge in their explanatory schemes.[3] It is argued that: '*these distinctions are so deep-seated and so much part of our cultural heritage that the attempt to do away with them would make the resulting analysis utterly incomprehensible for its intended audiences*' (van de Belt, 2000, endnote 30). In the light of this it is probably more fruitful to emphasise how nature and society evolve together (hence *co-production* or *co-evolution*, see van der Ploeg 1999; Hebinck and van der Ploeg, 2001), how the micro-meso-macro interrelate

[3] For this debate, see Callon and Latour (1992), Verschoor (1997, this book) and Collins and Yearly (1992a, 1992b).

(Hebinck and van der Ploeg, 1997), and how the global and local join in everyday life (Arce and Long, 2000; Long, 2001).

A constructive element in the actor-network theory of Latour *c.s.* is that it in one way or another builds upon the idea that there is no distinction between scientists, technologists or farmers: they all are craftsmen in their own ways. They all construct facts, artefacts, and commodities, and the fate of their uses are in the hands of later users. Once accepted by the latter, these become part of their lifeworlds, but not without modification and thus accompanied by what Latour c.s. labels as 'translation'. To counteract translation, innovations are presented to users in the form of a 'black box' (Rip and Kemp, 1998:329). For this purpose allies (both human and non-human) are enrolled to create networks that aim to prevent modification. If innovations are not applied according to design principles – unpacking the black box as it were (Hebinck, 1995) – end-user's actions will be sanctioned (Benvenutti, 1982, 1985) to maintain the configuration of the several elements that constitute the box. In actor-network theory the notion of 'script' is used to postulate that artefacts shape actor actions as well as structure the form and contents of their practices:

> '*When 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. (...) 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. (...) The technical realisation of the innovator's beliefs about the relationships between an object and its surrounding actors is thus an attempt to predetermine the settings that users are asked to imagine for a particular piece of technology and the prescriptions (...) that accompany it*' (Akrich, 1992: 207-208).

Let me explain some of this with an example. The 'Green Revolution' represents the processes of enrolment and networking with the 'hybrid maize school' and Norman Borlaug c.s. as builders of a network of institutions, both from the private and public domain. These networks present the miracle seed hybrid maize to farmers in the form of a package that consists of seed and at least fertiliser together with a whole series of other technical recommendations on how to plough and plant. The package is accompanied by a necessary set of institutional arrangements such as advice (or extension) to secure adoption of the innovation, and markets for seed, fertiliser, output, capital and machinery. If the end-user (the farmer) reads the 'script' or unpacks the black box, thus altering the set of prescriptions – by for example not buying fresh seed every year but recycling from previous harvest – yields will drop dramatically (by up to 70%). In such circumstances the miracle seed is thus not 'a configuration that works' (Rip and Kemp, 1998: 330; Hebinck, 1995). This institutional environment – once conceptualised by Benvenutti (1982) as the Technico-Administrative Task Environment (TATE) - also sanctions those who re-open the black box by labelling farmers that do not comply with the prescriptions as 'laggards' (see also Röling *et al.*, 1973; Röling and Leeuwis, this book). In turn it may be argued that the institutional environment for agriculture is also certified. If, like in most parts of Africa, such institutional arrangements collapse, the so-called 'agrarian crisis' will be on the doorstep, messing up the adoption of technologies and stimulating processes of distancing rather than interlocking.[4]

[4] The set of institutions and arrangements has been criticised again by representatives of new institutional economics of failure, and of being inefficient and ineffective. Structural adjustments and

Synthesis: socio-technological regimes

It may be clear from the above that the early rather deterministic perspectives on technology development and change are inadequate in that they cannot not properly handle the position and influence of the so-called end-users. The same can be said about Kloppenburg's social constructivist explanatory scheme that seemingly only incorporates the technologists and their interests per se. The advantage of the actor network theory is that artefacts and end-users, given their emphasis on processes of translation, come to play a central role in explaining technological change).

Despite the criticism on the actor-network theory (van den Belt, unpublished; Rip and Kemp, 1998), I propose a synthesis of the two schools of thought. Van den Belt (*ibid*: 11) wishes to enrich the social constructivist perspective '*with the insight from the actor network theory that scientists and technologists often act as agents of social change, without giving up the possibility of providing 'social explanations' for their actions*'. This puts network builders and their interests, networks, institutions and social relationships at the forefront of understanding technology and change. The discourses of the network builders are then essential elements in a strategy to market the innovations and to ensure uptake by the 'end-users'. Rip and Kemp (1998) warn against viewing technological change through technology, technologists or artefact alone and propose to incorporate the social environment with its own dynamics that have already shaped opportunities and ideas about new technologies. They therefore formulated the twin concepts of (socio-) technological regimes and landscape. The landscape forms the broader socio-technical and institutional context for the regime(s). It involves policy discourses of the state such as technological progress and modernisation that target the further development of specific technology trajectories and that fit the vanguard farm in the Netherlands (van der Ploeg, 1999) or the estate or telephone farmers in Kenya (Hebinck, 1990).

A socio-technological regime is defined as '*the rule-set or grammar embedded in a complex of engineering practices, production process technologies, product characteristics, skills and procedures, ways of handling relevant artefacts and persons, ways of defining problems – all of them embedded in institutions and infrastructures.*' (Rip and Kemp, *ibid*: 338). Regimes structure or guide the search activities of engineers, and incorporate farmers and their specific ways of handling the technology - be it adoption, adaptation, or redesigning - into the field of agriculture: '*Regimes are outcomes of earlier changes, and they structure subsequent change. Novelty (or innovations) evolves within existing regimes starting at the level of local practices (e.g. the micro level). It spreads over time, partly by accommodating to existing regimes; eventually it may irreversibly transform the socio-technical landscape*' (*ibid*: 338).

Socio-technical regimes should in fact be conceptualised as multiple or heterogeneous regimes (Geels and Kemp, 2000: 17). I will argue in this chapter that such definition is essential for understanding technological change. Technological change occurs both '*from within*' as well as '*from below*'. The

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institutional reforms such as deregulation of state controlled markets are required to get 'development' going and to 'get the prices right'. An argument exists for abolishing state controlled markets as these have been rather inefficient and tend to favour certain groups in society. In my understanding, however, the deregulation of the Kenyan food and export crop markets has created more chaos then ever, particularly for agriculturists that specialise in one or two commodities.

example of OPV maize breeding referred to earlier is, in a technical sense, clearly an example of change 'from within'. The currently increasing emphasis on OPVs echoes the changes in scenario that have been occurring in technology development since the early days of the Green Revolution, and not only within NGO-like networks, but also within CYMMIT. CYMMIT, once the temple of the hybrid High Priests now progressively allocates core funding to breeding OPVs (CIMMYT, 1999, 2001). Furthermore, a CIMMYT maize breeder in Harare argued in an interview that the context particularly in Africa has dramatically changed. '*Solving problems requires investment*', but '*world-wide agricultural research funding is decreasing*' (August 2001, *pers.com*). Furthermore, due to free trade, the deregulation of seed market and privatisation, the seed market is markedly different from what it was during the early days of the Green Revolution. The explanation that is offered is that '*new contexts that we need to adjust to*'. The change of CIMMYT is not only due to the 'internal' adjustments, whereby the position of Director General is very important. Things may have changed considerably but '*the old guys are still there*'. Reference was specifically made to the founding father of the Green Revolution and Nobel Price winner Norman Borlaug. 'External' pressure also played an enormous important role. '*In the past we were not challenged by the social, economic and political environment.*'

A clear illustration of CIMMYT strategic changes, now more than ever before, is the development of linkage programmes and networking. CIMMYT clearly looks for strategic alliances with farmers, the public sector, private seed companies, other elements from the private sector such as distributors and retailers to select, breed and distribute maize seed. The '*Mother-Baby*' trials in Zimbabwe and the leaflet '*Farmer Voices Heard*' is an expression of this.

Technological change 'from below', that is from the perspective of the farmer, his wife, the family, the farm, and/or the field(s) befalls at what Rip and Kemp (1998) and Geels and Kemp (2000) call the 'niche'. The niche may very well be the level where alternative technologies are developed, some of them giving rise to the emergence of new regimes that co-exist with the predominant regime. These niches may challenge the predominant regime (pressure 'from below') which is rather static, inert and entrenched. Geels and Kemp (*ibid:* 17) argue that an important difference between regimes and niches is that different social processes are involved. The regime is characterised by relatively stable networks, which manage to constantly reproduce themselves. Within these networks, the direction of technological processes and progress is relatively clear cut and beyond dispute. The niches, on the other hand, are formed by less stable networks in which a variety of experiments are carried out that enforce debates and negotiations. In niches, the learning processes are open-ended and less obvious, progress is made through trial and error, and there is no dominant design. Furthermore, the development of niches depends on the willingness to exchange experiences.

The concept of the socio-technical regime has several advantages above earlier frameworks and provides the dynamic optic on processes of (technological) change that Long has been arguing for. Firstly, the concept links and connects technology with society: technology is socially embedded and evolves in a social context, hence *co-evolution* or *co-production* (Hebinck and van der Ploeg, 2001). It thus captures both the technologist and the end-user, allowing for an analysis

of their relationships and struggles, and thus the encounters between the various bodies of knowledge actors refer to when designing and evaluating technological innovations. Secondly, it provides insights into how technological change proceeds. Technological change does not follow certain trajectories predetermined by the technologists (as Kloppenburg wants us to believe) but can, and often does, chaotically follow different trajectories. In earlier publications (Hebinck, 1990, 1995), I elaborated on this by emphasising that farmers (always) redesign technological innovations which in turn gives rise to differentiated patterns of agricultural development that may provide a seedbed for changes to regimes 'from within' or 'from below'. This is in line with Long's view that agricultural '*development is many sided, complex and often contradictory in nature*' (Long and van der Ploeg, 1988: 37) and that '*no single ordering principle prevails*' (Long, 2001: 241). This '*definitive adieu to structure as explanans*' (Long and van der Ploeg, 1994: 80) is important for an understanding of technological change, its continuities and discontinuities, and the co-existence of socio-technological regimes and niches that sometimes interact and sometimes don't. Thirdly, the concept of the socio-technical regime builds upon notions like networks and their builders, and processes of enrolment. Network interactions and institutional configurations sustain and reproduce technological regimes (and niches as well). Networks are perceived as fluid, dynamic, and constituted by multiple actors. Hence, the use of the notion socio-technical networks as a useful tool for the analysis of the generation and spread of innovations (see Hebinck and Mango, forthcoming). This also implies that innovations or novelties are not stemming from laboratories and research stations only. Fourthly, the notion of socio-technical regime specifically includes the cultural dimensions of technological change and positions culture analytically as part of a complex set of social relations of production that shapes agricultural practices (Hebinck and van der Ploeg, 1997). Cultural repertoires - or grammar as Rip and Kemp (1998) put it – of designers and end-users form an essential component of regimes and niches. In this way, culturally embedded norms and values occupy a central place in the analysis of technological change.

The maize landscape in Kenya

This section will investigate the concrete shape the Kenyan maize landscape has assumed. What one might expect is the co-existence of various regimes, and that the predominant regime is increasingly evolving into different trajectories. The various maize breeding strategies are, next to the institutional configurations, important dimensions to consider. The predominant maize regime is, for the time being, labelled as 'modern' or 'formal' and based on hybrid maize breeding and selection, and the other regime is referred to as the niche or 'informal' one, which is based on the selection and breeding of local or landraces of maize varieties. Both will shortly be characterised with a focus on the dynamics of network configurations and the network builders. In the concluding section we will come back to heterogeneity, social interactions and the knowledge encounters.

The modern hybrid maize regime in Kenya

The current hybrid maize regime is an outcome of earlier breeding programmes that took place in Kenya during the colonial era. Maize breeding goes back to the early 1930s and gained momentum after 1955 (Ogada, 1969) when according to KARI, sources from 'local' germplasm collected from around Kitale formed the *Kitale Station Maize*. Ogada (1969) and Harrison (1970) refer to this as the Kenya Flat White. The origin of these so-called local varieties is traced back to South Africa, where they were introduced before the Boer War from Mexico via the United States. Collections were also made from the highlands of Central and South America for crossing with Kenyan local varieties. A cross between Kitale Synthetic II and Ecuador 573 varieties produced the first varietal cross hybrid H611 released in 1964. The release of the first hybrid signalled the beginning of a major transformation of the socio-technical regime that has evolved to constitute a complex network of seed companies and agricultural research institutions. This network runs on the insights and advances of agrarian science - and in particular - plant breeding, credit agencies, extension, foreign aid agencies, a quality control institute, numerous input suppliers and output traders, and farmers that have adopted the new hybrids. In the literature it is often referred to as the Green Revolution, which according to the World Bank, is a success story for Kenya and Africa (Douglas, 1980). Important network builders were maize breeders such as Michael Harrison - the 'father' of hybrid maize in Kenya - and the Dutchman Cees van den Burg who was the first managing director of the then state owned Kenya Seed Company that was established in 1956 in Kitale, the 'capital' of the White Highlands. KSC played a crucial role in the breeding, multiplication and commercialisation of hybrid maize.

In the early days of regime formation the state was also a contributing network builders and provided the regime with important legal, policy and political support frameworks. The development of the seed industry required a clear and enabling legal framework. The state enacted the Seed Ordinance in 1962, which was a copy of British law. When it appeared that this act did not address the development of the Kenyan seed industry, various revisions were made in 1972 - the Kenya Seed Legislation (1972), in 1991 - the Seed Regulations, and in 1994 – the Plant Breeder's Rights Regulations. The recent liberalisation of the seed market (during the mid-1990s) and the subsequent privatisation of the Kenya Seed Company called for clear regulations to facilitate orderly operations of seed certification and control as well as the registration of breeders' rights. The Seed and Plant Variety Act was gazetted in 1991 and revised and enacted in 1998.

One factor that played a crucial role was that around 1963, Kenya's estate producers yielded in excess of the domestic demand for maize. World market prices were, however, low at the time and considerable losses were faced. The area under maize cultivation in the estate sector fell by 50% and smallholder deliveries to the Maize and Produce Board fell by 60%. A government commission advised the production of maize solely for the home market until the widespread use of improved seeds and better husbandry practices could bring down costs and close the gap between the producer and international prices. The following year, the introduction of a new, improved and higher yielding seed variety would begin to bring these recommendations about (Government of Kenya, 1965: 46; Gerhart, 1976: 47; Leys, 1975: 106). Supported politically by agricultural and food policies to attain food security for the nation, the state

mustered backing for the reorganisation (or modernisation) of the older, preceding maize regime. Previously existing state institutions created during the colonial era - notably since the implementation of the Swynnerton Plan of the mid 1950's - were geared towards increasing the participation of African producers in the commodity economy, something which they had been denied before. The Swynnerton Plan proclaimed an agrarian revolution, finally destroying all elements of former colonial agricultural policies. More importantly, perhaps, the Swynnerton Plan provided the state with the legal means to realise the development of a technological-administrative structure upon which commodity production could expand. The majority of institutions that formed the core of the technological regime were mainly concentrated within the state apparatus. This not only resulted in the envisaged expansion of commodity production by small-scale African producers through the privatisation of land tenure, the extension of capital loans, extension services and provision of inputs. It also, very significantly, resulted in the political integration of these producers and an extension of state control into areas, which had previously had very little contact with commoditisation processes. The hybridisation of maize in particular signals, in a way, a further transformation of the existing technological regime based on the Swynnerton Plan into one that commoditised food production, particularly maize.

Foreign aid has played an essential role in the formation and further development of the maize regime in Kenya. Various donors like the Government of the Netherlands have provided support for the modernisation of some of the components of the technological regime. Dutch foreign aid was (until recently) channelled to Kenya almost immediately after Independence in 1963 to shape the maize seed industry - both the legal and seed control and certification components - in such a way that it would operate effectively and efficiently (see Klaassens, *et al.*, 2001). USAID and CYMMIT have also channelled a lot of support to maize breeding in Kenya since Independence. This kind of support has assisted the formation of intensive networks linking both international and national institutions in (maize) breeding with Kenyan partners such as KSC, Kenya Agricultural Research Institute (formed in 1986) and its various regional research centres, and the Kenya Plant Health Inspectorate Services.

The Kenyan State has also performed an important role in other ways. General agricultural policies and national food policies, revised and refocused many times since Independence, have provided the policy frameworks for the maize regime. Policy mechanisms and instruments to achieve the stated objectives and budget allocations to research and extension have had political backing, both at the level of state institutions and the bureaucracy, as well as from Kenya's ruling elite. State control over the agricultural economy - a heritage from the colonial period - was omnipotent and even further extended. State control has covered domains like marketing through statutory boards (like the National Cereals and Produce Board), input provision (through the Kenya Farmer Union and other co-operatives that politically controlled by the state) and controls of inputs and farm gate prices. While it may be argued that state control was (with some exceptions) rather effective in the early days of regime formation, it collapsed almost completely in the 1990s. State administered social change through the co-operative movement and the Co-operative Act, which by many was perceived as repressive, took away decisions in the running of co-operatives from its members

into the hands of civil servants appointed to implement the act. Co-operative marketing structures in coffee and milk and the administering of agricultural credits weakened considerably. Some of these co-operative structures virtually ceased to exist, and services were not rendered any longer. Currently, the role of the state is reduced enormously after donor imposed Structural Adjustment Policies to rationalise its operations and due to economic liberalisation. Donor support has dwindled because of corruption and nepotism with the result that budget support and foreign aid relations in the field of research and extensions have been terminated. The outcome of this is that agricultural extension (almost entirely funded by the World Bank through its Training and Visit programme) and credit supply has almost collapsed. KSC no longer enjoys a monopoly in the seed industry and now has competitors.

An essential component and trait of the modern maize regime is the combination of agrarian sciences and its contributions to the design of the new maize technology. The result of the advances in scientific plant breeding, agronomy and soil sciences in Kenya culminated into a package. This can be considered as the most visible outcome of the modern maize regime. The package per se, including the image that hybrid maize is an economical crop to grow for farmers as it supposedly augments the returns to labour, is increasingly prescribing and shaping agricultural practices in such a way that it progressively operates within the domain spanned by markets and technology supply (Hebinck and Van der Ploeg, 1997). A major characteristic of the hybrid maize regime is that maize production is embedded in - and presupposes - the expansion of commodity relations, and more particularly the commoditisation of the objects of labour. The externalisation and institutionalisation of farm related tasks in specific institutions such as seed companies, financial institutions, extension services and advice, marketing bodies, seed quality control, and input distributors is imperative for this regime. The technology associated with the high-yielding maize varieties is not merely a package of physical inputs, it also incorporates a package of new agricultural practices. The new technology follows a new crop calendar, given the longer maturing period of the new maize varieties, the advice not to inter-crop with other food crops such as beans, and the associated changes in cropping patterns and crop rotation. Each of the 'new' inputs is associated with a new set of agricultural practices and recommendations. Farmers are now required to know how much seed to plant, when and how much fertiliser to apply on which type of soil and in what proportion of nitrogen, phosphorus, and potash. Similarly, the farmer must understand which type of seed is vulnerable to which type of pest, and what the various options of pest control are with varying implications for timing in the use of chemicals, human labour, crop pattern and rotations. Maintaining relationships with research and extension and other advice agencies thus plays an important role in the production of hybrid maize and the efficient operation of the maize technological regime.

Regime changes 'from within': recurrent selection of Open pollinated varieties

The discourse of modernisation - the only available option to increase food production via an increase of crop yields through the development and adoption of a capital intensive package consisting of hybrid maize, fertiliser and pesticides

– has gained substantial (if not predominant) ground in Kenya. Claims from farmers that local maize varieties do better and even out-perform hybrid maize varieties are met with suspicion and often rejected without serious investigation. Scientific knowledge is perceived as superior to local knowledge. While this is still the dominant thought, the maize landscape and the discourse has evolved and changed over the last 10 years in Kenya. Increasingly, OPVs are in pre-lease and/or waiting for release pending the approval of KEPHIS and the outcomes of the National Performance Trials that are compulsory by Kenyan law (KEPHIS, 1999:9-12). Recently, some NGO-like institutions such as CARE-Kenya and Lagrotech have started breeding programmes that are quite different from the ones linked to the formal research and breeding networks in the country or elsewhere in the world.

A group of plant breeders in West Kenya launched a seed company, Lagrotech, and set out to develop a composite variety of maize that is high yielding but requires little inputs. Starting from local land races such as the *Hamisi Double Cobber* - a farmer improved local variety from the Vihiga District in West Kenya - Lagrotech developed the *Maseno Double Cobber* (MDC) and released it in 1996. The MDC is high yielding and produces two cobs with little commoditised inputs. Lagrotech recommends the use of inorganic fertilisers as well. Farmers can regenerate seeds up to the third filial generation beyond which yield starts to decline. This is a major difference and advantage compared with hybrids, particular in areas where access to money is problematic. The MDC and other OPVs are the outcome of the motivation that a '*researcher' task is to solve problems*' as a CYMMIT maize breeder in Zimbabwe coined it (*pers. com.* August 2001). The principal breeder of Lagrotech: '*researchers who claim that their work is relevant for improvement of agriculture in the tropics should (...) put them in practice. It is on this basis that Lagrotech tries to come up with a maize variety that will be acceptable to my people.*'

Maize breeders of KARI regional centres, i.e. Kitale, Kakamega and Katumani particularly are currently more engaged than ever before in recurrent selection of OPVs. Breeders increasingly engage now in on-farm trials and testing, and taking on board farmer preferences. This change within KARI was set in motion since the early 1990s and is partly the result of 'internal' changes pushed by a younger generation of scientists. It is also partly due to donor funded programmes specifically aimed to move KARI from on-station to on-farm and adaptive research. However, it must be recalled that in the early 1970s farming systems research was periodically carried out together with foreign donor funded programmes (see Klaassens, *et al.* 2001).

The MDC is Lagrotech's response to the phenomena that hybrid maize is no longer widely grown in the region. Lagrotech packages the MDC in 2-kg polythene packets and sells it to farmers at much lower prices than the hybrid varieties. Between 1996 and 1998, farmers in Luo land were very enthusiastic about this maize variety. Later they came to learn that its yield declines as they continue to reproduce it. Farmers, on the other hand, feel that it is a better option than the normal hybrid, as it requires little inputs, but they continue to look for more stable local varieties whose yields do not decline over time.

Most of the OPVs are early maturing, resistant to maize streak virus, suitable for green maize production, and flinty grain types. Hybrids generally do not have

such characteristics. Evaluations of the OPVs have shown that the economic returns, particularly when grown in harsh environments, therefore match that of the more expensive hybrid seed (ref. CYMMIT leaflet *New Maize offer better livelihoods for poor farmers*, 2001 announcing the release of OPVs for the Southern African region). Breeding, and above all, the multiplication and marketing of OPVs does come without problems though. Private seed companies are not interested (or are prohibited to engage) in multiplying OPVs. One of the challenges is to set up a proper system of seed production, distribution, marketing, retailing and quality control. These ideas centre on setting up small seed businesses and/or community based organisations. It must be noted that the experiences with community based seed programmes shows that these issues are not easy to solve. Stability and reliability is what hampers organisations of this type and corresponds with the interpretation of niches by Geels and Kemp (1998). Another important issue is that OPV breeding is based on genetic variation, through cross-pollination and recycling. Maintaining genetic variation and accessing genetic material is hence crucial. One of the problems for Africa may be that maize is a recent crop, which implies that naturally present variation (as in the Vavilov centres of Central America) is somewhat limited. It may be argued that the OPV programme is meant to supplement or improve the lack of genetic variation in Africa. In the next section we will elaborate on this as farmers in Luo land argue otherwise.

One important trait of the OPV breeders is the strong belief in the superiority of scientific breeding principles. It is maintained that OPVs yield approx. 30% - 50% more than 'traditional' varieties (or landraces), particularly under drought conditions and low soil fertility, e.g. '*two of the factors that commonly keep farmers in a cycle of poverty*' (CIMMYT leaflet). Interviews with various maize breeders support this predominant view. Reference is made to the inability of farmers to identify superior genotypes from the phenotypic appearance of maize cobs.

Recurrent mass selection[5]

Maize is a typical open pollinated crop (this is one of the reasons that multiplication of hybrid maize needs to take place in 'clean' environments). In an open field, each plant has a different genetic composition with different individual characteristics. In practice, a farmer chooses seed from desirable individual plants or cobs. The seed from these different plants are shelled, mixed, stored and planted *en mass* to produce the next generation. This is done by practically all of the farmers who select their own seeds for the next season. Through mass selection, other farmers produce their own local maize seeds, some of which have proved to perform better with minimal physical inputs than hybrid maize. Farmers generally select and breed maize seed that matures early, can be grown under conditions of unstable rainfall, is pest resistant, has an ability to yield when cultivated even without inorganic fertilisers, and agrees with specific end uses such as taste and palatability.

The yearly mass selection of seeds from the previous year's harvest means that landraces or local maize varieties are in a process of continuous change. The

[5] This section is partly based on Hebinck and Mango (forthcoming).

actual selection of seeds for the coming season begins in the field and the selected cobs are partially dehusked and then hung in the kitchen above the fireplace. This selection is based on *phenotypic* characteristics of the maize stalk and the cobs. Only the large regular cobs are selected for seeds, and only the seeds from the middle part of the spindle are used for sowing. Mass selection is effective in increasing gene frequencies for easily measurable characteristics such as plant type, maturity, grain characteristics, disease tolerance, tolerance to drought and strength of the stalk. It is therefore relatively easy for farmers to select for traits like large cobs, early maturity and other easily recognisable characteristics such as colour, taste and palatability.

James Otieno Okatch, from Nyamninia village in the Luo region east of Lake Victoria, is one such farmer who generates his own maize seeds. West Kenya is known for its local maize varieties. The story of Otieno and his *zero-type* is rather telling in that it shows the dynamics and particularities of a niche co-existing with the predominant socio-technical regime, which is based on mass selecting and breeding of maize seeds. After his mothers' death in 1989, his wife remained at home to continue with the farming activities that his mother had been carrying out. It was in this year that they planted hybrid maize for the first time. He is the eldest son among three brothers, so it was imperative that he had to *golo kodhi* (this is the principle that the eldest family member in the compound - usually a male - sows first) before the families of the other brothers. In accordance with the principle of *golo kodhi,* he had to use family seed and was therefore obliged to use the old seed his mother had been keeping. He was lucky to find them hanging above the fireplace in his mother's kitchen and he used them along side of the hybrid maize. Since he owns many African *zebu* cattle he had enough manure to not have to buy fertiliser. After planting and settling his wife at home, he decided to report back to his work in Nairobi. The performance of the family seed that they got from their mother's kitchen compared to the hybrid maize they had planted was astonishing. Since nobody knew exactly what type of maize variety it was, Otieno gave it a name, *zero-type*. Nelson Mango and I visited Otieno's homestead in 1997 during one our maize variety collection tours in the region. While pointing at the samples of maize that we held in our hand, he gave us one of his zero-type cobs and said '*look here. See for yourself. This cob is much bigger than the hybrid you have in your hand. So what is your judgement?*'

In 1991 Otieno retired and returned to his homestead. He is very proud of his zero-type maize, and shows it to everyone who visits him or is interested in farming. This maize does very well with organic manure alone and *striga* is virtually absent. Most villagers buy these seeds from him and try them out. However the majority of them lost their zero-type seed during the so-called hunger period when much of it was consumed instead of stored. His brother Erasto Muga is not part of the exchange. He kept seed received from Otieno but like the other farmers, lost them through consumption. Otieno was no longer willing to give his brother more seed because he thought Erasto was lazy. Erasto died in 1998 and Erasto's wives now plant local yellow maize instead.

Otieno generates these seeds through mass selection, which begins in the field. First he looks at the stem, which should be big and strong. Then he looks for stems and leaves that should be big and healthy. The cobs of the maize should be drooping downwards after attaining physiological maturity (after the grains have

reached dough stage). This, says Otieno, ensures that water cannot get into the cob when the maize is left in the field to dry. The cob should not be opened to expose the grains to pest attack and no water should get inside. The maize stalk should have prop roots up to the third node above the ground to resist lodging. Finally, the spindle of the maize should not have less than twelve lines and should be well filled with grain. Otieno learned these selection techniques from his parents. He does not know much about hybrids prefers sticking to the family seed. Through yearly mass selection, Otieno has managed to maintain the zero type successfully. Like many other farmers, Otieno does not preserve the seed with chemicals but rather ash burnt from dry cattle dung or from sedges, which grow in swampy places down the river.

Farmers like Otieno compare their local varieties - at least 20 varieties exist in the region (Hebinck and Mango, forthcoming) – each with different names and different traits, including hybrids. Apart from yield and yield stability, the farmers narrate that hybrid maize lodges more than local varieties of maize, that the cobs from hybrids open easily resulting in cob rot and bird damage, that they are less resistant to weeds, pests, diseases and suddenly changing weather conditions. They also argue that hybrid maize is too long maturing. Local maize is preferred because of all of the above-mentioned characteristics. Besides, it tastes much better.

The virtues of the zero-type are explained by the villagers with reference to Otieno's late mother. The villagers keep on telling Otieno that this superior seed was a blessing from his late mother because he fed his visitors well during the funeral. There was enough beer and food. The elders were pleased with Otieno, as '*he did not tie money to his pockets.*' Before drinking beer they poured a little portion of it on the ground to honour Otieno's ancestors. This, according to them, had obviously had a good effect on the family seed that Otieno had been using since then. The elders in their explanations would keep referring to the importance of upholding the *golo kodhi* principle. *Golo kodhi* does not only guarantee a good yield, but also strengthens the authority of the elders over the younger generation.

Conclusions

The maize landscape in Kenya has evolved around different social processes, repertoires, experiences and commitments, and represents different bodies of knowledge as is apparent in the varying ways in which maize is selected, bred, multiplied and exchanged. Whereas hybrids and OPVs progressed from the application of agrarian sciences, albeit in different ways, the local maize is embedded in local knowledge passed on from one generation to another and shaped by local cultural repertoires such as *Golo Kodhi*. The 'modern' regime is typified by relatively stable and global networks, which manage to constantly reproduce themselves. The direction of technological processes and progress is relatively clear-cut, contained in scripts, and relatively beyond dispute in agrarian sciences. This goes for both the hybrid and the OPV way of breeding: both are embedded in the principles of agrarian sciences. OPV breeders, though, increasingly challenge the hybrid maize breeders, giving rise to changes in regimes 'from within'.

The direction of the mass selection and breeding practices, on the other hand, is less clear and more open ended. The networks are localised, based on experimentation and a dominant design and script is absent. Its development in the long run depends most probably on the willingness to exchange experiences. In contrast to the 'modern' regime, the dynamics of the niche are such that a mass of options have emerged over time, which are part and parcel of the cultural, social, institutional and environmental context in which it evolves. The 'modern' hybrid maize regime in contrast offers limited choices.

Typical for the regimes and niches is that the network builders - be they Borlaug, Harrison, Lagrotech breeders or James Otieno - claim their success and work to be relevant for the 'nation' and its people. Most interesting is that local knowledge repertoires clearly question *and* contest scientific knowledge. Claims made by experts that their products are higher yielding are immediately counter-claimed by local farmers such as Otieno arguing that local maize tastes better, has nicer colours and out yields hybrids. The mass selection and breeding of local maize has the advantage above OPVs and hybrids that technology development corresponds with the contexts of the users. Farmers certainly mention this as important if they compare local varieties with hybrids and OPVs. These issues point at knowledge encounters that are embedded in practices such as breeding, selection and cultural repertoires.

These encounters also take another specific form. The claims made remain largely assumed and there is very little effort in Kenya to scrutinise them individually. Farmers like Otieno are actually the only individuals who can rightfully claim to have tested a wide range of maize varieties over the years. This suggests that the various regimes and niches rarely interact, or as Long would formulate it: the knowledge encounters or knowledge interfaces involve *discontinuities* rather than *linkages*. This is apparent in the way hybrid maize proponents have always claimed success in Kenya despite empirical research which shows that it never managed to replace the local varieties, varieties that have been viewed as inferior to hybrids. Successes, measured only in terms of adoption rate, vary per region: in the Luo region it was still below 20% in 1973, while in the same year districts like Trans Nzoia, Kakamega and Nandi had reached an adoption rate of almost 100% (Gerhart 1976: 27; Hebinck, 1990). Recent research in the Luo region (Hebinck and Mango, forthcoming; Mango, 2002), however, indicates a sharp decline in the use of hybrids. Interestingly enough, an employee from KEPHIS in Kitale narrated in an interview I had in 1998 that the hybrid success story '*was based on forging data about adoption rates. The World Bank badly needed a success*', he said. '*Kenya was to be that good example and happily went along with it*'.

The different bodies of knowledge with regard to maize breeding that have emerged in Kenya over the years underpins Long's argument that processes of social transformation involve knowledge encounters and the co-existence of social forms such as socio-technical regimes. Heterogeneity is continuously produced and reproduced, providing (at least theoretically) a breeding ground for continuing experimentation and the enrichment of knowledge. Empirically, however, this may not be the case. Earlier in this chapter, reference was made to niches as social spaces where alternative technologies emerge and are developed: some of them, such as mass selection, may give rise to the emergence of new regimes that co-exist with and challenge the predominant regime. Despite being

a largely localised phenomenon, mass selection certainly has its dynamics and definitely has a role to play in solving issues of food security alongside the modern regimes of hybrids and OPVs. At a more abstract level, if its discourse is taken seriously, the experiences and dynamics of mass selection and breeding of local varieties will broaden the horizon of technology development. Geels and Kemp (2000: 55) refer to this as 'strategic niche management'. Given the discontinuities between this particular niche and the 'modern' regime, strategic management for the time being will have to remain with the localities themselves.

The particular niche discussed here also represents a critical phenomena of processes of social change taking place in the rural areas of Africa: processes that evolve around distancing from 'externally' driven socio-technical regimes, which have been established over the years. Distancing is part and parcel of the formation of 'new' or the re-continuation of socio-technical regimes. The conceptualisation of socio-technological regimes captures both stability (of the predominant regime) and changes (the dominant regime being challenged by others). This chapter attempted to explain this with reference to the various network configurations and the claims made. Notions like regimes and socio-technological change build upon heterogeneity: the co-existence of social forms of social, cultural, economic and technological evolution at any one point in time. The debate on the relationship between the actor and structure in social sciences can consequently be 'solved' with a conceptualisation of structure as being '*an extremely fluid set of emergent properties, which, on the one hand, results from interlocking, transformation and/or distantiation of various actor' projects while on the other hand, it functions as an important point of reference for further elaboration, negotiation and confrontation of actor projects*' (Long and Van der Ploeg, 1994: 81).

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