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Industrial Transformation and Agriculture: Agrobiodiversity Loss as Sustainability Problem

Franziska Wolff

1. Introduction

Despite leading a shadowy existence in the public biodiversity debate, the issue of the loss of agrobiodiversity is hotly debated in expert circles. A broad understanding of agrobiodiversity can be described as that part of biodiversity that contributes in the context of agriculture to nutrition, livelihoods and the maintenance of habitats. Its scope covers agricultural crops, productive livestock, raw materials, medical plants and animals used for transport. Agrobiodiversity is "man-made" biodiversity resulting from plant and animal breeding efforts. It highly threatened mostly by the spread of modern agriculture and the globalisation of food markets.

This article recognizes today's agrobiodiversity loss as a socio-ecological conflict and a second order problem (Jahn/Wehling 1998), as it significantly stems from earlier attempts to solve social problems (namely food insecurity in the early 20th century). By way of an extended policy-analysis it will be shown that beyond economic processes and technological developments, interest-formed policies and multi-level governance structures - especially intellectual property rights, sovereignty regimes as well as on seed trade and livestock breeding regulations - impact negatively on agrobiodiversity. Reflexive strategies will be necessary to overcome this sustainability problem characterised by structural uncertainty.

2. Industrial Transformation and agriculture

Industrial Transformation can be described as the changes in production and consumption patterns necessary on the path to sustainable development against the backdrop of complex society-environment interactions (Vellinga/Herb 1999). Despite the inclusion of the term "industrial", the concept certainly is not confined to the secondary, i.e. industrial sector: it has it's relevance for the primary sector of resource extraction and agriculture, too. This is valid particularly since the two sectors are interrelated to an ever increasing extent: Not only have soil and nature as prime production factors become increasingly substituted, but agricultural production has become intensely industrialized and integrated into the industrial production chain.

While the agricultural sector in the 19th century still disposed of a high autonomy via-a-vis the other economic sectors, today, most inputs such machines, fertilizers, seed, feedstuff and agricultural outputs are being manufactured industrially outside the actual agricultural sector (Bechmann 1990: 30, see also Ditt et al. 2001, Münkel 2000, Schulz 1996, Franz 1962). Production chains have become longer: food industry (which processes raw foodstuff industrially and demands standardised agricultural products to be easily treated by machines) and a highly concentrated trade sector hold a dominating position. With the politically promoted mechanisation of agriculture irreversible investment („sunk costs“) have escalated, and pressure has increased to compensate these costs by means of a higher productivity: i.e. through intensive land use systems, the use of machines, fertilisers and pesticides, monocultural cultivation - and the breeding of high yielding crops and high performing livestock. These processes have caused massive social and ecological effects, encompassing not only in a dramatically altered job profile of the farmer and a sinking job rate in agriculture but also unsustainable production and consumption patterns with impact among others on agrobiodiversity. For the breeding sector, the interrelatedness of policy, technological and environmental change as well as the need of Industrial Transformation will be described.

3. The concept of agrobiodiversity

The term agrobiodiversity has evolved only in recent years in the wake of the general biodiversity discourse, which really began in the 1980s. Analogous to the term biodiversity, agrobiodiversity encompasses different levels. It relates to the diversity of agro-ecosystems as well as that of species of crops and farm animals, and to the genetic variance within populations, varieties and races. In its broadest sense, agrobiodiversity also comprises soil organisms in cultivated areas, insects and fungi that promote good production, wild species from off-farm natural habitats as well as cultural and local knowledge of diversity and management forms as the basis of the exploitation of diversity (Thrupp 2001). This article focuses on species and genetic diversity.

Though the term agrobiodiversity emerged late, a wide intersection of the topic was already analysed under the term “genetic resources” in the 1960s when the FAO started to discuss the genetic foundations of plant breeding. Genetic resources for food and agriculture (GRFA), generally speaking, encompass the genetic material contained in (traditional and modern) plant varieties and farm animal species as well as well as in primitive and wild relatives that are used, or may be used, for the production of food and agriculture (FAO 1996a, 1999). The term of agrogenetic resources therefore not only embraces diversity in actual use, but also that of potential use and value (“latent diversity”, cf. Gollin/Smale 1999). They are the raw material from which new crop varieties and breeds are being developed.

During the last three decades the understanding of agrobiodiversity has developed from the recognition of the importance of genetic diversity, particularly for crops and an emphasis on the *ex situ* conservation of genetic resources in the 1970s, to the adoption of an *in situ*/on farm approach where plants and animals are kept in natural surroundings or used within agricultural production systems in the 1990s. Finally, agrobiodiversity thinking has become embedded in an integrated, holistic agro-ecosystem approach (Aarnink et al. 1998).

4. From riches to risk

While in animal breeding genetic erosion is conceded by most relevant actors, with respect to plants the diagnosis of agrobiodiversity loss is not undisputed. The plant breeding industry e.g. stresses that “although the visible diversity in farmers’ fields may have been reduced, the diversity of valuable genes has been increased by introgression of new materials” (ASSINSEL 1996). Not only does the analysis vary according to the level of diversity analysed (genetic, species, ecosystem), but also according to the measures of diversity and the methods of analysis employed. However, the following data and assessments can be considered reliable. In the report on the “State of the World’s Plant Genetic Resources for Food and Agriculture (PGRFA)”, the FAO (1996) describes as “substantial” the loss in diversity of plant genetic resources for food and agriculture (PGRFA) including the disappearance of species, plant varieties and gene complexes (“genetic erosion”). World nutrition today is mainly based on a mere ten crops. For Germany it is estimated that, compared to the first half of the twentieth century, 75 percent of cultivated plants in agriculture and horticulture have disappeared (UBA 2002: 403); in some areas “genetic erosion” is even supposed to have reached over 90 percent (TAB 1998). Similar processes have been taking place globally from the mid nineteenth century onwards (GTZ 2000). Concerning livestock, half of the breeds that existed in Europe at the turn of the century have become extinct; a third of the remaining 770 breeds are severely endangered. In Germany only 5 out of at least 35 indigenous breeds of cattle remain. The FAO predicts that worldwide 28 percent of livestock breeds are currently at risk of extinction (FAO 1993).

5. Agrobiodiversity loss as sustainability problem

Sustainability problems can be defined as conflicts with a social, ecological and an economic dimension both in terms of causes and impacts. However, they can also be defined structurally via their reflexive nature and the underlying interaction between social, ecological and technological change. All three approaches will be applied here.

5.1. The impacts

Why is agrobiodiversity loss problematic at all? This question will be answered with respect to the social, ecological and economic impacts that characterise agrobiodiversity loss as a sustainability problem.

In terms of its ecological dimension, the loss of robust cops and livestock adapted to their surrounding eco-systems (soil, climate) and the subsequent use of genetically homogenous high yield varieties and high performance animals (kept in high-tech sheds) makes necessary numerous unecological inputs: These varieties and races are not only more vulnerable, often prone to diseases caused by breeding (“burn out syndrome”), but they dependent on high and stable inputs of (fossil) energy, fertilizers and pesticides in the case of plants, and food, energy, and pharmaceuticals in the case of animals. The loss of locally adapted traditional varieties and races also impacts on the surrounding eco-system and wild biodiversity. On the other hand, the protection of landraces and indigenous livestock breeds is worthwhile despite their lower yields since they often possess valuable traits such as disease and pest resistance and are better adapted to harsh conditions and poor quality feed, which are qualities desirable for low-input, sustainable agriculture.

In terms of social impacts, the loss of genetic resources poses a threat to food security. Genetic resources, along with soil and water, constitute the foundation upon which agriculture and world food security are based (FAO 1996: 6). The destruction of the diversity of these resources not only increases vulnerability in terms of animal diseases, pests and harvest failures, but it also undermines the foundations of future breeding and development paths. Beyond the immediate uses of agrobiodiversity as described above (relevance to nutrition, livelihoods, habitats), agrobiodiversity is important to preserve possible future development paths: Genetic diversity found in domestic animal breeds and plant varieties allows farmers and breeders to select stocks or develop new breeds and varieties in response to changes in the environment, threats of disease, new knowledge of human nutrition requirements, changing market conditions and societal needs, all of which are largely unpredictable. A second social dimension of agrobiodiversity loss is the equity issue. It becomes relevant in relation to property rights regulating the balance between farmers and agribusiness, and in relation to the distribution of benefits between agrobiodiversity rich countries in the South and industrial countries in the North appropriating the returns when utilizing these resources.

Finally, agrobiodiversity loss also has economic impacts: the genetic, species and agro-ecosystems variety protects against vulnerability to e.g. climate stress, insect pests and diseases that can devastate a uniform crop, especially on large plantations. There are famous examples of economic disasters springing from 'genetic monoculture' such as the 19th century Irish potato famine and the US pest "Corn Leaf Blight" in 1969. With farm animals, too, lacking genetic diversity impedes adaptation to diseases, parasites, or variations in the availability and quality of food. Thus, agrobiodiversity loss increases the economic risks for individual farmers and can undermine the stability both of agriculture and the food business (Thrupp 1997).

5.2. The causes

The causes of agrobiodiversity loss are manifold and interrelated. The economic development, above all the spread of modern, commercial agriculture and intensive, high-input production systems features as prime driver of diversity decrease, putting native varieties and breeds at risk (FAO 1996a: 13, FAO 2003). Native varieties and breeds are substituted with high-yielding crops and breeds that no longer need to be adapted to natural (climate, soil etc.) conditions, since machinery, irrigation, fertilizers and pharmaceuticals homogenize habitats (in a both costly and environmentally harmful way). In developing countries, this process has been reinforced by a donor policy that has promoted the import of exotic breeds and crossbreeding and that threatens the survival of local breeds (Geerlings et al. 2002: 6). Both the markets for agricultural inputs and for agricultural outputs have been increasing in size, thus feeding into a globalising food market that demands goods in huge consignments. In order to process them industrially, those agricultural goods need to be homogenous. Therefore, apart from the yields it is the requirements of industrial cultivation, husbandry and processing (and to some extent consumer demand) that determine the breeding objectives rather then nutritional value, taste, improved stress resistance or adaptation to natural conditions.

A second driver of agrobiodiversity loss is seen in the technological realm. Modern, highly selective breeding methods contribute to the problem by making possible dangerous degrees of homogenisation. In livestock breeding e.g. artificial insemination, multiple ovulation and embryo transfer are applied to reproduce only a few top performers; a huge number of other individuals are thus excluded from breeding and the genetic distance within populations is correspondingly reduced. Hybrid breeding, with both animals (e.g. poultry, pigs) and plants (e.g. corn, rice), and in the future cloning are methods used to reproduce genetically homogenous and high performing livestock and plant varieties. In the case of animals, impacts on the genetic pool are expected when traditional pure breeding gets replaced by the modern methods (Wetterich 2001: pp. 45). Also, since hybrid breeding produces infertile breeds and seed farmers cannot use the material to continue breeding/growing according to their own selection preferences, they have to instead content themselves with commercially bred/grown livestock and seeds, which they even have to buy again every year. In plant breeding, 'Genetic Use Restriction Technologies' (GURTs) have the same effect.

In the social and political realm, policies and legal regimes contribute to agrobiodiversity loss, such as breeding law and intellectual property regimes. In chapter 5, a selection of these factors is discussed in detail. Interrelated with these policy factors, conflicting societal interests and interpretations characterise the arena and hamper a conflict resolution. In plant breeding, the mere problem perception is contentious, as was mentioned above.

5.3. The structure

Structurally, agrobiodiversity constitutes a genuine socio-ecological constellation: As opposed to wild biodiversity, agrobiodiversity (for the most part) is characterised by the proximate interaction between natural 'material' and human action. The diversity of productive livestock and crops is the result of a century of human breeding efforts based on locally differentiated resources. It reflects the diversity of various agricultural production systems and their cultural and social dependency. Also, the development (as well as the destruction) of agrobiodiversity is closely related to the human knowledge of cultivation and husbandry as well as the emergence of different breeding techniques and technologies. Maintenance of agrobiodiversity, too, is inseparably linked to the use and utilisation of crops and livestock by humans - unlike with wild biodiversity, protection in the sense of 'leaving it alone' does not suffice.

Besides the socio-ecological structure, agrobiodiversity loss like many other sustainability problems is characterised by a reflexive nature: A substantial part of the problem can be described as being caused by the unintended feedback of a previous problem solving strategy. Specifically, it was the post-war policy of food security that aimed at alleviating food scarcity but as a side effect destroyed agrobiodiversity. It massively promoted the industrialization of agriculture, first in the developed nations (e.g. through the EC Common Agricultural Policy) and later in developing countries. The "Green Revolution" - the political push for the introduction of high yield crops, irrigation, fertilizers, pesticides and mechanization from the 1960s on - aimed at closing the so-called 'development-gap' between the South and North. The model of food security not only led to major increases in production output, but also contributed - among other factors - to the global homogenising of production structures and market conditions. Agrobiodiversity loss thus can be considered a "second-order problem" (Jahn/Wehling 1998), to the extent that it is at least partly caused by efforts to solve (other) problems. The efforts have led, as a result, to the reduction of the fundamentals of agricultural production: agrobiodiversity. The development, therefore, is paradoxical: the result of breeding for a high yield and homogeneity for "food security" destroys the race, species and genetic diversity and, therefore, the resources on which the breeding itself is established.

6. The role of policy regimes and governance structures

The economic and technological developments detrimental to agrobiodiversity (described in chapter 5.2) were partly supported by policies and governance structures such as intellectual property rights and sovereignty regimes that regulate access to and control over genetic resources as well as seed and livestock breeding law. Those have intentionally, or as side effects, supported the orientation towards high output and homogenisation, thus also affecting the choice of plants and livestock in agricultural use.

6.1. The regulation of access and control

Access to and control of plant and farm animal genetic resources is regulated by Intellectual Property Rights (IPRs) in the realm of private law and, in the context of public (international) law by sovereign rights of states (Kameri-Mbote/ Cullet 1999).

6.1.1. Intellectual property regimes

Breeding, particularly of plants, heavily relies on Intellectual Property Rights. The background of this can be found in the specialised nature of agricultural production and the fact that breeding involves a high amount of work as well as intellectual and financial efforts. Especially for new plant varieties (not so much for animals), breeders' returns are endangered by the biological possibility that farmers would reproduce the seeds. Without breeders' efforts, on the other hand, it is argued that the supply of agricultural production with high quality seeds would suffer (Wuesthoff et al. 1999: 96). Against this backdrop, in the early twentieth century intellectual property rights that originally applied to industrial inventions were merely extended to living matter to compensate breeders' efforts.

Two major IPR regimes can be distinguished that impact on agrobiodiversity in varying degrees: plant variety protection (PVP), applying only to plants, and patents.

Plant Variety Protection (PVP)

PVP systems have emerged in Europe from the late 1920s onwards. At the core of PVP are the so-called Plant Breeders' Rights (PBR), a specific form of Intellectual Property Right, which provides an exclusive right over the variety a breeder has developed. The main difference from patent protection lies in the restriction of PBRs to the concrete variety as a marketable product, while patents provide generic protection. In the 1960s an international harmonisation of national plant protection laws took place and the International Union for the Protection of New Varieties of Plants (UPOV) was founded. Today, with 53 member states (increasingly from the developing world, too) the UPOV Convention has become the international reference system for PVP.

Plant Breeders Rights require that anybody who (re-) produces, conditions, offers for sale, markets or imports/exports propagating material of the protected variety needs the authorization of the breeder, which the breeder may subject to conditions (usually royalties) and limitations. (Art. 14 UPOV Convention) The breeders rights are restricted by the so-called breeders' exemption and the farmers' privilege (Art. 15.1, 15.2), both of which were cut back in 1991. The breeder's exemption constitutes the right to use protected varieties for the breeding of other varieties and for experimental purposes, while the farmer's privilege refers to the farmer's right to save and re-use (formerly also to sell) harvested material. Depending on national implementation, the plant variety protection may cover all plant varieties and needs to last a minimum of twenty years (Art. 3, 19 UPOV Convention).

In two senses the plant variety protection system of UPOV can be seen as harmful to agrobiodiversity. Firstly, the criteria for variety protection - the so called "DUS requirements" on Distinctness, Uniformity/Homogeneity and Stability of new plant varieties - impact on plant variability. Secondly, it is argued that Plant Breeders Rights, like other IPRs have indirect effects on agrobiodiversity by restricting access to genetic resources.

Within the DUS requirements it is particularly the uniformity criterion (Art. 5 (1) iii, Art. 8 UPOV Convention) that meets with criticism. It aims at restricting genetic diversity within a plant variety, because in order to apply a Plant Breeder's Right it is necessary to unequivocally distinguish the variety from other varieties. This presupposes physical distinctiveness and uniformity, which disappear at the expense of significant genetic variability (Crucible Group 1994). In the field, uniform varieties are less able to buffer stress (diseases, lack of growth factors) without suffering major qualitative and quantitative losses (Léon 2002: 33). At the same time, the uniformity criterion precludes the protection of old landraces, which are frequently rich in genetic diversity within a variety (Dutfield 2000). From a broader perspective, the uniformity criterion is identified as a factor that makes PVP biased towards plant breeding for industrial agriculture (GRAIN 1999): Compliance with this criterion inclines breeders to develop varieties that have low adaptability and are highly adjusted to monocultural production systems for large markets. Contrary to this rationale, it is also argued that PBRs enhance genetic diversity because the introduction of PVP regimes has boosted the growing number and registration of new varieties (UPOV 2002). However, linking the number of licensed varieties and the degree of genetic diversity neglects the issue of genetic distance or the degree of relationship between varieties. Phenotypical diversity does not give evidence of the genetic diversity of a plant variety (Neumeier 1990: 231; Butler/Marion 1983: 72, Prall 1998).

The indirect impacts of PVP on agrobiodiversity result from the restricted access they determine. The breeders' authorisation to (re-) produce, condition or market propagating material means that the material is not freely (i.e. free of charge) accessible. For the breeder, the right, in the first place, increases the incentive for commercial plant breeding. Secondly, it promotes the development of varieties with the largest market potential. This leads to the predominance of major crops that are widely adapted across large areas and that feature characteristics that best meet the needs of commercial farmers and the marketing or processing industries (Crucible Group 1994). This impedes diversity. Therefore, the strengthening of PBRs in the 1991 UPOV revision is to be seen critically. PBRs have been strengthened with respect to the object of protection (extension to *all* plant genera and species), to the scope of protection (extension to 'essentially derived' varieties and to harvested material) as well as to the possibility for member states to grant patents on top of breeders' rights ('double protection'). At the same time, the Breeder's exemption was restricted. These revisions mostly go back to pressures resulting from the growing importance of biotechnology (Bragdon/Downes 1998: 20). A further indirect effect of PVP is that it probably reduces the flow of scientific information and germplasm from the private to the public sector (Butler 1996). This is due both to the private sector's interest in not having public competitors who develop varieties for public welfare as well as to the forced market orientation within public research institutes in times of scarce public funding.

Patents

Originally, patent law was not designed to apply to living matter, i.e. to material capable of self-reproduction or of being reproduced in a biological system. However, in the United States plant patents have been granted since the 1930s. Internationally, patent law is becoming more and more important with the growing relevance of biotechnological methods, in particular genetic engineering. The patenting of biological material is regulated in international patent law such as the WTO Agreement on Trade Related Intellectual Property Rights (TRIPs), the European Patent Convention (EPC) and the EC Biotechnology Patent Directive. The interpretation of these, however, led to a number of highly contentious questions. The TRIPs constitutes the international minimum standard for all WTO members. It codifies that member states need to provide patents "for any inventions, whether products or processes, *in all fields of technology*" (Art. 27 (1) TRIPs, italics added). At the same time, "plants and animals other than micro-organisms, and essentially biological processes for the production of plants or animals other than non-biological and microbiological processes" may be excluded from patentability in national legislation. However, states are bound to provide for the protection of plant varieties either by patents or by effective *sui gen-*

eris systems (e.g. plant variety protection, cf. Leskien/Flitner 1997) or a combination of the two regimes (Art. 27.3 (b) TRIPs). In the industrialized world, there is usually a lot less leeway in terms of legal coverage. In the EPC, patents in the field of biological matter are excluded merely for "plants or animal *varieties* or *essentially biological processes* for the production of plants or animals" (Art. 53 (b) EPC, italics added). This implies that plant and animal components such as genes, gene sequences or cells, individual plants/animals as well as certain (non-microbiological) processes actually are patentable. The patent exemption on plant and animal varieties as well is being watered down by the European Patent Office judicature. In the EC Biotechnology Patent Directive, plant and animal varies *prima facie* are also excluded from patentability (Art. 4.1 (a)) However, this provision is qualified by the clause that "Inventions which concern plants and animals shall be patentable if the technical feasibility is not confined to a particular plant or animal variety" (Art. 4.2). US patent law is even more expansive.

What is the background of this discussion? Generally, in order to receive a patent, an innovation in the first place needs to qualify as an invention. The term "invention", though, is defined in none of the international agreements on patent law. Nonetheless, there is a general agreement that innovations need to be practical and technical. In a second step, in order to be eligible for patent protection, the invention needs to be new, involve an inventive step (i.e. are 'non-obvious') and be capable of industrial application ('usefulness'). Finally, the granting of patent protection requires the disclosure of the invention. As for patents on biological matter ('biopatents'), a major dispute surrounds whether or not plant or animal genetic material may at all constitute the subject of an invention (WTO 2002, 1995; Marin 2002; Watal 2001). This raises doubts with respect to both practicality and technicality. In terms of practicality, it is still controversial whether products of biotechnology that are, or are based on, genes or cells taken from nature or isolated from pre-existing living matter constitute a product of nature and as such a unpatentable discovery, or whether they are patentable inventions. In the court practice of most industrialized countries, however, there is a clear, though not uniform, trend towards recognizing naturally occurring substances as patentable subject matter if they were isolated or purified and if their existence was previously unknown (Leskien/Flitner 1997: 9). The patentability as such of living matter is no longer disputed by most courts. In terms of technicality, over the last years in many countries (as well as implicitly in the TRIPs Agreement) living beings have been ascribed a 'technical nature' that is a prerequisite for patenting. Reproducibility, as an additional requirement to prove technicality, leads to the necessity of disclosing inventions relating to or relying on biological material that is not publicly available and cannot be described in writing alone; this conundrum is partly resolved by the possibility of depositing biological material for the purpose of sufficiently describing a product patent. On top of the decision of whether plant and animal genetic innovations fulfil the legal criteria of an invention at all (practicality, technicality), the specific patent requirements of novelty, non-obviousness/inventive step, usefulness/ industrial applicability as well as sufficient disclosure need to be satisfied (cf. Marin 2002; Dutfield 2000; Correa 2000, 1992; Leskien/Flitner 1997). Then again, these requirements are insufficiently specified in international agreements (e.g. TRIPS) and interpreted in different ways in national legal systems. However, they have proved not to be insurmountable for the granting of biopatents.

Patents impede the development of agrobiodiversity by restricting access to genetic resources used in breeding and research (CIMMYT 2000: 26). Similar to Plant Breeder's Rights in conventional plant breeding, the utilisation of germplasm, seeds of animals with a patented element (product patent), presupposes the right-holder's authorization. However, patents are more exclusive since licences to competitors can be refused. Only research without market-orientation is exempted. Also, licence fees are more costly than PBR royalties and may develop even prohibitive effects. When processes for the genetic modification of plants and animals are patented (process patents) third parties depend on the patent holder's authorisation not only for the immediate application of the patented process, but also for the use, selling or import of products immediately derived from the process. Not only due to this generic protection, but also due to the usual lack of a breeder's exemption and a farmer's privilege, the exclusive right provided by a patent has stronger exclusive effects than Plant Breeder's Rights. It is unclear whether a system of compulsory cross-licensing between patents and plant breeders' rights will suffice to secure access to genetic material for breeding purposes.

Experience with patents on plant biotechnological innovations corroborates the feared restrictions on access and utilisation of the protected products and processes. Patent licences, if granted by the patent holder, reduce the incentives for third parties to engage in research and breeding within the scope of protection of the patent. This indicates that broad patents, which extend to second-generation uses, have stifling effects on the breeding efforts of competitors of the first patentee. An example was the US patent on all transgenic cotton plants. With its extremely wide-ranging exclusive rights it had caused a standstill in cotton research so that in the end, the US Agriculture Department attained the patent's annulment (Seiler 2000: 16). The problem is aggravated by the cumulative application of IPRs. Developing a transgenic plant variety may lead to multiple rights, such as Breeder's Rights (on the variety) and patents (on selectable marker genes, traits, as well as transformation and gene expression technologies) (cf. Seghal/van Rompaey 1992). There are already over 9000 patents on staple crops (Action Aid et al. 2001: 8); in the case of animals, in Europe alone more than 50 animals have been patented with some 600 animal patents awaiting approval (Greenpeace 2001: 8). The multitude of IPRs and their accumulation will step up the costs of the breeding process as well as that of the end product. In the case of plants, this will increase the pressure to develop 'universal varieties' with a big market share that can be cultivated under very different natural conditions and feature only a minimum of uniform characteristics. It will also shift any added value from farmers to agribusiness and within agribusiness from small breeders to major companies that are equipped with the appropriate technology and with patents. Today, four multinationals hold 44 per cent of all patents on staple crops (Action Aid et al. 2001: 8). Concentration processes are likely (Ect Group 2003), leading to the fusion of corporate genebanks and breeding populations, thus not only reducing diversity of breeding strategies but also increasing the risk of genetic erosion.

Against this backdrop, the current tendencies of strengthening international IPR regimes are questionable. While TRIPS is still being severely criticized (especially from a developing country perspective), a new trend has emerged especially with the US, but also in the EU, to conclude bilateral "TRIPS Plus" treaties with developing countries that go beyond TRIPs. For example, they define the UPOV 1991 provisions as an effective sui generis system and demand "the highest international standards" in intellectual property rights protection, including patent protection of plant and animal varieties and of biotechnological inventions (GRAIN 2003). At the same time, the development of the Substantive Patent Law Treaty (SPLT) under the auspices of WIPO is being pushed (cf. WIPO 2002). The draft treaty not only strives for minimum standards (like TRIPS) but it defines both the top and the bottom line of IPR standards. The draft strongly expands the conditions of patentability (no concept of invention, no technicality), will probably restrict exclusions from patentability and aims at prohibiting member states from making any further demands on patent applicants than those found in the treaty (GRAIN 2002). Some potential for a movement away from mere tightening of patent regimes might be provided by internal processes in the WTO. Firstly, in 1999 a review of TRIPs Art. 27.3 (b) was started. It was initiated largely because the United States, under pressure from private industry, wanted to negotiate stronger life patenting requirements without exclusions for plants and animals

(Bragdon/Downes 1998: 11, cf. CIEL 1998). However, other members have perceived the review as an instrument to drive back bio-patenting. As the process has reached a deadlock, it is at present unforeseeable whether the US position will prevail. Secondly, the Doha Mandate in § 19 sets on the negotiation agenda the relationship between the TRIPS Agreement and the Convention on Biological Diversity (CBD). This raised the question whether TRIPS should be amended to incorporate certain requirements of the CBD (WTO 2002: pp. 3). Particularly, patent applicants might be required to disclose the origin of any genetic material or traditional knowledge used in inventions and to demonstrate that they have obtained prior informed consent from the competent authority in the country of origin and entered into appropriate benefit-sharing arrangements. Though it is unclear whether the development of an IPR regime for traditional knowledge (cf. WIPO 2003, IISD 2003, Dutfield 2002) might not lead to a further tightening up of the IPR system, which can be considered detrimental to agrobiodiversity, disclosure of origin and prior informed consent address "bio piracy" of biological resources and traditional knowledge, thus adding to a more equitable system (Correa 2003: 1). However, determining the "origin" of genetic resources for food and agriculture will prove difficult, since international exchange in breeding has led to a strong interdependency among countries. A last strand of discussion to mention is the debate on the design of "effective sui generis systems" under Art. 17.3 (b) TRIPs. This provision is only relevant for developing countries, which have yet to dispose of a regime for plant variety protection. A number of suggestions have been made. They range from the adoption of a UPOV 1991 or UPOV 1978 to developing alternative PVP systems with different criteria as well as to an opening of the protection system for benefit sharing agreements, Farmers' Rights or the protection of communities' intellectual rights (Biothai/Grain 1998, Leskien/Flitner 1997).

Farmers' Rights

Farmers' Rights are a very open concept that was meant to countervail 'classical' Intellectual Property Rights in the field of plant genetic resources for food and agriculture, especially with relevance to developing countries. They were created as a reaction to the asymmetric benefits derived by the Southern donors of plant agrogenetic resources (i.e. seed that was developed by local farmers and communities but that was unprotected by any IPR) and the Northern users of this germplasm. In the context of the (non-binding) International Undertaking on Plant Genetic Resources for Food and Agriculture (IU), the FAO Conference in 1989 defined Farmers' Rights as "rights arising from the past, present and future contributions of farmers in conserving, improving, and making available plant genetic resources, particularly those in the centres of origin/diversity" (Res. 5/89). As pledge to the recognition to Breeders' Rights the FAO member states recognised Framer's Rights. However, a substantive definition of those rights was not made. It was envisaged that the realization of Farmers' Rights should ensure a flow of benefits from the use of plant genetic resources, to farmers and their communities. FAO Resolution 3/91 therefore laid down that "Farmers' Rights will be implemented through international funding on plant genetic resources, which will support plant genetic conservation and utilization programmes, particularly, but not exclusively, in the developing countries". More radical proposals strived for developing Farmers' Rights into some form of property rights equivalent to Plant Breeders' Rights: "Farmers developing a new, distinct, variety would own it, just as plant breeders own varieties they have developed. Access to the variety would be under farmers' control" (Wood 1998: 24).

The International Seed Treaty signed in 2001 takes up the concept of Farmers' Rights which here includes the protection of traditional knowledge relevant to plant genetic resources for food and agriculture (PGRFA), the right to equitably participate in sharing benefits arising from the utilization of PGRFA, and the right to participate in making decisions, at the national level, on matters related to their conservation and sustainable use (Art. 9.2). The responsibility for implementing Farmers' Rights, however, is entrusted to the nation states.

While the effects of Farmer's Rights on North-South equity are obvious, it is unclear how exactly they will impact on agrobiodiversity. A plausible argumentation, however, is that local participation will help keeping local varieties in the developing countries. This might especially be relevant against the backdrop of weak performance of high yielding or GMO varieties under the conditions of the South and the experience of unfavourable side-effects like additional costs for the necessary agrochemicals.

6.1.2. Sovereignty

At the international level the questions of access relates to the public vs. national sovereignty over resources. As with private right restrictions (IPRs), access to, and exchange of genetic resources can be hampered by way of sovereignty regimes.

In 1992 when the Convention on Biological Diversity (CBD) was passed, a major shift in the property regime concerning genetic resources took place: Up to then, biological resources were considered a "common heritage" or public good, and access to them was unrestricted. Compared with this, the new regime was one of national sovereignty over genetic resources, including those for food and agriculture. Thus, biodiversity was attributed the same status as other natural resources like oil and ores. The background for this change was that during the 1980s the utility value of biodiversity (for pharmaceutical and industrial purposes) became more apparent, especially combined with the emergence of new methods of biotechnological use and bioprospecting. The utilisation perspective began to dominate the international debate on biodiversity loss that led to the CBD negotiations (Elliott 1998: 74). As it is the South where the major part of global biodiversity is concentrated, developing countries played an important role in raising equity concerns about the open access system. They argued that if Northern companies were to continue to exploit the species and genetic resources of the South, while the South had to pay when making use of the breeding results, an equitable sharing of benefits was necessary to compensate for the unequal exchange. The concept of common heritage favoured by the industrialised countries and nature protectionists was successfully rejected (Henne 1997: 190). The CBD instead recognizes the sovereignty of nations over their genetic resources, thus defining property rights. It also requires the establishment of conditions of access to genetic resources and the fair and equitable sharing of the benefits arising out of their utilization (Art. 15 CBD). The core of the access regime is a bilateral system that is subject to mutually agreed terms and prior informed consent. On a case by case basis, nation states and companies that want to use genetic resources from the country sign public-private contracts on the exchange of genetic resources as well as monetary and non-monetary benefits such as technologies and knowledge. A number of such biopartnerships have been agreed with varying degrees of success (Marin 2002: pp. 120, Bialy 1998). The crucial point is the negotiation of fair and clear contractual terms in a situation that might be asymmetric in terms of information and power shares.

As the exchange of genetic material in the field of agriculture is much more common, breeding having long since been an internationalised activity, it was obvious that the CBD bilateral system would not be optimal for agro-genetic resources, for the transaction costs of negotiating bilateral agreements would simply be too high. Also, it was feared that developing countries would stop to contributing genetic material into international gene banks since access to ex situ collections was not addressed by the Convention - a loophole threatening to undermine the CBD. Therefore, in order not to thwart the CBD adoption, it was agreed to regulate this issue under the auspices of the FAO, traditionally responsible for agriculture. This change of forum lead to the revision of the International Undertaking on Plant Genetic Resources for Food and Agriculture (IU), a non-binding instrument that had to date governed access to plant genetic resources for food and agriculture (PGRFA). Still based on the concept of "heritage of mankind", the IU needed to be brought into harmony with the CBD. After eight years of tough negotiating, an internationally binding Seed Treaty (International Treaty on Plant Genetic Resources for Food and Agriculture/ITPGR) was signed in 2001, which regulates facilitated access to PGRFA.

The crucial difference in the access regimes of CBD and Seed Treaty is that the latter is based on a Multilateral System (Art. 10 ITPGR). This Multilateral System consists of a list of 35 food and feed crops for which the member states will provide facilitated access. The respective genetic material belonging to public institutions will be kept in the public domain. "Facilitated access" means that an exchange free of charge or at minimum fees may exclusively take place for breeding, research and - expressly not for industrial purposes (Art. 12.3 (a) (b)). Unlike in the CBD there is no need to apply prior informed consent procedures on a case-by-case basis. Although a number of countries (among others the EU) aimed at maintaining open access to PGRFA, a restriction in the form of a list was inevitable; especially the Group of Megadiverse Countries under the leadership of Brazil had fought hard for it and wanted to keep it as short as possible. A standardised Material Transfer Agreement (MTA) will specify the details of access and will also be the basis for private contracts between the providers (mostly gene banks) and the demanders of PGRFA. Many questions are still open and will need to be clarified once the Treaty comes into force. One of those questions is the status of intellectual property rights, since the interpretation of the Treaty's wording on the protection of material received via the multilateral system is still very contentious. Some discern it as a loophole since the holder of an IPR, specifically of a patent, could restrict use of the protected sequence or compound by others, and even access if the patent covered the method of isolation, so that the Seed Treaty's intention of facilitating access would be undermined (Dutfield 2002: 17, CIPR 2002: 69). Despite some weak spots the ITPGR is certainly an essential instrument for ensuring the sustainable use of PGRFA. It might serve as a blueprint for dealing with farm animal genetic resources that have not yet been the object of much specific consideration within international politics.

6.2. Seed and breeding regulations

Seed and breeding law is national law, although some aspects in EC countries underlie European harmonisation. As an example, aspects of German seed law and animal breeding law will be described in order to outline what other legal factors apart from IPRs and international access regulation may turn out to restrict the development of agrobiodiversity. They are problematic in terms of agrobiodiversity to the extent that they promote the streamlining of selection criteria. Also, by implicitly furthering high performance varieties and races they contribute not only the displacement of traditional varieties/races but also to the spread of high input agriculture.

In plant breeding, independent of private law on variety protection, EU member states, most transition countries and some developing countries feature a compulsory variety registration under public law (Gisselquist 1999: 413). This means that in order to market seeds commercially, the variety needs to fulfil specific criteria. The basic principle of the German Seed Law (SaatG) concerning agricultural varieties goes: Seeds and seedlings can only be marketed when they are approved of; they will only be approved of when they belong to a variety that is registered (Rutz 2002: 8). For variety registration, Germany, like many other countries, has established a double set of requirements. Firstly, the "DUS" criteria, that are also crucial for variety protection, demand that plants grown from a specific lot of seeds are *d*istinct and *u*niform, and that their characteristics are *s*table over a minimum of 2 years. For the reasons outlined above (chapter 6.1.1), it is the uniformity criterion (§§ 30.1, 32 SaatG) that some experts are very sceptical about. In addition to the DUS, set seed registration in Germany presupposes that the variety demonstrates *v*alue in *c*ultivation and *u*se (VCU) (§ 30 (1), § 34 SaatG). A government agency, the Bundessortenamt (Federal Agency for Varieties), conducts the DUS and VCU tests, which are paid for by the breeding companies, who also pay an annual fee for the listing of registered cultivars. The VCU, or performance criteria, are a bundle of value designating qualities such as qualities of cultivation, resistance, yield and quality. The VCU is, under German Seed Law, the toughest standard that a breeder has to comply with in order to get a new crop registered; some 90% of applications fail, mostly due to lacking VCU (Steinberger 1999: 34). Varieties are considered to have value in cultivation and use when the entirety of their 'value designating qualities' represents a distinct improvement vis-à-vis existing varieties (at least within a regional area) in terms of the exploitation of either the harvested material or any products thereof. Individual, unfavourable characteristics may be compensated for by other favourable qualities (cf. § 34 SaatG). The specification of VCU, which is crop-specific, is being defined by the Bundessortenamt, i.e. by the executive powers. Although there have been some change in the weighting of the qualities (Steinberger 1999), high yield for many crops still constitutes the predominant orientation. In terms of agrobiodiversity, this legal provision adds to economic incentives for a relatively mono-structured alignment of plant breeding. Per se, a standardisation of selection criteria is promoted. Thus, variety registration as a means that was, and is, intended for consumer (i.e. farmer) protection as a side effect streamlines plant breeding according to state-defined preferences. And those preferences are not shared by every farmer; organic farmers, for example, require varieties with different qualities since chemical inputs in cultivation are prohibited in organic farming (FiBL/Öko-Institut 2003: pp. 55). Another bottleneck of diversity is that seed sale of old cultivars - traditional varieties as well as out-of-date commercial cultivars - is illegal. This issue, however, is being tackled by way of an EU initiative on conservation varieties. Registration of land races and varieties endangered by genetic erosion shall do without the DUS criteria and with liberalised VCU requirements. At the moment, the implementation provisions are still being drawn up by the European Commission.

Beyond seed and beering law, marketing standards and grades of goods play an important role in terms of agrobiodiversity. Based on UN/ECE norms, the EC (and for some additional crops German legislation) have specified standards for a vast number of fruit and vegetables, potatoes etc. that are relevant in trade. The standards regulate quality grades, sizes (diameter, weight), tolerances vis-à-vis sorting errors, packaging and labelling for agricultural products that are sold freshly (aid 2001). While the standards aim at protecting processors, traders and consumers against cheating and aim at furthering simplification and differentiated sales, they also impact on the variety of marketed crops. Those varieties of apples, tomatoes and potatoes that are bigger or smaller than required, that are not as regular as required cannot be offered for sale to the end user except in direct marketing on farms. This has led to a comprehensive drop out of cultivation and sale of many crop varieties and to the dominance of 'standard cops'.

The regulatory regime on livestock breeding reflects to a large extent the economic conditions. Over a long period of time, animal breeding and husbandry law have supported one-sided selection strategies focused on economic performance. They have thus contributed to the depletion of farm animal diversity. Although in the meantime the objective of "genetic diversity" is codified in the German Livestock Breeding Act (§ 1.2 (4), § 4.1 TierZG), the longstanding specification of selection criteria through state agencies, which used to build the basis of performance tests and of obligatory assessments of breeding quality, has fostered a narrowing of animal genetic diversity.

This trend has been resumed by including into the Breeding Act the promotion of "breeding progress" as an undefined legal term (§ 5 TierZG). As a consequence of this orientation, the administrative bodies give permission for the insemination of cattle, pigs, sheep, goats and horses only if the breeding value of the sperm donating animal is higher than the average breeding value of comparable animals (§ 10.2 (1) TierZG). For chickens, there is no legal control of breeding. Nor is there access to the breeding process for chicken farmers since the existing breeding lines of laying hens and broiler are private property of a small number of trans-national breeding companies; farmers only raise hybrid chickens and they, themselves, cannot breed, correspondingly influencing genetic diversity.

7. Conclusions

This article has shown that access restriction in the form of IPRs and sovereign rights as well as high performance oriented regulation of crop and livestock breeding might impact negatively on agrobiodiversity. The respective regimes have only developed in the last 80 years, gaining rigidity parallel to the increasing relevance of biotechnology (Raustiala/Victor 2004). From the 1920s onwards, these various regimes started to replace an open access regime and a largely unregulated seed and livestock sector. It needs to be stressed that the former regimes actually contained a number of deficiencies. The introduction of variety protection (plants) and performance testing (livestock) certainly increased productivity in times when food security in Europe was still endangered. Also, before the introduction of seed testing there was the danger of cheating farmers by not procuring information on the quality of the seed. The solution of restricting and privatising access and of prescribing selection objectives, however, might turn out to have caused new problems: the loss of agrobiodiversity.

Having described agrobiodiversity loss as unintended feedback of previous problem solving strategies, the imminent challenge now is not only about reducing given obstacles and introducing new instruments. It is also about using *reflexive* strategies to avoid causing new problems in the future. Elements of a reflexive strategy could be integrated knowledge production, the anticipation of systemic consequences, adaptivity of problem-solving, as well as participatory evaluation and goal formulation (Voss/Kemp 2003). Some of these elements have already become reality, such as participatory breeding approaches as promoted by the FAO; others need to be developed.

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