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Genetic Use Restriction (or Terminator) Technologies (GURTs) in Agricultural Biotechnology: The Limits of Technological Alternatives to Intellectual Property

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Chidi Oguamanam†

Introduction

A major challenge to sustaining exponential advances in biotechnology and digital technology in the last couple of decades has been the need for a suitable protection and appropriation regime for these technologies. While the malleability of intellectual property rights continues to be stretched to accommodate novel advances in both digital and biological technologies, indications are that other proprietary options are increasingly becoming attractive to stakeholders in these technologies.[1] The limits of traditional intellectual property rights and, perhaps more so, the natures of the two technologies have forced stakeholders to explore alternative protective regimes. The need for a tighter proprietary framework to support digital and biotechnology endeavours stems mainly from the perception that valuable information or inventions in the two areas are particularly expensive to generate and effortlessly inexpensive to reproduce.[2]

With regard to genetic modification in plant materials or agricultural biotechnology in general, the inherently self-reproducing nature of transgenic or genetically modified materials, particularly seeds, makes it rather tasking for traditional intellectual property rights to efficiently protect the proprietary interests of inventors and investors alike. This article evaluates the progression of knowledge protection in agricultural biotechnology through traditional intellectual property rights, its *sui generis versions, legislative interventions, and contractual devices to the contemporary epoch of a molecular or technology-driven intellectual property alternative exemplified in genetic use restriction technologies (GURTs), more commonly known as terminator technology.*[3]

Terminator technology is a very recent and emerging phenomenon. It derives its nickname from Arnold Schwarzenegger's science fiction movie of the same name.[4] Generally, terminator technology is a two-prong biotechnological device for inducing sterility in seeds to fundamentally alter their self-reproducing character, or to induce trait susceptibility, selection or suppression. Since the first patent for this technology was granted in the United States in March 1998,[5] terminator technology has been perceived in the broader context of genetic modification in food and agricultural materials. Oppositions to the technology are staked on that inclusive background and they encompass traditional objections to genetic modification and attendant privatization of life forms. In a nutshell, the grounds of objection include ethical concerns about a technology that is oriented toward seed sterility and trait manipulation, the general environmental or ecological impacts of terminator varieties, as well as long and short term effect of terminator varieties on biological diversity and public health.[6]

Other sources of reservation include the nature of interaction of terminator varieties with other crops and the potential of the varieties to induce sterility on non-terminator or non-transgenic varieties through the phenomenon of "gene wandering". Also, there is unease over the potential impact of terminator technology in regard to displacement of traditional agricultural practices of indigenous, rural and smallholder farming communities, such as seed-exchange and the component cultures of *seeding.*[7] Equally, a considerable source of worry is the suggestion that if the six big Northern based global multinational life sciences corporations[8] that now capitalize on the convergence of crop biotechnology with *agrochemical and seed production were to adopt terminator technology, it would accentuate the North–South asymmetry in agriculture and food production to an unprecedented level. Such an oligopoly would grossly limit farmers' choice in terms of crop varieties, trait selec*tions, local adaptation of materials, etc.[9] thus raising concerns about paucity of agro biodiversity and food security, especially in the developing countries.

The foregoing concerns do not exhaustively articulate the reasons for the intense popular reservations over

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terminator technologies or GURTs and the phenomenon of genetic modification. However, they are sufficient to establish the diverse grounds upon which such objections are staked. In response to these concerns, consideration of terminator technology has been incorporated into regulatory initiatives on the genetic modification of living organisms at national and international levels.[10]

It is important to indicate that the technologies are not yet approved for commercial exploitation and available knowledge about them is based on greenhouse and laboratory experimentations.[11] Unlike other products of agro biotech, such as genetically modified food and transgenic plant materials, debates on health, biosafety and other ramifications of terminator varieties are now underway at the United Nations Convention on Biological Diversity (CBD)[12] as a prelude to anticipated official approval of the technologies for commercial exploitation.[13] In general, the emphases of popular global apprehension over genetic modification as a whole and terminator technology in particular are placed on ethical, health, biosafety and broader environmental questions. While focusing on these, general concerns about terminator technology barely broach the policy implications of the self-enforcing technological alternative to intellectual property rights which this technology portends.[14]

This article examines the adequacy of terminator technology as a potential substitute for traditional intellectual property. It acknowledges that the technology provides a stronger protection and reward mechanism than that offered by the traditional intellectual property rights regime. However, terminator technology or any other technology for that matter, is outside the pantheon of intellectual property regimes. Fundamentally, terminator is a technological answer to the quest by private sector interests to improve appropriability of returns on investments in agrobiotech. It potentially represents a panacea to the long standing industry struggle over the profitability of private research in agrobiotech and the need to improve appropriability of returns on investments in self-pollinating plant varieties. Terminator technology constitutes a molecular or cellular proprietary control mechanism for plant genetic resources (PGR).

Consequently, terminator technologies are attractive assets to private sector investors in agricultural research. However, the nature of terminator technology as "a technological response to an institutional problem"[15] undermines a major policy plank of intellectual property rights, namely, the preservation of knowledge in the public domain through time limit on protection and the requirement of compulsory disclosure. As a prospective molecular substitute for or imitation of intellectual property, terminator technology not only provides no known agronomic benefit to farmers,[16] but also has the potential to freeze up opportunities for knowledge transmission, accretion, development and diffusion of technology in transgenic crops. This article argues that any potential technological substitute for intellectual property that sacrifices the latter's underlying public policy objective of the promotion and dissemination of knowledge in the public domain may be overkill in the hands of industry. To the extent that terminator technology does not account for the public domain consideration which is a material aspect of intellectual property, it may not be an acceptable substitute. Even though they may fix perceived institutional problems, by their nature, technologies alone do not address the public policy nuances imbedded in conventional intellectual property jurisprudence.

In exploring the foregoing issues, this article is divided into three major parts. Part I evaluates the private sector's quest for profitable appropriability of returns on investments in agricultural biotechnology, with emphasis on plant/seed breeding. It also explores the progressive response of intellectual property to accommodate that desire. Part II focuses on the nature and concept of GURTs as a self-enforcing technological imitation of intellectual property and ongoing public policy scrutiny of the technologies. It evaluates the terminator initiative as akin to industries' vote of no confidence on extant attempts by conventional and *sui generis* intellectual property regimes to accommodate their quest for a tighter appropriatary and control regime. Part III broaches the public policy underlying the philosophy of intellectual property and evaluates the shortcoming of terminator technology as a technological imitation intellectual property. The paper concludes by pointing to the need for direct inclusion of intellectual property considerations in the ongoing discussions on the way forward for GURTs. This paper, then, is meant to assist in creating a balance between the extant focus of those initiatives on environmental, biosafety, health and socio-economic issues and a consideration of the intellectual property ramifications of GURTs.

Part I

PGR and Intellectual Property: The Dynamics of the Pre-Terminator Era

Plant Breeding Regime and Other *Sui Generis* Response

Historically, farmers generated new plant varieties or improved on existing ones through trans-generational and informal innovations with PGR. In such traditional settings, farmers chiefly relied on general observations of ecological patterns in the "careful selection from randomly occurring mutations in nature".[17] Varieties were deliberately selected first on the basis of their adaptability to the vagaries of local ecological conditions before consideration was given to their economic viability. Because of the informal and communal nature of traditional agricultural endeavours, appropriability of *new or improved genetic resources or novel plant varieties was a matter of no serious concern. The incremental nature of such informal innovations made it difficult to identify when and from whom a new plant variety was introduced.* [18]

All this changed with the advent of formal scientific and entrepreneurial plant breeding some 125 years ago.[19] Plant breeding became a target of organized scientific activity, a situation that raised concerns not only about incentives for public sector research but also in regard to returns on private sector investments in the field. Unlike the traditional approach, scientific plant breeding is essentially an exercise in deliberate incorporation of specific or desired traits to create new or hybrid varieties using molecular techniques and other scientific information.[20] From its evolution as early as the *14th century,* [21] intellectual property rights, specifically patents, were limited to conferring exclusive rights to inventors of industrial or technical inventions.[22] Thus, historically, the paradigms of conventional intellectual property as a mechanism for appropriation and control *of technical inventions did not extend to living materials* such as plants or plant varieties.[23]

With the formal scientific and private sector entrepreneurial approach to plant breeding, the paradigms of intellectual property rights extended to living materials[24] through a rather dynamic trajectory that we will explore shortly. In regard to PGR, the self-reproducing nature of seed, like the fluidity and easy replication of information in digital technology, does not guarantee effective control over the use of a proprietary plant variety that has been released to the farmer. According to Srinivasan and Thirtle, "[t]he vast discrepancy between the benefits that could be appropriated privately by the breeder and the total social benefits [inherent in the self-reproducing nature and agronomic value of seed] implied that the market mechanism would fail to produce a socially desirable level of investment or effort in plant breeding".[25] Attempts to mitigate this form of "market failure" in both developed and developing countries by the provision of investment through public sector research in plant breeding, while partially successful, could not endure because of dwindling financial support.[26]

Declining public sector investment in R & D in an era of privatization, a progressive extension of intellectual *property rights over living materials, and private sector-driven exponential increase in the biotechnology* [27] industry dictated that the issue of control or appropriability of investment in plant breeding and seed production be tackled. In order to profitably "commoditize"[28] seeds, it became necessary that "institutional [interventions or regulatory] barriers be placed on [dealings with] self-reproducing characteristics of seed . . .".[29] This imperative paved the way for the progressive evolution of intellectual property rights on PGR in the former's conventional and *sui generis formulations, and lately, in the technological imitation of intellectual property rights represented by the terminator.*

Increasing private sector participation in plant breeding in Europe, the United States and Canada, spurred a spate of Plant Variety Protection (PVP) legislation. As mentioned earlier, because of the historical emphasis of conventional intellectual property, specifically patents, on technical inventions and industrial products and processes, it was not considered a suitable appropriation regime for living materials in general and plant breeding in particular.[30] Indeed, the plant breeding process is not easily expressed in the exact technical details required for the patenting of technical inventions.[31] While early PVP legislation in European countries dated from around the 1940s,[32] the United States had a head start with the enactment of the *Plant Patent Act (PPA) of 1930*[33] which aimed at granting special patent protection for innovations in asexually reproducing plants, especially for the horticultural industry. That legislation provided the juridical framework for the subsequent *Plant Variety Protection Act (PVPA) of 1970* [34] which targeted sexually or non-asexually reproducing plants.[35]

Despite the variegations in the details of various PVP laws in European States, the U.S. and Canada, essentially, they confer rights on breeders (hence, plant breeders' right or PBR) and impose limits on the rights of users or buyers of protected seed, in order to facilitate breeders' profitable seed trade in proprietary varieties. However, given the divergences in national PVP laws, distortions in the scope of rights of plant breeders across national boundaries compelled the need for a uniform transnational PVP regime. Premised on the national treatment principles, the 1961 International Convention for the Protection of New Plant Varieties (UPOV)[36] was born to address this need. UPOV recognizes the importance of isolation, distinctness or identification of a variety as its warrant for intellectual property protection. Under the UPOV, uniform criteria for protection of new plant varieties are limited to varieties possessing the features of novelty,[37] distinctiveness, uniformity and stability.

While facilitating breeders' rights, including breeders' exclusive commercial trade in propagating materials or seeds of protected varieties, the UPOV as a *sui generis IPRs regime is clearly distinct from conventional patents. Like other national PVP regimes, the* Convention incorporates two exemptions to breeders' exclusive appropriation and control of a protected variety.[38] The first exemption grants farmers the privilege to use farm-saved seeds from protected varieties obtained from breeders. Thus, breeders' rights did not trump farmers' age-long traditional practices to save seeds even of a protected variety after harvest.[39] The second exemption, referred to as research exemption, allows the use of protected varieties for research or experiment. Under this exemption, a subsequently resulting variety could be commercialized without the authorization of, or payment of compensation to, the original holder of the plant breeders' right. The practical translation of this exemption is that under the UPOV regime of 1978 plant breeders' right did not include the right to genes as principal genetic materials of protected varieties.[40]

The enactment of national PVP legislation in most developed countries and the subsequent coming into effect of a harmonized international PVP regime under the UPOV in 1961 did not have the desired impact of boosting profitable private sector participation in plant breeding, or so it was perceived. Aside from the perennially self-reproducing nature of seeds that makes proprietary control impossible, exemptions in those regimes on the bases of farmers' privilege and research are cited as the glaring weaknesses of the PVP regime that scuttled viable appropriation of returns from non-hybrid crops.[41] Despite paucity of data, available information, even though limited in scope, indicate that PVP laws have not yielded private sector quest for profitability of breeding non-hybrid crops.[42] Essentially, because of these two exemptions, the PVP is perceived as to be deficient as an incentive regime for protection of innovations in seed breeding.

Not surprisingly, the UPOV has been revised three times since 1961.[43] The most radical of these revisions was the revision of the 1978 version in 1991. The latter is a major departure from the prior regime and an aggressive attempt to plug its "leaky" provisions and perceived indulgences to farmers. Under the 1991 UPOV, breeders' rights supersede farmers' privilege and extend to all species and all circumstances for reproduction of the seeds of protected varieties. Member states have the option to provide for a farmers' exemption under national law.[44] It extends breeders' rights to even harvested material,[45] or varieties "essentially derived" from a protected one.[46] It increases the duration of rights to 20 years,[47] all in an attempt to bring PVP laws as close as possible to the tighter utility patent regime.

These changes in UPOV have since been reflected in the national laws of a majority of its member states. For instance, "in almost the whole of Europe, farmers' privilege no longer exist except in the case of small farmers",[48] whereas all other farmers are required to pay royalties to PBR holders for the use of farm-saved seed associated with a protected breed.[49] In Canada, the 1990 *Plant Breeders' Rights Act*[50] seems to have pre-empted the 1991 UPOV revisions even though it provides for an 18-year duration of breeders' right. The principal PVP law in the United States on the protection of inventions on sexually reproducing plant varieties is the 1970 PVPA.[51] Along the spirit of the earlier UPOV regime, the PVPA allowed farmers' sale of farm-saved seeds of a protected variety. This popular practice, nationally referred to in that country as "brown-bag" sales,[52] not only secured seeds for farmers for the next planting season, but also enabled them to sell farm-saved seeds to other farmers and persons.

Yet, because of the prevalence of brown-bagging, its perceived impact on the profitability of seed companies' operations reopened concerns about a tighter appropriability regime for propagating materials. Following on the heels of encouraging judicial decisions circumscribing farmers' (also crop) and research exemptions in the U.S.[53] and the 1991 revisions of the UPOV, in 1994, the U.S. amended the 1970 PVPA. The new amendment prohibits farmers from selling farm-saved seeds while it preserves their rights to save seeds for the sole purpose of replanting their fields only. Similarly, the research exemption has been circumscribed to ensure that it does not cover non-experimental undertakings.[54]

Contractual Response

A responsive and tighter PVP regime is at the instance of individual governments and, in the case of the UPOV, a collective initiative of mainly industrialized countries of North America and their European counterparts.[55] Private sector actors in agricultural biotechnology and seed production, in particular, have grown in power and in the influence they wield in the corridors of power in both their home base in the North and their outposts in the South. For the most part, they share in the credit of getting governments to address industry sponsored urgency to improve the appropriability of returns on investments in agricultural biotechnology and self-pollinating or non-hybrid plant varieties in particular.

Indications are that these corporations are not resting on their oars. Despite strides in improved PVP regimes, agrobiotech corporations have continued to adopt customized contractual arrangements and marketing strategies to ensure improved appropriability and profitable returns on investments. As part of their marketing strategy, seed corporations have, in the last two decades, been involved in a spate of mergers and acquisitions in an effort to consolidate both their service and product delivery, and to secure tighter appropriation of their intellectual properties. Commercial agricultural or agrobiotech research, industrial seed and allied agrochemical production now converge and concentrate under few corporate strongholds.[56] It is then possible for them to take on individual or boutique farmers whose choices are limited in take-it-or-leave-it contractual agreements.

For instance, by means of special purchase and other contracts[57] with "terminator clauses",[58] farmers are restrained from dealing with the harvested crop of a protected variety otherwise than for sale or consumption as food. Thus, it is possible and certainly legitimate for seed corporations to resort to contractual devices in order to undermine the little statutory window that allows farmers to use farm-saved seeds of a protected variety in their own farms under PVP laws. Similarly, in this asymmetrical contractual paradigm, corporations also negotiate highly intrusive powers in order to monitor or audit farmers' compliance with these onerous agreements. Today, farmers' fields, in the eyes of multinational seed corporations, also double as potential forensic laboratories of evidence against recalcitrant farmers. This is so in the former's quest to improve appropriation of return on investment and to enforce compliance with onerous contractual agreements. This, sometimes, involves the use of private investigators or what has been termed "gene police".

Developments on the Patent Regime

Apart from improvements in PVP laws as a *sui generis intellectual property option and special contracts, efforts to improve appropriation and control of PGR are evident in the progressive judicial re-conceptualization and expansion of the patent regime to the realm of living rganisms. In retrospect, the original reluctance to xtend patent protection to living materials appears to ave been shortsighted as it is no longer sustainable. At esent, only a few would fault the characterization of t approach as one premised on obsolete jurispru- ce.*

In a 1980 landmark decision, the U.S. Supreme Court held in *Diamond v. Chakrabarty*,[59] that a non-naturally occurring human-made genetically modified bacterium designed to breakdown components of crude oil was patentable subject matter under U.S. law.[60] The significance of that decision transcends its specific facts. It lies, perhaps, in the Court's recourse to the legislative history of the U.S. *Patent Act in making a declaration that when interpreting the Act, a liberal approach is preferred.* [61] Thus, according to Chief Justice Burger, "Congress intended statutory [patent] subject matter to 'include anything under the sun that is made by man'".[62] Thus, creations of "human ingenuity", including non-naturally occurring living materials, constitute new, useful, "manufacture or composition of matter" under section 101 of the U.S. *Patent Act. As if to remove any lingering doubts, in 1985, the U.S. Patent Board of Appeals held that the existence of both the 1930 PPA and the 1970 PVPA did not preclude the application of tility patents on new plant varieties.* [63] The U.S.'s so called liberal approach which has seen a patent issued for a genetically modified *onco mouse is different from the Canadian approach which has denied patent protection to the same concept.* [64]

Conventional or utility patents are attractive to commercial breeders because they provide stronger protection and control. They are not subject to research and crop or farmers' exemptions which remain sticking points in the PVP regime. Unlike the case with PVP or other intellectual property regimes, a patent right excludes the claim of earlier or later inventors who independently or contemporaneously invent the exact same subject matter (in this case a new plant variety) over which there is an existing patent. Essentially, patent protects against production or manufacture or all other forms of exploitation and use of a patented product or process.[65] The law interprets the concept of "use" for the purposes of patent infringement very liberally to the advantage of a patent holder.[66] In the famous 2004 decision of the Supreme Court of Canada in *Monsanto Canada Inc. v. Percy Schmeiser*,[67] the Court observed that where a party employed a patented invention and thereby deprived the patent owner full or exclusive enjoyment of the patent monopoly, it does not matter what the offending party intended, or that he did not profit from the invention. Given its emphasis on preventing farmer profiteering at the expense of breeders, it is not likely that the PVP regime we have *reviewed could provide such an extensive protection to a right holder that utility patent does. Thus, empirically, the scope of protection of right holders under utility patent trumps the rights of breeders under the PVP regime.*

Proprietary stakeholders in agrobiotech can now indulge in multiple protection options to secure the appropriability and control of their investments. To this end, the 1994 International Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) [68] under its controversial Article 27 provides, in part, that "[m]embers may provide for the protection of plant varieties either by [utility] patents or by effective sui generis system or combination thereof …".[69] It is important to point out that today TRIPS represents the most comprehensive and arguably the most authoritative global regime on intellectual property rights. As a component *instrument of the Uruguay Round of General Agreements on Tariffs and Trade (GATT), its so called min*imum standards of intellectual property protection are applicable to all members of the World Trade Organization (WTO) which administers the GATT. In regard to intellectual property, TRIPS is described as "the only game in town".[70] It has entrenched a concurrent protection of plant varieties by both patent and PVP.

Whether under various national PVP laws, including their international consolidation under the UPOV, or various national intellectual property laws, including the global intellectual property regime under *TRIPS, intellectual property rights are expensive and difficult to enforce. Despite the complexity and cost of* procuring these legal proprietary devices, seeds are still propagating materials. Thus, there is a limit to which seed exchange and propagating materials on their own can be monitored even by the most aggressive right holders whether as plant breeders or utility patentees or both. Private sector pursuit of a cost efficient and watertight proprietary control mechanism for genetic materials in agrobiotech remains an ongoing commitment. That commitment takes a totally novel dimension in the phenomenon of terminator technology.

Part II

The Era of the Terminator

History and Nature of Terminator

Three years after the coming into force of the TRIPS Agreement in 1995, the United States Department of Agriculture (USDA) and Delta & Pine Land Company astonished the world when, in 1998, they announced obtaining U.S. Patent No. 5,723,765 titled "Patent for the Control of Plant Gene Expression".[71] That is the first "terminator" patent. Since that patent was obtained, many multinational agrochemical and seed corporations have continued to research into this novel biotechnological phenomenon and to procure patents in genetic seed sterilization.[72] Essentially, terminator technology is a new biotechnology or genetic engineering device to achieve suppression of true-to-type-second generation seeds or genetic copy propagation.

For the most part, this technology is industry's weapon to prohibit unauthorized seed-saving of proprietary seeds by farmers in order to maximize appropriation of returns on agrobiotech investments in seed production and effective marketing of component agrochemical inducers. As indicated in Part I, both utility patents and PVP laws, apart from being expensive to procure and enforce, do not guarantee rights holders' absolute control and appropriation of their interests in PGR. Instead of trusting farmers as users of proprietary varieties to honour the intellectual property rights of breeders, crops are genetically modified to deprive them of the ability to germinate when replanted using terminator technology. This vests crops with a self-enforcing capacity in regard to breeder's intellectual property rights. Unlike the PVP regime, terminator technology vests in the breeder absolute control of plant gene and cell.

Terminator technology is, however, not all about seed sterility. The technical description of the underlying technologies is "genetic use restriction technologies" (i.e., GURTs). Loosely, there are two embedded principal biotechnological devices in issue. The one incorporates variety-genetic use restriction technologies (V-GURTs), and the other is trait-genetic use restriction technologies (T-GURTs) derogatorily called "traitor [gene] technology". Both of them involve deployment of external stimuli to manipulate expression of exogenous genes in plants.[73] In V-GURTs, the expression of the exogenous genes is designed for the sole purpose of inducing sterility. It is this form of GURT that largely accounts for the intense public abhorrence of the technologies and thus constitutes the target of the technologies' bad publicity. This is the reason for the popular designation of GURTs as terminator technology. Quite unlike V-GURTs, in T-GURTs deployment of external stimulus is designed to activate the expression of genetically engineered or value-added traits without hampering seed viability.[74]

GURTs' public relations deficit largely derives from V-GURTs, as the *real "terminator" technology. Somehow, the unholy reputation of V-GURTs over*shadows the promise of T-GURTs as agro biotech's potential marketing instrument of choice for service and product delivery in a converging industrial environment. By means of T-GURTs, seed and allied agrochemical corporations can market both proprietary seed variety and component agrochemical inducers. In order to "unlock" or activate value-added engineered traits in a proprietary seed, farmers will have to buy the relevant chemical inducer that targets specific genes responsible for activating desired traits. Thus, it is possible for a farmer to buy a seed with, for example, five potential value-added traits but who could only afford, or would only need three of those while leaving the rest latent. In this way, T-GURTs could enable seed companies to practice price discrimination of a kind.[75] The price of a seed may be tied to or mitigated by that of component agro chemicals required for activating its engineered traits. A farmer pays and gets only what he/she has ordered and no more.

T-GURT seeds are capable of propagation beyond the first generation because they are always fertile. However, a farmer seeking to take advantage of the value-added traits in the next planting season would have to fall back on the seed company that has the intellectual property over the agrochemical that unlocks or switches the desired value-added traits. Thus, by means of T-GURTs, seed companies can take advantage of their intellectual property rights in agrochemicals in order to keep the price of proprietary seeds low without compromising their quest for maximum appropriability of returns on investments in agricultural biotechnology.

A number of features distinguish V-GURTs from T-GURTs. First, the latter are said to require few genetic changes and are easier to be adapted into target plants and generally simpler to operate.[76] Second, T-GURTs do not render sterile seed, since farmers can, subject to prevailing PVP laws, replant T-GURT seeds in the next planting season even though they would need to buy external chemical inducers or the "key" from the seed company in order to take advantage of the engineered traits. Because T-GURT seeds are fertile, farmers can reproduce them and not depend on seed companies for seed, a situation that may positively impact on the cost of seed.[77]

The fact that T-GURTs do not render sterile seed undercuts one of the key criticisms of the terminator concept. Credible opposition to terminator technologies, particularly on ethical and socio-economic grounds, is anchored essentially on the phenomenon of seed sterility. The latter undermines the natural concept of seed as a genetic copy propagation material, and has the potential to engender dependency of resource poor farmers on seed corporations, the so called "gene giants". That criticism does not have much bite when extended to T-GURTs as it does in regard to V-GURTs. However, the potential tendency of T-GURTs to escalate chemicalization of agricultural production raises biosafety and environmental concerns.

Thirdly, it would appear that conceptually, T-GURTs do not foreclose the operation of farmers' or crop and research exemptions in the various PVP laws, the UPOV and under the Food and Agricultural Organization's International Treaty on Plant Genetic Resources for Food and Agriculture (FAO/ITPGRFA).[78] However, T-GURTs would seem to curtail the extent of farmers' or crop and researchers' exemption under these regimes. This is so because a farmer's right or researcher's latitude to deal with T-GURT varieties does not extend to the engineered traits which are, perhaps, their most important attraction.[79] Access to the traits is circumscribed by pre-existing intellectual property over proprietary chemical inducers.

Finally, unlike V-GURTs, T-GURTs do not portend an interminable regime of appropriation. Patent rights over the component chemical inducers, i.e., so called "keys" that unlock engineered traits have, in most cases, a 20-year term. Consequently, at the expiration of the patent term, farmers would have uninhibited access from the public domain to the know-how for making the agrochemical inducers. However, independently, the viability of these chemicals is not guaranteed. The use restriction, or terminator inducers are strictly bundled with and customized to engineered traits in target crops otherwise these traits may not be available.[80] It would perhaps require development of competing varieties from scratch in order to impeach or dilute pre-existing terminator processes.[81]

As a result of the bad publicity and credible and often well-founded concerns about terminator technology, big seed corporations and other key agricultural bodies, notably, the Consultative Group on International Agricultural Research (CGIAR) and the Food and Agricultural Organization (FAO) have shunned the technology.[82] By now, terminator technology has become a public relations disaster for seed multinationals, mainly because of the aggressive public enlightenment campaigns of NGOs, notably the Canada-based ETC Group *and motley indigenous peoples' and environmental and allied interest groups. By 1999, Monsanto made a volte-face from its initial support for commercialization of* terminator[83] and, with that, sacrificed its proposed merger with cotton giant, Delta & Pine Land — a joint holder of a pioneer terminator patent. Yet, the seed giants could not resist the temptation to keep scrambling for terminator patents and warehousing them perhaps for an opportune time. Since the first terminator patent was issued in 1998 in the U.S., many more terminator patents have been granted in that country and elsewhere.[84] It is interesting to note however, that after disavowing terminator technology, Monsanto has continued to pursue development of T-GURTs, which it considers a credible and viable alternative to V-GURTs.[85]

Regulatory Initiatives on GURTs

Concerns over terminator technology have not gone unheeded. As an aspect of genetic modification,[86] the potential impact of terminator technology tends to constitute a flashpoint for wider international and national initiatives to regulate genetic modifications in food and agriculture. Broader regulatory initiatives on genetically modified organisms (GMOs) are not the subject of this paper and as such would not detain us here. Keeping our focus on terminator technology, in 1998, the Fourth Conference of Parties (COP), which is the decision making organ of the CBD, requested the Convention's technical advisory body, the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to consider, assess and elaborate scientifically-based advice to the COP on "whether there are any consequences for the conservation and sustainable use of biological diversity from the development and use of new technology for the control of plant gene expression as described in U.S. Patent No. 5,723,765".[87] SBSTTA's report was premised on a background paper prepared by multi-disciplinary experts in relevant fields[88] which had the benefit of input from diverse stakeholders after wide consultations.[89] Building upon the SBTTA initiative,[90] at its 2000 meeting, the fifth COP, while resolving to continue inquiry on GURTs, recommended as follows:

> [I]n the current absence of reliable data on genetic use restriction technologies, without which there is an inadequate basis on which to assess their potential risks, and in accordance with the precautionary approach, products incorporating such technologies should not be approved by Parties for field testing until appropriate scientific data can justify such testing, and for commercial use until appropriate, authorized and strictly controlled scientific assessments . . .[91]

The CBD's scrutiny adopts an integrated approach to GURTs as the latter are implicated under each of the Convention's four elements of the program of work on agricultural biodiversity.[92] As a follow-up to the above decision, two years later (2002), the sixth COP decided to establish an *ad hoc technical expert group (AHTEG) on GURTs to further analyze the potential impacts of GURTs, this time, on small holder farmers, indigenous and local communities and on farmers' rights.* [93] Meanwhile, the 2000 fifth COP had invited the FAO's Commission on Genetic Resources for Food and Agriculture (FAO/CGRFA) and other relevant organizations to take a convergent approach "to further study the potential implications of genetic use restriction technologies for the conservation and sustainable use of agricultural biological diversity and range of agricultural production systems in different countries, and to identify policy questions and socio-economic issues that may need to be addressed".[94]

At its seventh biannual meeting in Kuala Lumpur in February 2004, the COP re-turned the 2003 AHTEG report on GURTs to SBSTTA, pursuant to the latter's advice requesting it to consider the report in order to provide the CBD with technical advice on the way forward in regard to GURTs.[95] Also in the same forum, the FAO/CGRFA report on GURTs which was commissioned a year earlier than the AHTEG mandate, was submitted to the COP.[96] In approaching its assignment, the outcome of which will be presented at the eighth COP in 2006, the SBSTTA is determined to take an integrated approach to the two reports, given the different but the inter-related nature of their emphases[97] and, perhaps more importantly, because of the central role of SBSTTA in the evolving policy deliberations on GURTs. It is interesting to note that the AHTEG on GURTs recommended that the COP reaffirm its decision to withhold commercial approval of the technologies.[98] It also urged parties to the CBD "not to approve GURTs for field-testing and commercial use"[99] in light of a continued paucity of data on GURTs and in accordance with the precautionary principle.[100]

Two issues arise from the ongoing attempt at devising a policy or regulatory framework for GURTs. First, as noted earlier, the focus of the approach is on GURTs' impact on environmental, biosafety, ethical, health and food/seed security, including traditional agricultural practices in rural economies. For instance, even though the 2000 COP mandate to the FAO/CGRFA requested the latter to work in collaboration with other international agencies and research bodies, that has not really struck a balance in the focus of the discussions between environmental and safety concerns and other considerations such as intellectual property rights.[101] Similarly, the COP mandate to the AHTEG encouraged it to take into account not only the FAO/CGRFA work but that of other agencies, including the UPOV and World Intellectual Property Organization (WIPO)'s Inter-Governmental Committee on Intellectual Property and Genetic Resources, Traditional Knowledge and Folklore (IGC/IPGRTKF).[102] Even though the potential intellectual property ramification of GURTs are highlighted in both the FAO/CGRFA and the AHTEG as well as in other expert reports, because of their mandated focus on biosafety, health and socio-cultural, economic and other considerations, no robust discussion has been generated on the intellectual property question.

It must be admitted, however, that none of the bodies directly involved with the two reports on GURTs is an intellectual property body. The reference to WIPO's IGC/IPGRTKF is only as a potential collaborative institution whose interest in GURTs is perhaps perceived, albeit erroneously, as peripheral. Neither WIPO nor the IGC was represented at the AHTEG deliberations; and the WIPO did not send a written memo.[103] On the contrary, UPOV which administers the international treaty on PVP or plant breeders' right — a form of intellectual property right — was actively represented at the deliberations. UPOV did not only make an elaborate presentation, it also, in a rather controversial circumstance, submitted two memos to the CBD secretariat articulating its position.[104] However, UPOV shied away from seizing the momentum to open an elaborate discussion on the policy implications of GURTs as self-enforcing technological intellectual property. Rather, it adopted a self-serving approach and limited its participation to highlighting key advantages of the UPOV PVP regime over GURTs. Compared to the UPOV PVP model, GURTs, the UPOV position paper rightly concluded, "may have considerable disadvantages for society".[105] In essence, UPOV portrayed the potential introduction of GURTs as a punitive fate that awaits recalcitrant farmers should they undermine the UPOV plant breeder regime.[106]

Shortly after the AHTEG meeting, the U.S. disclaimed the UPOV criticism of GURTs.[107] Consequently, UPOV withdrew it first memo and substituted one that abandoned its original and informed criticism of GURTs. The result is that whilst technical and expert opinions on potential environmental, biosafety, health, agronomic and other impacts of GURTs are elaborated in the two major ongoing CBD initiatives on GURTs, intellectual property receives only peripheral treatment and is not considered a key subject matter in the mandates and terms of reference of both FAO/CGRFA and the AHTEG and the first mandate of the SBSTTA.

The second issue is that through ongoing deliberations, agrobiotech and multinational seed corporations are able to make the case that GURTs have additional benefits beyond the popular and yet undisputed belief that they are technological control mechanisms for appropriation of investment returns on agricultural biotechnology. Thus, no discussion of GURTs would be complete without mention of the technologies' less-talked-about potential benefits. Mention of just a few key such benefits will suffice.

Perspectives on Potential Benefits of GURTs

On an ironic note, though major concerns about GURTs, like all GM crops, hinge on their indeterminate potential long term environmental consequences, GURTs, especially V-GURTs, constitute devices that aim at controlling unwanted escape of genetic material into the wild or the environment. Perceived as "efficient technology for environmental containment of transgenic seed (V-GURTs) or transgene (T-GURTs)",[108] this characteristic of GURTs is said to be biotechnolgy's solution to the topical question of how to mitigate the liability of proprietary rights holders for crop contamination, i.e., intruding transgenic species in the wild or in organic or even other transgenic farmer's fields.[109] However, as attractive as that seems, for open-pollinating species potential outcrossing of V-GURT varieties, or in the case of T-GURTs, of negative traits, through natural dispersal of excess pollens may have a counterproductive effect.

This may result in spreading sterility or unwanted traits, by horizontal gene-flow, into neighboring and wild relatives.[110] Also, as part of their potential advantage, T-GURTs have the unique potential to enable farmers to time target the activation of a desirable trait, or withhold the same, on the basis of the prevailing exigency at that phase of plant or animal development.[111] Thus, even though there is credibility in the claim that GURTs have potential environmental benefits by curtailing transgenic pollution or gene wandering, such a claim is not absolute, especially in relation to open-pollinating as opposed to self-pollinating crops.[112] Overall, GURTs have potential both as sources of environmental pollution as well as for environmental containment or preservation.

Similarly, like genetic modification practices in the agricultural sector, GURTs are perceived as biotechnological device with potentials to boost global food production and supply. At face value, the phenomenon of seed sterility is antithetical to an increase in food production because of its potential for crop contamination and consequent inducement of yield drops in cultivated areas. However, given its potential to stimulate profitable plant breeding, GURTs are likely to result in an increase in food supply,[113] mainly by formal private sector farmers. At the same time, GURTs could circumscribe availability of new and useful propagating varieties to local farming communities, and the scope of seed choice open to traditional or rural farmers. Thus, one of the criticisms of GURTs evident in both the AHTEG and the FAO/CGRFA reports is that GURTs potentially concentrate breeding efforts, with emphasis on value-added crops, in the private sector. This comes at the expense natural agro biodiversity and agronomic enhancements in traditional or informal farming practices.[114] With regard to T-GURTs, they offer farmers a menu of value-enhancing traits that collectively operate to ensure efficient crop production practices. Despite their capacity to induce seed sterility, the argument that GURTs have potential to increase food supply, albeit at some indeterminate socio-economic and environmental costs, may be hard to impeach.

As part of the broader process of genetic modification, GURTs might not only mitigate risks of potential liability in the mismanagement of biomedical and pharmaceutical research activities, they could also help achieve some degree of precision and efficiency in such activities. GURTs are exportable technologies of relevance in biomedical and pharmaceutical research and in human and animal drug trials and in the phenomenon of biopharming.[115] By means of lethal or sterile genes and trait selection mechanisms, GURTs have potential to control the use of transgenic materials against unintended purposes in unintended environments and time. For instance, V-GURTs can potentially mitigate the unwanted spread of gene-altered pharmaceutical crops or other transgenic therapeutic and biomedical research materials.

In 2002, remnants of ProdiGene biopharm corn, which is genetically engineered to produce protein used to manufacture a vaccine against swine diarrhea, sprouted amongst soybeans that were planted in the same field the subsequent year. Consequently, they polluted crops meant for human consumption.[116] Meanwhile, the polluted soybeans became intermixed with other soybeans from other sources and required removal from the human food chain. In another incident, ProdiGene's biopharm corn was suspected to have polluted normal corn planted for human consumption adjacent to the transgenic biopharm corn field. This resulted in the destruction of 155 acres of corn fields.[117] Similarly, StarLink corn which was engineered to produce a bacterial protein[118] that creates Bacillus thuringiensis (Bt) insect resistance, was originally approved for animal feed. This was because of its known adverse and allergic effect on humans. But in 2000, the transgenic corn created panic when food stuff associated with it found its way onto supermarket shelves in the U.S..[119] With incidents of the pollution of non-transgenic crops by transgenic breeds and accidental intermixing of biopharm crops with their counterparts meant for human consumption,[120] the potential relevance of GURTs in environmental containment as applied to the biopharmaceutical and medical research context presents one of the possible benefits of the technologies.

Lastly, GURTs represent a potential catalyst for research and development (R & D) in agricultural biotechnology.[121] Again, like genetic engineering in food and agriculture, GURTs have the potential to enhance knowledge about plant genomes and overall functional understanding of plant and animal genetics and reproductive biology.[122] There are at least two perspectives to the view that improving R & D in agricultural biotechnology is one of the benefits of the GURTs. The first derives from the nature of the technology and science of GURTs. Technologies, such as T-GURTs, for instance, that have the potential to identify, explore and to functionally control the immense genetic potentials in plants for targeted objectives, have the promise of pushing the frontiers of agricultural biotechnology to an unprecedented level. Perhaps there is no more direct evidence of this than in the continued research and application for GURTs patents even though the technologies are yet to be approved for commercial exploitation.

The second perspective to the view that GURTs are a potential boost to R & D in agricultural biotechnology is anchored on the principal objective of the technologies. We have previously identified this objective as the need to ensure profitable appropriability of returns on investments and concentration of seed monopoly in transnational seed corporations, a trend which critics describe as "biosafedom".[123] As a technological control strategy that plugs the "leaky" loopholes of the permissive PVP regime and other constraints of conventional intellectual property rights, GURTs are the potential armour that the industry appears to have been waiting for to decisively win their running battle with farmers' rights to use farm-saved seeds. Capturing industry sentiments, Pendleton argues that "[t]he combination of poor legal protection for innovations in crops and easy appropriation of IP limits companies' willingness to expend significant amounts of capital required to develop advanced crops".[124] According to him, in addition to good "farmstead economics", improvement in global food supply hinges for the most part on efficient and cost-effective intellectual property which terminator technology offers.[125]

In their study, economists Srinivasan and Thirtle found that "[i]f terminator technology were to be applied to self-pollinated crops, appropriability of returns would increase dramatically and the level of research expenditures could potentially go up to the level of hybrid crops, *i.e., increase four times the current level".*[126] Because of their unequivocal potential value, generally, the debate over terminator technology now transcends an inquiry unto whether they could satisfy the ever-changing utility tests in modern patent jurisprudence.[127] It needs evaluating how fit is a self-enforcing technological or molecular control alternative to intellectual property can be as a substitute to conventional intellectual property. To what extent, if at all, can terminator technologies accommodate the public policy considerations that underlie conventional intellectual property rights? That is the central consideration of Part III.

Part III

GURTs: Public Policy Deficit of a Technological Alternative to Intellectual Property

Intellectual Property Theories and Public Domain Imperative

There are diverse and often overlapping theories of intellectual property rights.[128] However, all of them share the consensus that intellectual property rights are "loose clusters of legal doctrines"[129] that supervise the allocation of rights over knowledge.[130] Since our major focus is not on intellectual property jurisprudence *per se, elaboration of theories of intellectual property will not burden this paper. It suffices to tap into two of the* leading theoretical perspectives on intellectual property relevant to our discussion on GURTs, namely, the incentive/reward and contractarian theories of intellectual property rights.

The general view that GURTs, as watertight technologies or molecular control mechanisms, will boost R & D in agricultural biotechnology is premised on one of the fundamental theories of intellectual property rights. It stems from the notion that an appropriate incentive or reward mechanism for innovation, be it by way of intellectual property or not, results in increased inventiveness. While the truth of this claim cannot be easily dismissed, nonetheless, it is not absolute.[131] Innovations in biotechnology or other areas of human endeavour would continue to occur with or without the existence of appropriation mechanisms. A better view would be that, whether in its conventional or an imitative technological form such as GURTs, intellectual property is a useful incentive to enhance the commercialization of innovation more than it is a motivation for inventiveness.[132]

The contractarian doctrine of intellectual property right supports a concept of notional contract between an innovator and the state. In exchange for the disclosure of valuable information, the latter grants a creator or inventor of intellectual work an exclusive right of exploitation of the work for a *fixed period after which* the work resides in the *public domain.*[133] While this theory may be more apt in the realm of patents and PVP regimes, it applies with lesser persuasion to copyright and trademarks, and does not have practical relevance to trade secret.[134] Nonetheless, a fundamental strength of intellectual property rights which applies to virtually[135] all their divergent but inter-related theoretical justifications, including the reward/incentive and contractual accounts, is the recognition of residual domiciliation of, and access to, useful knowledge in the public domain. We will return to this point shortly.

In addition to its uneven scope of application over different regimes of intellectual property rights, one other drawback of the contractarian model is that there is no objective way of balancing the value of the monopoly conferred on the inventor or rights holder. Specifically, it is hard to ascertain whether the value of the monopoly is commensurate with society's benefit in a given invention. Similarly, it is not clear if the inventor is short-changed by the traditional time limit of the monopoly in comparison to the invention's potential interminable residual value in the public domain. If anything, this goes to show that intellectual property transcends economic considerations and cannot be accurately evaluated on that basis.

The above synopsis merely samples the controversial nature of theorizing intellectual property rights. Because each traditional theory of intellectual property *rights provides some accurate but not entirely absolute degree of theoretical justification, there is no exclusive or unified theory of intellectual property rights.*[136] This is more so because the dynamism in the nature and evolution of technology, knowledge and information, foists on intellectual property an equally dynamic and correspondingly malleable character. Thus, if ever there is a characteristic common to all regimes of intellectual property rights, it is their instrumentalist character.[137]

As a mechanism for allocation of rights over knowledge, intellectual property serves the instrumental purpose of mitigating and balancing often competing claims of both the knowledge generator and that of society in the use of knowledge. Conventional intellectual property rights recognize the legitimacy of creators' or inventors' claim to exclusive exploitation of their knowledge under the "just dessert" philosophy.[138] Of equal concern to intellectual property as a matter of policy endorsed by statute, is the need to encourage creativity, inventiveness and knowledge generation.

In *Feist Publication Inc. v. Rural Telephone Service Company,*[139] speaking in relation to copyright, the U.S. Supreme Court observed that the "promotion of progress of science"[140] is the cardinal objective of copyright. This observation captures the jurisprudence of intellectual property. Reiterating the same rationale, the Canadian Supreme Court has held recently, first in *Théberge* and reaffirmed in both *Desputeaux and CCH Canadian* *that copyright law should aim at mitigating and balancing the competing interests in the encouragement and dissemination of intellectual and creative works and creators' desire for just rewards for their efforts.*[141]

In its historical evolution, patent has been associated with well-reasoned public policy regarding the granting of privileges on the basis of careful consideration and balancing of interests.[142] Intellectual property is a mechanism that, among other things, aims at promoting the advancement of, and access to knowledge in the arts, science, technology and all fields of human ingenuity. For instance, copyright encourages a concept of originality that enables authors to build upon the earlier works of others.[143] Despite its emphasis on novelty, patent law recognizes true inventors as those who stand on the shoulders of others to make unique contributions that advance knowledge.[144] And since one of its main missions is promoting the generation of knowledge, intellectual property jurisprudence recognizes that no knowledge is generated in isolation.[145]

*Intellectual property's underlying jurisprudence is not simply a matter of a monopoly economics of inven-*tion and creativity. The ability of inventors and creators of intellectual work to engage in sustainable generation of knowledge is linked to a vibrant flow of knowledge in the fountain of the public domain.[146] Since no knowledge is generated in isolation, a rich public domain is a treasure haven and feeder artery that supplies the lifeblood for intellectual creativity in the private domain. *Thus, as part of its underlying public policy, intellectual property rights jurisprudence strives to balance the utilitarian and economic arguments for private domain monopoly and the need to increase the sphere of "public domain available for creative manipulations and expression"*[147] in order to fulfill the mission of knowledge promotion, diffusion and dissemination. To achieve this all important balance, patent laws, for example, requires disclosure of valuable information in exchange for imposing a fixed duration of monopoly for rights holders. It also grants other specific statutory and common law exemptions to monopoly rights.

A few illustrations of conventional intellectual property rights' public policy strategy to mitigate the tension between private domain monopoly and public domain consideration will now be helpful. We begin with copyright. Like most regimes of intellectual property, copyright imposes a fixed duration for a creator or author's copyright in a protected work. Perhaps the copyright regime's respect for the diffusion of knowledge is more pronounced during the life of a copyrighted work. This *is seen in the exemptions created on the basis of fair* dealing, which include research or private study, criticism or review, and news reporting.[148] While courts struggle to interpret the scope of these exemptions and to balance the competing interests in the context of the complex nature of multiple claimants to rights in created *works, especially in the digital era,*[149] these exemptions *underscore the point that diffusion of knowledge is a public policy imperative of intellectual property rights.*

Unlike copyright, the patent regime does not extend generous exemptions. However, for the most part, it upholds the policy of encouraging diffusion of knowledge by insisting on a meticulous process of disclosure of protected inventions by way of patent specification[150] and by a strict enforcement of the fixed patent term. It bears no stressing that the requirement of disclosure and a fixed duration pave the way for a residual deposit of vital knowledge in the public domain so as to facilitate development and diffusion of technology.[151]

Because of its territorial limits as a subject matter of national law, patent law also serves other instrumental objectives. For instance, ideally, a country can determine, from time to time, the scope or limits of patentable subject matter in order to ensure quicker diffusion of knowledge in areas of national socio-economic policy priority.[152] Furthermore, patent law serves a public policy objective by being deliberately restricted in a manner to protect *ordre public or morality and to avoid commercial exploitation of other culturally sensitive and prejudicial endeavours.*[153] In essence, intellectual property strives to ensure the balancing of diverse policy considerations, including the need to reward creators of innovation on the one hand, and generation, diffusion and dissemination of knowledge in the public domain, on the other.

Finally, both national and international PVP regimes under the UPOV, as *sui generis forms of intellectual property rights, uphold the requirement of disclosure and a fixed duration of rights for breeders. At its early phase, plant patents required the deposit of samples of a novel variety since conformity with technical requirements of patent specification was then hard to* achieve in the plant breeding context.[154] In addition to disclosure and a definite duration of right, PVP, like copyright, provides two key exemptions, namely, farmers' or crop exemption which accommodates farmers' traditional practice to use farm-saved seeds, and research exemptions. Despite the progressive circumscription of the scope of these rights through the transformation in the PVP regime explored in Part I, preservation of some of the rights are indicative of the fundamental policy thrust of intellectual property rights in regard to diffusion of knowledge and the protection of the public domain.

As evident in Part I also, the two exemptions are the "leaky" windows that GURTs attempt to permanently shut. Not only that GURTs could close the window of exemptions, the former also have the potential to undermine the disclosure requirement and the fixed term of intellectual property rights and, with that, dispense with key public policy imperatives that underlie the jurisprudence and theory of intellectual property rights in favour of one-sided monopoly economics of invention and creativity.

Intellectual Property, Local PGR Knowledge and GURTs

As an aspect of its instrumentalism, intellectual property is, historically, a malleable phenomenon. As we have seen in Part I, the progressive re-conceptualization of PVP law demonstrates the dynamism of intellectual property rights through which it accommodates changes in knowledge and technology, socio-economic and other public policy imperatives. The same is true of the extension of the patent paradigm to living materials. As a technological imitation of intellectual property rights, GURTs do not have the traditional flexibility of intellectual property rights the significance of which, in the PGR context, is a hot button issue. Over the last three decades, there have been concerted efforts, especially through various international environmental treaties, like the CBD, and organizations such as WIPO and the FAO, to commence a preliminary dialogue on reconfiguring conventional intellectual property in response to what a writer has called its crisis of legitimacy.[155] This is a reference to the inability of intellectual property to accommodate informal local or indigenous knowledge forms.

In the context of PGR, both the FAO/ITPGRFA[156] and the CBD[157] realize that indigenous knowledge accumulated through multi-century trans-generational labours of farmers in the development and preservation of plant varieties, provide the primary resources now being "improved" and appropriated by scientific corporate breeders.[158] In this regard, there is an ongoing debate on how to ensure that indigenous knowledge is adequately accommodated, if not by conventional intellectual property rights, by its *sui generis or cross-cultural formulations.*[159] Perhaps more importantly, the re-conceptualization of intellectual property rights in response to the demand of local knowledge holders have entrenched the concept of equitable "benefit-sharing" for all stakeholders, especially in the development and use of PGR. Under GURTs, the ongoing debate to address the crisis of legitimacy in the intellectual property system in *order to, among other things, accommodate indigenous or local knowledge forms and benefit-sharing in PGR is* potentially foreclosed because of the technologies' one-sided focus on breeders' interests.

We have noted that before the advent of formal scientific breeding, farmers' agronomic innovations were incremental in nature and arose as incidences of their informal dealings with PGR. The problem of appropriation of returns to innovation hardly assumed a centre stage. The public sector's dominant involvement in the early stage of agricultural biotechnology and agro science research ensured that the situation remained undisturbed. The entrance of the private sector into formal scientific research in agriculture raised the critical issue of appropriation of returns on investment, particularly upon the backdrop of declining public sector commitment to such research. Even in that context, the invocation of traditional intellectual property regimes or their sui generis options, such as PVP, was gradual in its extension to the realm of living materials after historic reluctance. When it did, it recognized that by their nature and on the basis of history, PGR has fostered agronomic progress and agro biodiversity through a public domain regime of crop diffusion. Exemptions, such as farmers' right to use farm-saved seeds, researchers' experimentation, the need for disclosure of innovation and the limited terms of intellectual property, all helped to ensure some measure of diffusion of knowledge in plant biotechnology without necessarily compromising innovators' monopoly claims.

Before GURTs, or more appropriately without GURTs, it can be argued that the prevailing approach to the diffusion of agricultural innovation is far more sensitive to the public domain than would be possible if GURTs were commercially approved. This is so despite the progressive curtailing of the scope of farmers' and researchers' exemptions under the PVP regime, and their complete absence in the utility patent framework. Indeed GURTs have the potential to concentrate agricultural research in the private sector and to restrict diffusion of the resulting knowledge. As "a technology with no agronomic benefit to farmers",[160] GURTs underscore the limitations of a technology control mechanism and their inherent crisis of fitness as a potential substitute to intellectual property. GURTs do not account for the underlying public policy consideration of intellectual property rights, namely, the balancing of the interests of innovators and that of users or the public and perhaps more importantly, the need to encourage the promotion, *diffusion and dissemination of knowledge. Along these* sentiments, Pendleton avers that "[i]n contrast to the farmers of the 19th century and public breeding programs of the 20th century, the 21st century agribusiness concern is less concerned with sharing discovery than with selling them".[161]

GURTs are deficient in at *least five public policy features of the intellectual property rights. First, unlike patents, GURTs are not limited by a fixed term. A sterile* seed is an irrevocably suicidal breed that has no redemptive agronomic value that could reside in the public domain. Second, GURTs, again unlike patents, do not have a compulsory disclosure requirement and, as such, create no notional contractual obligation on the breeder. Third, GURTs, unlike PVP, do not have farmers' and researchers' exemptions and are not susceptible to other instrumental public policy interventions common to traditional intellectual property rights. Fourth, GURTs do not have a mechanism for balancing the competing interests of innovators and users of protected varieties and the public domain at large. Fifth, GURTs do not account for benefit-sharing or for the potential to accommodate informal farmers' or indigenous contribution to improvements in PGR.

As self-enforcing technological device, GURTs represent an efficient imitation of intellectual property, especially the patent regime. Because of its tight use restriction focus or framework,[162] it does not factor in the underlying public domain orientation of intellectual property jurisprudence. Thus, it has all the attractions of intellectual property, especially the patent regime, while it portends to confer only a fraction of its benefits to only a portion of stakeholders.[163] Even though the component technologies underlying GURTs may be the subject of patents and/or PVP, their relevance lie in facilitating the primary purpose of promoting sterility and restriction of the use of protected traits, thereby circumscribing the two major points of diffusion of knowledge and the promotion of crop potential agronomic benefits. GURTs potentially limit farmers' dealing with PGR to growing and selling of commodity grains[164] for consumption or other uses. In the specific case of V-GURTs, farmer's dealing with seed is circumscribed by the breeders' remote control of value-added traits. In effect, GURTs are potential threat to farmers' traditional sources of agronomic innovation.

Conclusion

The exponential progress made in agricultural biotechnology in the last couple of decades and the decline of public financing of agricultural research have yielded the entrenchment of the private sector in agricultural biotechnology research and exploitation. This state of affairs has heightened the pressure from industry stakeholders for a profitable appropriation of return on investments in agricultural biotechnology, especially seed production. Through progressive refinements, intellectual property rights, both in their conventional and *sui generis* formulations, have extended their paradigms to living materials after a historic reluctance. Also, they have attempted to circumscribe, or more appropriately, to regulate farmers' exploitation of the propagating nature of seeds so as to accommodate plant breeders' claim for reward for their investments. In these endeavours, intellectual property rights have not completely undermined their public policy thrust in regard to balancing the interests of innovators against the need for the diffusion of knowledge and the protection of that knowledge in the public domain.

The advent of terminator technology is the latest attempt by industry to seek a tighter appropriation model that has the potential to shut out the public policy concessions and exemptions that are available to farmers and users of PGR under intellectual property rights. Despite their potential to stem the tide of gene wandering, essentially, GURTs are self-enforcing cellular or molecular technological alternatives to, or imitations of, conventional intellectual property protection mechanisms. As a techno-fix to seed industry's institutional problem, GURTs have the attractions of intellectual property. However, they are deficient in terms of the underlying public policy: the technologies mainly address the needs of the seed industries at the expense of farmers and other users of PGR, and generally disregard the diffusion of agronomic innovation knowledge. Technological devices, no matter how ingenious, cannot fit within the pantheon of conventional intellectual property rights.

Like its precursor in crop hybridization,[165] economists are wont to argue that the potential success of GURTs may be a matter for market forces to determine.[166] However, the public policy thrust of intellectual property rights regarding diffusion of knowledge in the public domain, transcends interests that propel and justify economic and market forces arguments. Indeed, the long term consequences of a device that has no, or, at best doubtful agronomic benefit may never be known or measured in strict economic terms. As such, the public policy that underlies intellectual property philosophy is one which technology alone is incapable of meeting. In the context of PGR, GURTs undermine all existing concessions inherent or provided under the regime of intellectual property and its promise in terms of equitable benefit sharing of PGR and accommodation of indigenous knowledge in the direction of a cross-cultural dialogue on intellectual property rights.[167]

Current public policy scrutiny of GURTs, as championed by the CBD, has continued to emphasize environmental, biosafety and socio-economic concerns. Although intellectual property has been implicated and incorporated in the ongoing initiatives, there is no concrete, focused or institutional attempt to explore the implication of the attempt by this technology to usurp or undermine conventional intellectual property regime. In order to have a balanced and informed policy on GURTs in the unfolding conversation, the present emphasis on environmental, health, safety and socio-economic concerns must be balanced with a more elaborate consideration of intellectual property. Without doubt, a stronger involvement by WIPO and other relevant intellectual property organizations is imperative in the ongoing scrutiny of GURTs.

Notes:

[1] Hinting on a potential *nunc demitis of intellectual property in the context of biotechnological innovations, renowned civil society activist, Pat Mooney, observes that arguably "IP is no longer essential — or, at least, the sole effective mechanism" for the protection of stakeholders' interests in biotechnology. See Pat Roy Mooney, "The Impetus for and Potential of Alternative Mechanisms for the Protection of Biotechnological Innovations" (Paper prepared for the Canadian Biotechnology Advisory Committee Project Steering Committee on Intellectual Property and the Patenting of Higher Life Forms, March 2001) at 8 online: CBCA, http://cbac-cccb.ic.gc.ca/epic/internet/incbac-cccb.nsf/vwapj/AltMechanisms_Mooney_e.pdf/$FILE/AltMechanisms_Mooney_e.pdf and http://*cbac-cccb.ca/epic/internet/incbac-cccb.nsf/en/ah00381e.html [Mooney].

[2] See George S. Takach, *Computer Law, 2nd ed. (Toronto: Irwin Law, 2003) at 79. The easy reproducibility of computer programs is analogous to that of seed; hence, the appropriability of innovations in digital and plant biotechnologies poses identical challenges. See Drew L. Kershen, "Of Straying Crops and Patent Rights" (2004) 43 Washburn L.J. 575 at 586 [Kershen].*

[3] Terminator is analogized to the "time-travelling deadly cyborg" acted by *California Governor, Arnold Schwarzenegger in the science fiction movie, "The Terminator". See Cullen N. Pendleton "The Peculiar Case of 'Termi-*nator' Technology: Agricultural Biotechnology and Intellectual Property *Protection at the Crossroads of the Third Green Revolution" (2004) 23 Biotech. L.R. 1 at 1 [Pendleton]; see also Eric Niiler, "Terminator Technology Temporarily Terminated" (1999) 17 Nature Biotechnology 1054. While industry prefers the technical term, genetic use restriction technologies (GURTs) which is an umbrella expression that encompasses concepts underlying the technologies, civil society and environmental NGOs prefer to use the more explosive term terminator in order to emphasize the* notion of seed sterility as the principal feature of the technologies.

[4] See *supra note 3 and accompanying text.*

[5] U.S. Patent No. 5,723,765 titled "Patent for the Control of Plant Gene *Expression" granted to joint applicants: the United States Department of Agriculture (USDA) and cotton giants, Delta and Pine Land Company. See infra note 71.*

[6] See, for example, Devlin Kuyek, "Genetically Modified Crops in African *Agriculture: Implications for Small Farmers" (briefing paper prepared for Genetic Resources Action International (GRAIN) Geneva, August 2002) online: GRAIN, http://www.grain.org/briefings/?id=12 [Kuyek].*

[7] In many indigenous farming communities and cultures, seeds are not only genetic copy propagation materials but they are also exchanged as symbolic gestures for fostering goodwill through marriage and for the sustenance of a trans-generational legacy of ecological sanctity through good breeding and agricultural practices between families and communities. It is commonplace in many African societies, for example, for families to give women (who form the bedrock of African agriculture) gifts of special seeds and domestic animal breeds with which to begin a new family after marriage.

[8] Namely, Monsanto, Astra-Zeneca, Dow, Novartis, Dupont, AgrEvo. See C.S. Srinivasan & Colin Thirtle, "Impact of Terminator Technologies in Developing Countries: A Framework for Economic Analysis" in R.E. Evenson, V. Santaniello & D. Zilberman, eds., Economic and Social Issues *in Agricultural Biotechnology (New York: CABI Publishing, 2002) 159 at 168 [Srinivasan and Thirtle].*

[9] *Ibid. at 168.*

[10] For example, in 2000 the CBD adopted the largely critiqued Cartagena *Protocol on Biosafety which purports to regulate international transport and release of genetically modified organisms to protect natural biological diversity. The text of the protocol is available online: Convention on Biodiversity http://www.biodiv.org/biosafety/articles.asp?lg=0&a=bsp-00. See Carlos Scott Lopez, "Intellectual Property Reform for Genetically* Modified Crops: A Legal Imperative" (2004) 20 J. Contemp. Health L. & Pol'y 367 at 384–385 [*Lopez*]*; Henrique Freire Oliveira de Sousa, "Genetically Modified Plants: A Need for International Regulation" (2000) 6 Ann. Surv. Int'l & Comp. L. 129 at 159–161 [de Sousa]. For a critique of the protocol, see Kuyek, supra note 6 at 8.*

[11] See *infra notes 91 and 99 and accompanying texts.*

[12] Reprinted in 31 I.L.M. 818 (1992).

[13] See discussions in part II, below.

[14] See *Lopez, supra note 10 at 388, Pendleton, supra note 3 at 17-18; Jeremy P. Oczek, "In the Aftermath of the Terminator Technology Controversy: Intellectual Property Protections for Genetically Engineered Seeds and the Right to Save and Replant Seed" (2000) 41 B.C.L. Rev. 627 at 628-9. [Oczek].*

[15] *Srinivasan and Thirtle, supra note 8 at 165.*

[16] *Ibid. at 171; see also infra note 160. The notion that terminator provides no agronomic benefit to farmers may not be conclusive yet since the ramifications of these technologies are yet to crystallize.*

[17] *Srinivisan and Thirtle, supra note 8 at 161.*

[18] See Chidi Oguamanam, "Localizing Intellectual Property in the Globalization Era: The Integration of Indigenous Knowledge" (2004) 11 Ind. J. Global Legal Stud. 135 at 144 [Oguamanam]; see generally Noami Roht Arriaza, "Of Seeds and Shamans: The Appropriateness of Scientific and *Technical Knowledge of Indigenous and Local Communities" (1997) 17 Mich. J.Int'l L. 940.*

[19] See *Srinivisan and Thirtle, supra note 8 at 161.*

[20] See OECD, *Traditional Crop Breeding Practices: An Historical Review to Save as a Basis for Assessing the Role of Biotechnology (Geneva: OECD, 1993).*

[21] See B.W. Bugbee, Genesis of American Patent and Copyright Law (Washington D.C.: Bureau of Public Affairs, 1967) [*Bugbee*]*; see also Fritz Malchup, United States Senate Committee on the Judiciary, Subcommittee on the Patents, Trademarks, and Copyrights, 85th Congress, Second Session, An Economic Review of the Patent System (S. Doc. No. 15) [Malchup].*

[22] *Malchup, ibid.*

[23] This was premised on the notion of common heritage and free exchange which enabled industrialized nations with superior scientific capacity to *appropriate exotic PGR from gene-rich countries. See Jack Kloppenburg Jr., First the Seed — The Political Economy of Plant Biotechnology, 1492–2000 (Cambridge, Cambridge University Press, 1998) at 167 [Kloppenburg Jr.].*

[24] For perspectives on the expansion of the concepts of patentability to living materials, see Ikechi Mgbeoji, *Patents and Plants: Rethinking the Role of International Law in Relation to Appropriation of Traditional Knowledge of Uses of Plants (J.S.D. Thesis, Dalhousie Law School, 2001) [unpublished] at 284–349 [Mgbeoji].*

[25] *Supra note 8 at 161.*

[26] See J.M. Alston, P.G. Pardey and V.H. Smith, "Financing Agricultural R & D in Rich Countries: What is Happening and Why" (1998) 42 Austl. J. Agric. Resource Econ. at 51–82. The authors observe that public sector support for agricultural R & D in developed countries increased between 1945 and the mid 1970s to a level higher than the rest of the post-World War II period and has remained in fluctuating but declining state ever since. The same pattern is true of developing countries. See generally *Mooney, supra note 1.*

[27] Through the use of molecular biology concepts, biotechnology facilitates the identification and tracing of varieties and their progeny. This enhances the enforcement of intellectual property over proprietary PGR.

[28] *Kloppenburg Jr., supra note 23.*

[29] *Srinivasan and Thirtle, supra note 8 at 162.*

[30] See Samantha M. Ohlgart, "The Terminator Gene: Intellectual Property Rights vs. Farmers' Common Law Rights to Save Seed" (2002) Drake J. Agric. L. 473 at 479 [*Ohlgart*].

[31] See *Mgbeoji, supra note 24 at 322-323. For instance, in the place of technical description, a deposit of sample variety of plant to be protected sufficed. See Srinivasan and Thirtle, supra note 8 at 163.*

[32] For instance, Netherlands had its Plant Breeding Ordinance in 1941. In Germany, the Law on the Protection of Varieties and Seeds of Cultivated *Plants was enacted in 1953. By the 1960s, most European States had their individual versions of PVP legislation.*

[33] *Plant Patent Act, 1930, 35 U.S.C. § 163 (2002)*

[34] *Plant Variety Protection Act, 1970, 7 U.S.C. § 2321 (2002).*

[35] See *Mgbeoji, supra note 24 at 384–385.*

[36] December 2, 1961, 815 U.N.T.S. 89 as Revised at Geneva on November *10, 1972, on October 23, 1978, and on March 19, 1991; popularly known by its abbreviation, UPOV which stands (in French) for Union pour la Protection des Obstentions Vegetales. Text of UPOV is available online:*

UPOV http://www.upov.int/en/publications/conventions/1991/content.htm.

37 It needs to be pointed out that the earlier version of UPOV contained only three criteria, namely, distinctiveness, uniformity and stability. The addition of the "novelty" criterion is owed to the 1991 revision which reflects advances in biotechnology that have made it possible to engineer new breeds that satisfy the novelty and non-obvious criteria. See Michael Halewood, "Indigenous Knowledge in International Law: A Preface to Sui Generis Intellectual Property Protection" (1994) 44 McGill L.J. 953 at 962.

38 The two exemptions are contained in the UPOV revisions of 1978.

39 For the first time, this "privilege" was elevated to the status of a "right" under the 2001 FAO International Treaty on Plant Genetic Resources for Food and Agriculture online: FAO ftp://ext-ftp.fao.org/ag/cgrfa/it/ITPGRe.pdf [FAO/ITPGRFA]. However, the treaty made the farmers' right subject to the national law of member states "as appropriate". This means that farmers in those states that are parties to 1991 revision of UPOV which circumscribes farmers' exemption and makes it subject to the discretion of member state and the interests of breeders, cannot fully realize the promise of FAO/IPGRFA. See Art. 9.3 of the FAO Treaty, online: FAO, http://www.fao.org/ag/cgrfa/itpgr.htm. For perspectives on the treaty, see Ali Mekouar, "A Global Instrument on Agrobiodiversity: The International Treaty on Plant Genetic Resources for Food and Agriculture" (FAO Legal Papers online #24 January 2002), online: FAO http://www.fao.org/Legal/prs-ol/lpo24.pdf.

40 See *Srinivisan and Thirtle, supra note 8 at 163.*

41 See generally *Srinivisan and Thirtle, ibid.*

42 On the impact of PVP regimes on private sector investment in non-hybrid crops in the U.S.A. and Latin America, see the following studies: Julian M. Alston, and Raymond J. Venner, "The Effects of U.S. *Plant Variety Protection Act on Wheat Genetic Improvement" (Paper presented at the Symposium on Intellectual Property and Agricultural Research, El Batan Mexico, March 5–7 1998), online: IDEAS http://ideas.repec.org/p/fpr/eptddp/62.html; B.A. Babcock and W.E. Foster, "Measuring the Potential Contribution of Plant Breeding to Crop Yields: Flu-cured Tobacco, 1954–87" (1991) 73 Am. J. Agric. Econ. 850–859, L.J. Butler, "Plant Breeders' Rights in the U.S.: Update of a 1983 Study" in J. Van Wijk W. Jafe, eds., (Proceedings of a Seminar on the Impact of Plant Breeders' Rights on in Developing Countries, Santa Fe Bogota, Colombia,* March 7-8, 1995) (Amsterdam: University of Amsterdam, 1995) 17–33, *L.J. Butler and B.W. Marion, The Impact of Patent Protection on the U.S. Seed Industry and Public Plant Breeding Food Systems Research Group,* Monograph 16 (Madison: University of Wisconsin, 1985), W. Jaffe and J. Van Wijk, *The Impact of Plant Breeders' Rights in the Developing Countries: Debates and Experience in Argentina, Chile, Colombia, Mexico, Uruguay (Amsterdam: Inter American Institute for Co-operation in Agriculture and University of Amsterdam, 1995), R.R. Kalton, P.A. Richardson and N.M. Frey, "Inputs in Private Sector Plant Breeding and Biotechnology Research Programs in the United States" (1989) 5 Diversity* 22–25; R.K Perrin, K. A. Kunnings, L.A. Ihnen, "Some Effects of the U.S. *Plant Variety Protection Act of 1970", Economics Research Report No. 46, Department of Economics, North Carolina State University, 1983. (All studies are cited in Srinivisan and Thirtle, supra note 8 at 163). See also Mooney, supra note 1 at 10.*

43 The first revision was in 1972.

44 See art. 15(2) of the 1991 revisions of UPOV, *supra note 36.*

45 This happens, for example, in a circumstance where the breeder was not *able to enforce his right over the propagating material. See Srinivasan and Thirtle, supra note 8 at 164; see also art. 14(2) of the 1991 revisions of the UPOV, ibid.*

46 According to *Srinivasan and Thirtle, this was in an attempt to curb the phenomenon of "cosmetic breeding", a practice by which imitators used the research exemption under the 1978 UPOV to indulge in breeding competing varieties that are merely marginal to the original and protected ones. See supra note 8 at 163-64. It is to be noted that the jurisprudence on what amounts to "essential derivation" is yet to crystallize.*

47 Trees and vines have longer duration of protection, not less than 25 years, *without an upward ceiling.*

48 *Srinivisan and Thirtel, supra note 8 at 164.*

49 *Ibid.*

50 See *Plant Breeders' Rights Act, RSC 1990 c. 20 which came into force in August 1, 1990.*

51 See *supra note 34. This must be distinguished from the Plant Patent Act of 1930, supra note 35, which first established the juridical foundation for patent on plants while dealing exclusively with asexually reproducing* plants. It diluted the strict requirement of conventional patent in order to accommodate plant patent.

52 *Srinivisan and Thirtle, supra note 8 at 164; see also Pendleton, supra note 3 at 12; Kershen, supra note 2 at 605.*

53 For instance, the Fifth Circuit in *Delta & Pine Land Co. v. Peoples Gin Co. 694 F.2d 1012 (5th Cir 1983), ruled against farmers' selling of farm-saved seeds through intermediaries for the reason that the major rationale of the PVP Act, 1970, was to mitigate profiteering on proprietary seeds at the expense of breeders. The Court believed the constraining* seed middlemen would reduce the volume of commercial transactions in farm-saved seeds so as to leave conducive ground for breeder profit which would encourage agrobiotech research in accordance with the *Congressional intent for the PVP Act. Also, in Asgrow v. Winterboer, 11 S Ct. 788 (1995) — a case decided after the 1994 amendment of the PVP Act but before it came into effect — the U.S. Supreme Court upheld a Northern Iowa District Court decision that the crop (also farmer) exemption of the 1970 PVP Act limits farmers' sale of farm-saved seeds to only the same amount as a farmer would need to plant in his or her own field. Also, the Supreme Court held that the reproduction of protected variety without intent to create new ones is not permissible under the research exemption of the Act. For further insight, see Peter J. Goss, "Guiding The Hand that Feeds: Toward Socially Optimal Appropriability in Agricultural Biotechnology Innovation" (1996) 84 Cal. L.R. 1397 at 1411–1423 [Goss]; see also Oczek, supra note 14 at 639.*

54 See *Asgrow v. Winterboer, supra note 53; see also article 15(1)(ii), (iii) of* the 1991 UPOV, *supra note 36.*

55 It needs to be mentioned that both in its origin and objective, the UPOV *aims at serving the interests of mainly industrialized countries of the North who enjoy a head start in agricultural biotechnology. Although the circumstances have not changed, in the last 10 years, attempts have been made to bring on board UPOV developing countries of the South, ironically, at a time when the original exemptions (on farmers' privilege and research) of earlier UPOV have been watered down.*

56 See *Mooney, supra note 1 at 8; Kuyek, supra note 6 at 4.*

57 See Jane Matthews Glenn, "Genetically Modified Crops in Canada: Rights and Wrongs" (2003) 12 J. Envtl. L. & Prac. 281 at 291. [*Glenn]; Mooney, supra note 1 at 7.*

58 These are clauses that prohibit farmers from saving or replanting any of the seeds from proprietary parent crop. This is a very difficult clause to *enforce but it shows the extent seed corporations can go to protect their proprietary seed. See Ohlgart, supra note 30 at 478.*

59 447 U.S. 303 (1980) [*Chakrabarty].*

60 The invention by Chakrabarty, a microbiologist, derives its utility from application in cleaning up oil spills because of the ability of the bacte*rium to "eat" up crude oil.*

61 See *Chakrabarty, supra note 59 at 308. According to Justice Burger, "[t]he Act embodied Jefferson's philosophy that 'ingenuity should receive liberal encouragement'".*

62 *Ibid. at 309.*

63 See *Ex Parte Hibberd, 227 U.S.P.Q (BNA) 443 (Bd. Pat. App. & Interfer*ences 1985); see also *Goss, supra note 53 at 1404-1405; Oczek, supra note 14 at 642.*

64 In *Chakrabarty, the U.S. Supreme Court held that while it adopts a liberal approach in interpreting the Patent Act, it is left for Congress, if it so wishes, to circumscribe the scope of the Act in regard to living materials. Surely, Congress is not in a hurry to do that. Conversely, in Canada, in Commissioner of Patents v. President and Fellows of Harvard College, [2002] 4 S.C.R. 45 [Harvard Mouse], the Supreme Court held that in section 2 of the Canadian Patent Act (equivalent to U.S. section 101), Parliament did not intend to include higher life forms as "manufacture" and that if Parliament intends to make higher life forms patentable, it* may have to amend the *Patent Act. Ironically, the same Court, two years later in Monsanto Canada Inc v. Schemeiser, [2004] SCC 34 [Schemeiser], held that cells and genes as lower life forms are patentable and the same patent covers plants (higher life forms) that embody or express patented genes and cells. It is difficult to understand the distinction by the Court between lower and higher life forms in its Harvard Mouse decision two years earlier.*

65 See section 42 of Canadian *Patent Act RSC, 1985 c. P-4 which gives a patentee "the exclusive privilege and liberty of making, constructing and using the invention and selling it to others to be used".*

66 See *Kershen, supra note 2 at 582-583.*

67 *Schemeiser, supra note 64.*

68 Reprinted in 33 I.L.M. (1994), Annex 1C online: WTO http://www.wto.org/english/tratop_e/trips_e/t_agm0_e.htm [*TRIPS].*

69 Emphasis added. It is not clear what "an effective *sui generis system means". Whereas virtually all developed countries who constitute the bulk of the membership of the UPOV argue the latter's PVP regime fits the tab of "an effective sui generis system", other countries in the devel-* oping world are not so inclined. See Joan Sutherland, "TRIPS: Cultural Politics and Law Reform" (1998) 16 Prometheus 291 at 295. Many developing countries including Kenya, India, Nicaragua, Costa Rica, Zimbabwe, Thailand, Bangladesh and Pakistan are working toward an *alternative effective sui generis PVP regime outside the UPOV model. See Susan K. Sell, "Post-TRIPS Development: The Tension Between Commercial and Social Agendas in the Context of Intellectual Property" (2002) 14 Fla. J. Int'l L. 193 at 205 (observing that "[i]t is important to note that TRIPS does not require UPOV protection; UPOV protection is not* the only permissible approach to *sui generis protection").*

70 Curtis M. Horton, "Protecting Biodiversity and Cultural Diversity Under Intellectual Property Law: Towards a New National System" (1995) 10 J. Envtl. L. & Litig. 1 at 27-28.

71 See *supra note 5 and accompanying text.*

72 Apart from the U.S., terminator patents have been issued in the following countries: Canada, Australia, Belgium, Bulgaria, Denmark, France, Germany, Greece, Hungary, Italy, Liechtenstein, Luxemburg, Netherlands, Republic of Korea, Romania, South Africa, Spain, Sweden, Switzerland, Turkey and United Kingdom. Applications are pending in Brazil, Israel, *Japan, New Zealand, Norway and Slovak Republic. See Erosion Technology and Concentration Group "Defend Food Sovereignty: Terminate* Terminator", online: ETC Group, http://www.etcgroup.org/documents/terminatorbrochure02.pdf [Food Sovereignty]; see also Ikechi Mgbeoji, "The 'Terminator' Patent and Its Discontents: Rethinking the Normative Deficit in Utility Test of Modern Patents Law" (2004) 17 St. Thomas L.R. 95 at 96 and n. 1 [*Mgbeoji "Terminator"], Pendleton, supra note 3 at 25-26. See generally Erosion Technology and Concentration Group, "Terminator Technology — Five Years Later" Communiqué Issue No. 79, May/June 2003, online: ETC Group http://www.etcgroup.org/article.asp?newsid=389 [Terminator Five Years Later].*

73 See *Pendleton, supra note 3 at 25 and n. 179.*

74 *Ibid. at 25.*

75 See *Srinivasan and Thirtle, supra note 8 at 163-164.*

76 See *Pendleton, supra note 3 at 26.*

77 See *Pendleton, ibid. (arguing that it is not clear whether it is more* profitable for farmers to produce their own seed on site or to have them supplied by seed companies) at 27. It is certainly more profitable for seed companies to supply seed for hybrid crops such as maize on a yearly basis but that does not seem to be so with seed for other crops which are sold on four-five yearly intervals. It is doubtful what would be the incentive for on-site seed breeding by farmers if desirable traits in T-GURT varieties cannot be accessed. See FAO/CGRFA "Potential Impacts of Genetic Use Restriction Technologies (GURTs) on Agricultural Biodiversity and Agricultural Productions Systems — Technical Study Report by FAO and its Commission on Genetic Resources for Food and Agriculture (FAO/CGRFA) for the CBD", CGRFA-9/02/17 Annex Rev. 1 of 14–18 October 2002 para. 20, online: FAO ftp://ext-ftp.fao.org/ag/cgrfa/*cgrfa9/r9w17ae.pdf and annexed to The documents of The Convention on Biological Diversity of January 12, 2004 as UNEP/CBD/COP/7/INF/31 online: CBD http://www.biodiv.org/doc/meetings/cop/* cop-07/information/cop-07-inf-31-en.pdf [*FAO/CGRFA Technical Report].*

78 See art. 9.3 of the FAO/ITPGRFA, *supra note 39.*

79 Compare *Pendleton, supra note 3 (arguing that Government may insist upon being given the key to engineered traits as a condition for permitting the marketing of T-GURT seed varieties, perhaps in order to guard against potential agricultural crisis) at 26.*

80 See *Srinivasan and Thirtle, supra note 8 at 168; see also Mgbeoji "Terminator", supra note 71 at 98 and n. 3.*

81 *Srinivasan and Thirtle, ibid. at 163.*

82 *Ibid. at 169; see also Pendleton, supra note 3 at 24; Erosion Technology and Concentration Group "Terminator Brochure 2002 1", online: ETC Group http://www.etcgroup.org/documents/terminatorbrochure02.pdf [Terminator Brochure]. CGIAR which administers the largest global coalition of agriculture research centres, disavowed the use of terminator technology in its research institutions. Through the activities of its CGRFA and by virtue of the provisions of the ITPGRFA, FAO has shown a determination not to endorse technology that could compromise farmers' traditional right to use farm-saved seed.*

83 The decision to disavow commercialization of terminator was also made by Astra-Zeneca, the world's second largest seed company after Dupont *and Monsanto. See Terminator Technology Five Years Later, supra note 72.*

84 Companies and institutions associated with terminator patent in the U.S. include: Syngenta, Zeneca, Novartis, Dupont, Pioneer Hi-Bred, Delta & Pine Land/USADA, Basf, Exseed Genetics, L.L.C./Iowa State University, Monsanto, Cornell Research Foundation, and Purdue Research Foundation. See *supra note 71 and accompanying text.*

85 See *Pendleton, supra note 3 at 25 and note 175 citing Geoff Tansey, "Bitter Battle Over Terminator Seeds", Financial Times (London) June 15, 1999 at 2.*

86 The application of GURTs to non-transgenic material yields a GMO. *More importantly, GURT applications are currently limited to transgenic* crops or crops that are susceptible to genetic modification.

87 See Decision IV/6 Agricultural Bilogical Diversity of the 1998 COP, online: CBD http://www.biodiv.org/decisions/default.aspx?dec=IV/6; see *also the note by the Executive Secretary of the CBD's Subsidary Body on Scientific, Technical and Technological Advice of of May 17, 1999 "Con-* sequneces of the Use of the New Technology for the Control of Plant Gene Expression for the Conservation and Sustainable Use of Biodiversity'' UNEP/CBD/SBSTTA/4/9/Rev.1 online: CBD http://www.biodiv.org/doc/meetings/sbstta/sbstta-04/official/sbstta-04-09-rev1-en.pdf [*UNEP/CBD/SBSTTA/4/9/Rev.1].*

88 Experts were drawn from biotechnology, plant breeding and agronomy, intellectual property, and other knowledgeable persons intersecting legal and socio-economic aspects of GURTs.

89 See Richard A. Jefferson, Don Byth, Carlos Correa, Garardo Otero and Calvin Qualset, "Genetic Use Restriction Technologies: Technical Assess-*ment of the Set of New Technologies which Sterilize or Reduce the Agronomic Value of Second Generation Seed as Exemplified by U.S. Patent No. 5, 723, 765, and WO 94/03619 — Expert Paper Prepared for the Secretariat of the Convention on Biological Diversity, 30 April 1999 (annexed to UNEP/CBD/SBSTTA/4/9/Rev. 1, supra note 87)".*

90 See Decision V/5 of the fifth COP titled "Agricultural biological diversity: *review of phase I of the programme of work and adoption of a multi-year work programme" online: CBD http://www.biodiv.org/decisions/default.aspx?m=COP-05&id=7147&lg=0 paras. 19 and 28 [COP Decision V/5].*

91 See "Agricultural Biodiversity: Genetic Use Restriction Technologies" online: CBD http://www.biodiv.org/programmes/areas/agro/gurts.asp.

92 The Convention divides its approach to agricultural biodiversity into **assessment** of status and trend in agrobiodiversity, identification and promotion of adoptive management practices and incentive measures in response to agrobiodiversity, promotion of capacity-building for farmers and other stakeholders in sustainable agrobiodiversity practices and mainstreaming of coordinated and integrated national policies, strategies and action plans on agrobiodiversity. See CBD, "Agricultural Biodiversity Work Programme", online: CBD, http://www.biodiv.org/programmes/areas/agro/programme.asp.

93 See *COP Decision V/5, supra note 90, para. 21.*

94 See *ibid. para 20-21.*

95 See COP Decision VII/3 online, CBD, http://www.biodiv.org/decisions/*default.aspx?m=COP-07&id=7740&lg=0 para. 4.*

96 See *FAO/CGRFA Technical Report, supra note 77. According to the FAO, this report was delayed because of the preoccupation of the body and its CGRFA with the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) which was signed in November 2001.*

97 For instance, in a notification memo of the SBSTTA meeting issued on *behalf of the latter by the Executive Secretary of the CBD, the scribe requested that public comments on GURTs should not include views already reflected in the AHTEG report and that of the FAO/CGRFA. See CBD notification No. 2004-091 dated November 1, 2004 online: CBD http://www.biodiv.org/doc/notifications/2004/ntf-2004-091-gurt-en.pdf.*

[98] See Recommendations of the AHTEG Report UNEP/CBD/SBSTTA/9/INF/6 (annex II) para. (a) online: CBD http://www.biodiv.org/doc/meetings/sbstta/sbstta-09/information/sbstta-09-inf-06-en.pdf [*AHTEG Report*].

[99] *Ibid. para. (b).*

[100] See principle 15 of the Rio Declaration on Environment and Development, June 14, 1992, 31 I.L.M. 874 online: United Nations http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm. In a nutshell, under this principle, lack of adequate scientific knowledge should not be a hindrance to taking measures to tackle situations that may pose serious and irreversible danger to the environment.

[101] See *Mgbeoji "Terminator", supra note 72 at 97.* Para. 20 and 21 of Decision V/5 enjoined the FAO/CGRFA to collaborate with UNESCO, UNEP, other "competent organizations and research bodies". In para. 23 of Decision VI/5 the COP invited FAO "to study the potential impacts of the application of GURTs in the framework of the 2001 ITPGRFA and to consider GURTs in further development of the Code of Conduct on Biotechnology as it relates to genetic resources for food and agriculture". Disappointingly, para. 22 of the same document "invites relevant organizations to study the impact of [the] technologies on the protection of intellectual property in the agricultural sectors …"; without specifically co-opting any intellectual property body to explore intellectual property dimensions to the ongoing scrutiny of GURTs. COP, Decision VI/5 online: CBD, http://www.biodiv.org/decisions/default.aspx?m=COP-06&id=7179&lg=0 paras. 22–23 [*COP Decision VI/5*].

[102] See *COP Decision VI/5, ibid paras. 21 and 24.*

[103] Unlike WIPO, FAO/CGRFA have been reasonably involved in the ongoing policy scrutiny on GURTs.

[104] See Erosion Technology and Concentration Group "Who Calls the Shots at UPOV", online: ETC Group, http://www.mindfully.org/GE/2003/UPOV-Terminator-Technology17apr03.htm.

[105] See *Pendleton, supra note 3 at 17 and n. 131; see also Terminator: Five Years Later, supra note 72 at 6 and n. 11.*

[106] See *Pendleton, supra note 3* (arguing that companies could use the threat of commercial application of terminator technology as a bargaining chip with governments and clients "as leverage to greater legal protections, better enforcement, or contractual concessions") at 13.

[107] It is noteworthy that even though the U.S. Senate is yet to ratify U.S. membership of the U.N. Convention on Biological Diversity, in keeping with the need to have inclusive pool, the USDA was represented at the AHTEG on GURTs. The USDA, along with the Russian delegation, and the representatives of Monsanto and Delta Land & Pine Co., Roger Krueger and Harry Collins maintained a pro-terminator stance during the deliberations in opposition to the original UPOV position. It was not surprising that the U.S. was to disclaim the UPOV shortly after the AHTEG. See Harry Collins & Roger Krueger, "Potential Impacts of GURTs on Smallholder Farmers, Indigenous & Local Communities and Farmers Rights: The Benefits of GURTs" (Official Position Paper of the International Seed Foundation (ISF) Prepared for the Expert Panel of the Convention on Biological Diversity February 19–21, 2003) online: ETC Group http://www.etcgroup.org/documents/collins_kruegerISF.pdf.

[108] See Annex I of the AHTEG Report, *supra note 98 para. (e) at page 7; see also FAO/CGRFA Technical Report, supra note 77 at 10, para. (i).* The AHTEG argues that this aspect of GURTs might prevent the exploration of other alternatives to gene containment at both legal and biological levels. Generally, there is strong doubt about the environmental containment claim of terminator proponents. See Erosion Technology and Concentration Group "Sterile Harvest; New Crop of Terminator Patents Threaten Food Sovereignty" online: ETC Group http://www.etcgroup.org/article.asp?newsid=290; see also *Mgbeoji "Terminator", supra note 72 at 118.*

[109] As biotechnology continues to advance, the issue of gene wandering is raising legal questions as to the liability of a proprietary rights holders in transgenic crops in the event of unwanted escape of transgenic materials into organic farmers' fields. The question of crop contamination helps to place under critical scrutiny the nature of the obligation of a proprietary rights holder and the rights of farmers be they organic or non-organic whose fields may be invaded by unwanted transgenic varieties. See, for example, *Schemeiser, supra note 64; Hoffmann v. Monsanto Canada Inc.* 2002 SKQB 190; *Glenn, supra note 57, Pendleton, supra note 3 at 12* and nn. 100-101, Lopez, *supra note 10 at 377-378.*

[110] To be susceptible to horizontal gene flow, plants must be sexually compatible. Asexually propagating self-pollinating crops have a lower risk of the incidence of horizontal gene flow. Even in the case of open pollinators, the risk of horizontal gene flow varies. Such risk is lower in corn unlike canola. The former does not grow outside of human cultivation and tendering and, unlike canola, corn does not have wild relatives. See *Pendleton, supra note 3 at 22-23.*

[111] For instance, during a draught or an epidemic outbreak, farmers may decide to withhold introduction of the trait for boosting animal or plant reproduction so as to mitigate the cost of the crisis and limit number of potential progeny likely to be in harm's way. See FAO/CGRFA Technical Report, *supra note 77 para. 17 at 3.*

[112] Corn and canola are examples of open pollinators. Self-pollinators include wheat and soybeans. It needs to be indicated that as part of ongoing research in GURTs, different methods of introducing terminator genes, like the use of tissue-specific promoters, are being explored with a view to reducing the risk of cross-pollination on neighbouring crops of wild relatives with the terminator gene. For instance, anther-specific promoter can be used to generate a plant without sexual male organ and inhibit the production of pollen; ovary-specific promoter generates a barren female plant, whilst pollen-specific promoter could induce sterile pollen in plants. The degrees of success of each of these and other devices would vary from variety to variety. See *Pendleton, supra note 3 at 23.*

[113] GURTs can be analogized to hybridization which is the practice of cross-breeding two plant relatives. Because progenies of hybrid plants do not breed fully, farmers rely on producers of hybrid seeds and do not, as a matter of economics, save hybrid seeds. Hybrid farmers in the U.S. have relied on the seed supplier on a yearly basis. Following George Shull's development of the first hybrid corn, in 1908, that country's domestic corn supply is today 100% hybrid. This is a profitable business with a track record of increasing production. See *Pendleton, supra note 3 at 20 note 141; see also Ohlgart, supra note 30 at 479; Oczek, supra* note 14 at 632.

[114] See *AHTEG Report, supra note 98 para. 5(a)–(e); see also FAO/CGRFA Technical Report, supra note 77 paras. 18–21; 34–36.*

[115] This involves the practice of producing therapeutic plant-derived proteins for manufacturing vaccines or making insulin and antibodies. Even though sometimes the vaccines may be in edible or injectable forms, they constitute health hazards when intermixed with food crops.

[116] See Andrew Pollack "Spread of Gene-Altered Pharmaceutical Corn Spurs $3 Million Fine", New York *Times, December 7, 2002 at A15.*

[117] See *Pendleton supra note 3 and nn. 106–109; see also "Biopharm Corn Contaminates Food Crop", online: Maine Organic Farmers and Gardeners Association, http://www.mofga.org/news20021213.html.*

[118] Cry9c.

[119] This triggered a massive recall of 300 varieties of corn-based products in the U.S. as well as a class action suit that was settled out of court. See *Lopez, supra note 10 at 378; see also Pendleton, supra note 3 at 12–23.*

[120] In some cases farmers may end up growing transgenic crops even without knowing of it.

[121] See *AHTEG Report, supra note 98 para. 16 (a), (b) at p. 10.*

[122] *Ibid. at para. 16 (c), (d).*

[123] See *Pendleton, supra note 3 at 18; see also Terminator Brochure, supra note 81; Mgbeoji "Terminator", supra note 72 at 116.*

[124] *Supra note 3 at 22.*

[125] *Ibid.*

[126] See *Srinivasan and Thirtle, supra note 8 at 167.*

[127] For insights on the evolution and dynamism of the utility criterion of patentability in relation to terminator, see *Mgbeoji "Terminator", supra note 72.*

[128] See *Malchup, supra note 21; see also Bugbee, supra note 21,* Peter Drahos, *The Philosophy of Intellectual Property Rights (Aldershot: Dartmouth, 1996); Adam D. More, ed., Intellectual Property: Moral, Legal and International Dilemmas (New York: Rowman and Littlefield, 1997) [Dilemmas]; Justin Hughes, "The Philosophy of Intellectual Property" (1988) 77 Georgetown Law Journal 287, Fredrick Abbott, Thomas Cottier and Francis Gurry, ed., The Making of the International Intellectual Property System (The Hague Kluwer Law International, 1999) [Abbott].*

[129] William Fisher, "Theories of Intellectual Property Rights" online: *Harvard Law School http://www.law.harvard.edu/faculty/tfisher/*iptheory.html.

[130] See David R. Downes, "How Intellectual Property Could be a Tool to Protect Traditional Knowledge" (2000) Colum. J. Envtl. L. 253 at 256.

[131] See Samuel Oddi, "The International Patent System and Third World Development: Reality or Myth?" (1987) 63 Duke L.J. 415; *Mgbeoji, supra note 24 at 62.*

[132] The connection between commercialization of invention and inventiveness is not quite simple. *Not all inventions are motivated by reward. Individual or communal creators derive motivation to invent from a number of reasons ranging from the sublime to the most absurd, including the proverbial motivation of necessity.*

[133] Emphases are deliberate.

[134] Both copyright and trade secret exist without registration with the state *and are protected under common law and may also be the subject of statutory protection. The same is true of trademark.*

[135] Exception may be made here in respect of trade secret which is not limited by a statute or common law imposed life span. A holder of a *trade secret is entitled to commercially exploit the secret for as long as* the holder can guarantee its secrecy. However, unlike patent, trade secret protection does not cover independent discovery of products and processes by other parties. Theoretically, it could be argued that trade secret does not inhibit diffusion of knowledge in an absolute manner.

[136] Chidi Oguamanam, *International Law Plant Biodiversity and the Protection of Indigenous Knowledge: An Examination of Intellectual Property Rights in Relation to Traditional Medicine (Ph.D. Thesis, Faculty of Law, University of British Columbia, 2003) at 96 [unpublished].*

[137] Exception may be taken of in respect of this observation to moral right which is a creator's residual right to protect and defend the integrity of *her work even after it has been sold or assigned. However, a creator's inherent right to the integrity of her work serves the instrumental* purpose of ensuring the creator's self-satisfaction in subjective interpreta*tion of her work. For moral rights, see Copyright Act, R.S.C. 1985 c. C-42, s. 28 [Copyright Act].*

[138] See John Locke, *Two Treatises on Government (1690) P. Laslett, ed.,* (Cambridge: Cambridge University Press, 1967), section 27; Adam Moore, "Toward a Lockean Theory of Intellectual Property" in *Dilemmas, supra note 127 at 81–103; Robert Nozick, Anarchy State and Utopia (New York: Basic Books, 1974) at 178–182.*

[139] 449 U.S. 340; 111 S. Ct. 1282.

[140] *Ibid. at 1290. The U.S. jurisprudence on intellectual property, particularly patents and copyright, derives from that country's constitution which vests in Congress power to make laws "[t]o promote the progress of science and useful arts, by securing for limited time to authors and inventors the exclusive rights to their respective writings and discov*eries". See art. 1, section 8, clause 8 of the U.S. Constitution; see also *Ohlgart, supra note 30 at 479; Teresa Scassa, "Recalibrating Copyright Law?: A Comment on the Supreme Court of Canada's Decision in CCH Canadian Limited et al. v. Law Society of Upper Canada" (2004) 3 Can. J. L. & Tech. 89 at 96 [Scassa].*

[141] See *Théberge v Galerie D'Art du Petit Champlain, [2002] 2 S.C.R. 336 para. 30; Desputeaux v. Chouette, [2003] S.C.C. 17; see also CCH Canadian Ltd. v. Law Society of Upper Canada, 2004 SCC 13.*

[142] See *Malchup, supra note 21.*

[143] See *Telstra Corporation Limited v. Desktop Marketing Systems Pty. Ltd,* [2001] FCA 612 (Australia) para. 83.

[144] According to Abbot, "societies, for centuries, evolved on the basis of *informal transfers of knowledge and technological advances in knowhow, from masters to students, from fathers to sons, from mothers to daughters". Abbott, supra note 128 at 130. Noting with approval, Mgbeoji avers, "[C]reativity is tied to tradition and the existing stock of knowledge". See Mgeboji, supra note 24 at 52 and nn. 138.*

[145] Consider the debate over the standard of originality in copyright: creativity (U.S.), skill and judgment (Canada) and sweat of the brow (U.K. and Australia). See *Scassa, supra note 140 at 91.*

[146] The general idea that when IP right holders enjoy monopoly they are *able to engage in more creative endeavour and increase the scope of available knowledge, at best, half articulates the intellectual property rationale. The missing half is that creativity and inventiveness also receive a boost (even from non-right holders) if the knowledge or infor*mation in the public domain is reasonably disseminated and made *accessible with minimum barrier as to its public availability.*

[147] See *Fisher, supra note 129.*

[148] See sections 29, 29.1 and 29.2, of the *Copyright Act, supra note 137.*

[149] See *Scassa, supra note 140 (arguing that even though in the later decision the Canadian Supreme Court takes a seemingly liberal view of fair dealing, developments in international law point to a determination to curtail "rights of fair dealing and 'open access to [protected] works') at* 96-7".

[150] See George Francis Takach, *Patents: A Canadian Compendium of Law and Practice (Edmonton: Juriliber, 1993); Mgbeoji, supra note 24 at 307 (for the view that the requirement of specification for the enrichment of the public domain is the soul of patent jurisprudence).*

[151] *Ibid.*

[152] The creation of a uniform global standard of intellectual property protection under the TRIPS Agreement has pulled back the power of national governments in regard to determining patentable subject matter. Nonetheless, the agreement is premised on the concept of intellectual property as a subject matter of national jurisdiction and Member *States still have the power to compulsorily license a patented invention, for instance, in cases of national health emergencies. See art. 31 of the TRIPS, supra note 68 (which provides states with a limited power of compulsory licence); see Oguamanam, supra note 18 at 167-168 and n. 134.*

[153] See art. 27.2 of the TRIPS, *supra note 68; see also Oguamanam, ibid. at 168.*

[154] For the gradual dilution of the orthodox criteria for patentability so as to accommodate innovations in plant biotechnology, see *Mgbeoji, supra note 24 at 310-311; see also section 161 of the Plant Patent Act, supra note 33.*

[155] See Rosemary J. Coombe "The Recognition of Indigenous Peoples and Community Traditional Knowledge in International Law" (2001) 14 St. Thomas L.R. 275 at 285; see also *Oguamanam, supra note 18 at 136.*

[156] See *supra note 39.*

[157] See arts. 1, 8(j), 10, 15 of the CBD, *supra note 12; see also Chidi* Oguamanam, "The Convention on Biological Diversity and Intellectual *Property Rights: The Challenge of Indigenous Knowledge" (2003) 7 Southern Cross U.L.R. 89.*

[158] See *Pendleton, supra note 3 at 16.*

[159] See Chidi Oguamanam, "Protection of Indigenous Knowledge in International Law: Towards a Cross-Cultural Dialogue on Intellectual Prop*erty Rights" (2004) Austl. I.P.J. 34.*

[160] See *Srinivasan and Thirtle, supra note 8 at 171. Contra supra note 16 and accompanying text.*

[161] See *Pendleton, supra note 3 at 16 and n. 128*

[162] See Timo Goeschl and Tim Swanson, "The Impact of Genetic Use *Restriction Technologies on Developing Countries: a Forecast" in Economic and Social Issues in Agricultural Biotechnology, supra note 8, 181 at 186.*

[163] Compare Pendleton: "Patenting crops is bad enough; TT [terminator technology] is even worse, combining all the vices of patents without any of their virtues", *supra note 3 at 16. This may not be accurate; at least, GURTs aim at securing monopoly for seed breeders that is perhaps a visible "virtue" of IP, albeit a narrow one because it is not balanced with other social policy considerations of intellectual property.*

[164] See *Kershen, supra note 2 (arguing that limiting a farmer who is naturally a seed grower to selling seed as commodity grain does not properly* balance the property rights of farmers in seed and the patent holder's right in the patented gene) at 607.

[165] See *supra note 113 and accompanying text.*

[166] *Pendleton, supra note 2 at 19-20; see also Mgbeoji "Terminator", supra note 72 (arguing, for example, that "[i]f terminator seeds were absolutely useless, they would not sell in the market place") at 103.*

[167] See *supra note 159 and accompanying text.*