Technology Transfer Perspectives Series

# Diffusion of renewable energy technologies

## Case studies of enabling frameworks in developing countries

UNEP RISØ CENTRE
ENERGY, CLIMATE AND SUSTAINABLE DEVELOPMENT

UNEP

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# *Diffusion of renewable energy technologies*

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**Editors**

James Haselip
Ivan Nygaard
Ulrich Hansen
Emmanuel Ackom

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UNEP Risø Centre on Energy, Climate and Sustainable Development
Risø DTU National Laboratory for Sustainable Energy
P.O. Box 49,
4000, Roskilde
Denmark
Phone +45 4677 5129
Fax +45 4632 1999
http://www.uneprisoe.org/
http://tech-action.org/

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# Contents

**Krishna Ravi Srinivas**
*Research & Information System for Developing Countries, New Delhi*

# *Role of open innovation models and IPR in technology transfer in the context of climate change mitigation*

**Abstract**

*Although the importance of Technology Transfer (TT) in Climate Change Mitigation is well accepted, the role of IPR (Intellectual Property Rights) in facilitating TT is a controversial issue. While there are extreme views on whether or not IPR presents a major barrier to technology transfer, the mainstream debate has moved beyond such polarised positions. Scholars have advanced nuanced positions, supported by empirical research. These include the use of alternative models like Open Innovation that go beyond traditional approaches on innovation and IPR, in order to facilitate TT, which is the focus of this article. The article discusses Open Innovation and Open Source Models, and various options like patent pools, and clearinghouses. The scope and limitations of these models, and the options in facilitating TT are discussed. The topic is assessed by way of a hypothetical example regarding the application of an Open Innovation Model to develop and transfer a technology relevant to climate change mitigation, i.e., development of rice varieties with enhanced nitrogen use efficiency. The article concludes that Open Innovation Models can play an important role in facilitating TT in the context of climate change mitigation.*

## Introduction

The need for Technology Transfer (TT) in climate change mitigation is well recognised. The IPCC (Intergovernmental Panel on Climate Change) defines technology transfer (TT) as 'a broad set of processes covering the flows of know-how, experience, and equipment for mitigating and adapting to climate change.' (IPCC, 2000; 3). Thus TT is much more than the transfer and installation of equipment, involving transfers of know-how and experience, including information about processes. TT enables the recipient to use the technology transferred, understand it and absorb it.

Innovators invest money and other resources in inventions of new products and processes, which results in innovation. Innovators need protection from others free-riding on their innovation. Intellectual Property Rights (IPR) constitutes a legally sanctioned mechanism to challenge such free-riding and to ensure that innovators' interests are protected. IPR is an incentive for innovation as the innovator receives specific rights in exchange for the disclosure of knowledge through patents etc. The rights available under IPR are subject to limitations as specified in the laws.

The role of IPR in TT, particularly in climate change, is contested. It has proved controversial in the UNFCCC (United Nations Framework Convention on Climate Change) negotiations, and developing nations and developed nations had disagreed about it (Gerstetter et al., 2010). In the final text of the Cancun Agreements there was no reference to IPR. Whether the proposed Technology Mechanism will handle IPR issues is not currently certain. In the debate over the role of IPR, many alternative models, which go beyond the traditional approaches to invention and transfers of technology, have been suggested (Reichman et al., 2008). This article examines the scope and limitations of some of the alternative models in relation to IPR/TT issues in respect of climate change mitigation.

The article is structured into six sections. The second section reviews the literature and conclusions drawn in it. The third section discusses the regulation of IPR, asking whether it facilitates or hinders TT, as well as the relevance of the TRIPS (Trade Related Intellectual Property Rights) Agreement for TT. The fourth section deals with open innovation models, the case for patent pools, commons and clearing houses and their scope, and the limitations in TT. The fifth section provides a hypothetical example of the application of open innovation for TT in climate change mitigation. The last section provides the conclusion.

## Empirical evidence for IPR and climate-change related technology transfer

A survey of the literature shows that there are divergent views on whether IPR hinder or promote TT in climate change. According to Maskus (2010; 136), 'how IPR and ITT (i.e., International Technology Transfer) interact in these areas are highly context specific and broad claims are not particularly helpful. Secondly, economists have barely begun the task of analysing the task of linkages between public-goods externalities and ITT'. Finally, as noted above, it is possible that transparent and enforced IPR could reduce the cost of TT.

The various positions expressed in the literature can be broadly classified as follows:

1) IPR is not a barrier to TT; in fact IPR is a necessary incentive for innovation. Although many factors affect TT, IPR is not the factor that hinders it (Brandi et al., 2010; Copenhagen Economics and IPR Co., 2009).
2) Those who argue that IPR is a barrier point out the North-South gap in terms of ownership of technology and royalty and licensing income. They cite previous experiences to argue that the North has been reluctant to transfer technology to the South. The roots of this position can be traced to the North-South divide on TT issues (Kariawasam, 2007, Ockwell et al., 2010). It is contended that the global legal regime has not been effective in achieving technology transfers to poor nations and that the market factors that determine the trade in technology are increasing the technological gaps between nations (Krishnachar, 2006). This view is similar

to those expressed by the G77 (Group of 77) and NGOs like TWN (Third World Network) (TWN, 2008).

3) It has been argued that in climate change TT, IPR is not a barrier, as most of the old technologies are in the public domain and developing nations' innovative capacity has increased (Barton, 2007).

4) Even if IPR seems to be a barrier, it is not an insurmountable one and should not become part of the UNFCCC negotiations. Many solutions are available for governments to intervene and facilitate TT. Proponents of this view (Lane, 2011; Ueono, 2009) point out that private-sector firms have successfully transferred climate change-related technology to developing countries without IPR becoming a barrier. Options are available under TRIPS, and caution is needed in taking steps that may undermine the role of IPR as an incentive for innovation (Maskus, 2010). Another view is that it is better to deal with the specific issues and to keep the IPR issue out of the UNFCCC negotiations (Drahos, 2009).

5) A group of scholars associated with the University of Sussex, UK, have concluded that a better approach to addressing this issue is to consider TT and IPR on a case-by-case basis rather than assume at the outset that IPR is or is not a barrier (Mallett et al., 2009; Ockwell et al., 2007; Watson et al., 2011). These authors have made their conclusions following extensive case studies on TT in climate change technologies to China and India and point out that factors like the capacity to absorb technology affect TT and vary from sector to sector. Hence generalisations are not helpful in formulating policies for TT. They have also come up with suggestions for addressing this complex issue.

6) Some studies examine TT and climate change with reference to TRIPS (e.g., Hutchison, 2006) and analyze how TRIPS can hinder or promote TT. I discuss this in the third section.

Although Mallett et al., (2009), Ockwell et al., (2007) and Watson et al., (2011), and, Lane (2011) and Ueono (2009) argue on the basis of case studies, their conclusions are not identical: while the former group situate their findings within a broader context of innovation policies, IPR and other factors like technology absorption and the market for technology, the latter two take into account only those studies where TT by private firms has been successful and argue on that basis.

Similarly Barton (2007) takes the position that most of the relevant technologies are in the public domain or are old. Since developing countries have become innovative, he argues, access and TT will not be hindered by IPR. However, the TWN bases its arguments on the historical experience and the North-South gap in technology ownership. Some studies (Maskus 2010; Maskus and Okediji 2010) take a nuanced position in making suggestions, while Brown (2010) calls for a holistic perspective on climate change-related TT.

The World Bank (2010) states that, '[t] here is no evidence that overly restrictive IPRs have been a big barrier to transferring renewable energy production capacity to middle-income countries. [...] In low-income countries, weak IPRs do not appear to be a barrier to deploying sophisticated climate-smart technologies' (p. 310). This resonates with the view that IPR protection is not the most important or deciding factor in TT and that its role in influencing TT can vary from technology to technology.

In recent years there has been much empirical research on patenting trends, patents in selected technologies and the ownership and transfer of technology in climate change mitigation (e.g., Dechezleprêtre et al., 2010; Lee et al., 2009; UNEP-EPO-ICTSD, 2010). These studies indicate that, while a handful of countries own a significant percentage of patents, some developing countries are also catching up. These studies point out that the top three or four countries have a significant share in all the relevant technologies. Thus, the debate has moved beyond these polarised views, and many new ideas, like using open innovation models, have been put forward for facilitating TT. I discuss some of them in Sections 4, 5 and 6.

It is necessary to understand the gaps in the literature, some of which are listed below.

1. These empirical findings are limited to certain technologies. There are not many case studies on IPR issues in TT in the context of climate change (both in adaptation and mitigation).
2. Many studies give more information on patenting and the ownership of patents and less about commercialisation or patterns in licensing and their impact on TT, particularly TT to developing countries.
3. Most of the studies on developing nations are limited to just a few countries. There is not much in the literature on TT to LDCs (Least Developed Countries) or to other developing countries.

Thus today, despite the above gaps, the literature has provided a nuanced and balanced idea of the role of IPR in TT in climate change mitigation and has also suggested new ideas and solutions.

## The role of IPR in technology transfer and relevance of TRIPS

The Expert Group on Technology Transfer (EGTT) of UNFCCC has identified Enabling Environments (EE) as one of the five themes in the framework to promote, facilitate and finance TT to non-Annex II Parties, particularly developing countries. Enabling Environments have been defined as 'government actions, such as fair trade policies, removal of technical, legal and administrative barriers to technology transfer, sound economic policy, regulatory frameworks and transparency, all of which create an environment conducive to private and public sector technology transfer'(FCCC/CP/2001/13/Add.1). IPR regulation is part of the enabling environment as it provides an incentive for innovation and transfer of technology. It is a part of the regulatory and trade policies of any nation. An IPR regime can thus hinder or promote TT.

Prima facie it may appear that the stronger the level of IPR protection the greater will be the tendency to transfer technology, as IPR are protected and respected. If so, how the state should regulate IPR protection and whether it should opt for stronger IPR protection as a strategy to encourage flows of technology through TT are the main questions.

A survey of the literature shows that there are no easy answers to such questions, and cautions against over-generalisation have been made by academics (see UNIDO, 2006; Hall and Helmers, 2010; Maskus, 2010; WIPO 2011 for surveys of the literature, while Johnson and Lybecker, 2009 can be consulted for an extensive survey of literature on TT). In the case of Foreign Direct Investment (FDI) and TT, in general the literature points to a positive correlation between IPR enforcement and TT via FDI, while other factors like country risk, investment policies, market size and the availability of low-cost skilled labour also influence TT through FDI. In other words, IPR enforcement may be necessary as an attractive factor, but it may not always be sufficient for TT through FDI. For example, despite the weak IPR protection, China could attract FDI and TT on account of other factors. In cases of TT through licensing, while the strength of the IPR protection does influence flows of TT, other factors like absorptive capacity are important for a country to benefit from the TT. Thus, while IPR protection does encourage TT, other factors too are important, and firms consider other factors as well, instead of deciding on the basis of IPR protection only. In other words, the specificities should be taken into account in understanding the flow of TT and a country's ability to benefit from it.

The historical evidence cautions us against taking a view that all countries should opt for stronger IPR protection as a strategy to attract TT and promote innovation. Kumar (2003) and Kim (2002) also arrive at the same conclusion and point out that Korea, Japan and Taiwan actually benefited from a weaker IPR protection regime in the early phases as this enabled substantial technological learning. On the other hand, the Commission on IPR and Development has drawn attention to the question of access to technology through TT and its implications for development of the host country (CIPR, 2002). WIPO (2011) points out 'that there is no one single intellectual property law and policy that maximises the transfer of technology in any given country' and underscores the differences in the dynamics of TT and its relationship with IPR regimes across countries (p. 18). Hence it is reasonable to argue that a strong IPR regime is desirable as a factor to attract TT, though it has to be balanced with the need to absorb technology and develop the capacity to innovate through learning-by-doing.

However, countries do not have an infinite number of choices in IPR law and policy, as most countries have become Members of WTO (World Trade Organization) and hence are bound to implement the TRIPS Agreement. The TRIPS Agreement is the outcome of protracted negotiations in the Uruguay Round and lays down the ground rules for IP protection. Being part of WTO Agreements, it has a strong linkage with WTO's Dispute Settlement Mechanism (see Maskus and Reichman (eds.), 2005 for articles on TRIPS and TT). TRIPS has provisions that emphasise the development dimension of IP rights and the role of TT in enabling countries to establish a sound technological base. Articles 7, 8 and 66.2 underscore this, while the latter also states: 'Developed country Members shall provide incentives to enterprises and institutions in their territories for the purpose of promoting and encouraging technology transfer to least-developed country Members in order to enable them to create a sound and viable technological base'. However, as the TT through Article 66.2 has not met the expectations of LDCs, suggestions have been made to establish mechanisms and provide incentives to facilitate TT by using Article 66.2 (Moon, 2011).

Some authors are skeptical about the positive role of TRIPS in facilitating TT (e.g., Correa, 2005). Referring to TT, climate change and TRIPS, Adams (2009) argues that TRIPS may impede the transfer of environmentally sound technologies (ESTS) to developing countries, while Hutchinson (2006) points out that countries can take advantage of the flexibilities of TRIPS. He is less sanguine about the positive contributions of TRIPS to TT. On the other hand, O'Regan (2009) takes the view that, while IPR is a hurdle in TT to developing countries, it can be overcome by various means.

## Open innovation and similar mechanisms to facilitate technology transfer

The discussion in the previous section indicates that, while the role of IPR in facilitating TT is controversial, the TRIPS Agreement can either facilitate or hinder TT. Instead of thinking solely in terms of limitations and barriers in TT on account of IPR, innovative solutions that combine the flexibility within the IPR regime and novel paradigms in owning and sharing knowledge and technology can be explored as potential solutions to facilitate TT. This section discusses two such novel paradigms, Open Innovation and Open Source, and illustrates their relevance and limitations in facilitating TT.

## Open innovation models

Open Innovation refers to a model of innovation in which firms seek ideas from a variety of sources, including users, universities, experts, etc. The core idea of Open Innovation is that firms can and should leverage ideas that are beyond the firm's boundaries and develop strategies to use them by making the innovation process more open, and that this can be done proactively. According to Chesbrough (2006), who pioneered the idea of Open Innovation, 'At its root, Open Innovation assumes that useful knowledge is widely distributed, and that even the most capable R&D organisations must identify, connect to, and leverage external knowledge sources as a core process in innovation' (p. 2). Herzog (2011) points out that the shift from 'closed' innovation to 'open' innovation needs to be accompanied by a change in the culture of innovation (p. 228).

Open Innovation is facilitated by advances in the distribution of knowledge and collaborative possibilities that are made available by information and communication technologies. Open Innovation networks can be organised for a specific purpose, while firms embrace Open Innovation as a philosophy and practice for pragmatic reasons. For example, companies are creating value by licensing intellectual property, establishing joint R&D ventures, or making other arrangements to benefit from technology outside the boundaries of the firm (Chesbrough, 2003, 2007).

The rationale for firms opting for Open Innovation stems from a pragmatic view that there are occasions in which cooperation in production and sharing can benefit all participants more than each participant trying to secure monopoly rights through patents and enforcing them. A study of 39 open-source initiatives in biopharmaceutical innovation highlighted the different ways in which companies are willing to share, excluding others outside the consortium but allowing access to members and opting for the joint management of knowledge assets so that all members can benefit and take advantage of knowledge and technology outside the firm (Allarakhia et al., 2010). Reichman (2003) and Foray (2004) point out that it makes sense to undertake cooperative knowledge production and open knowledge dissemination, as they provide joint benefits in circumstances when upstream discovery research cannot result in commercial products and when the costs of upstream competition are high.

## Open source models

The Open Source model is a collaborative mode of production, testing and distribution in which voluntary labour is a key component and the IPR is handled by using licenses, either GPL (General Public License) or a license derived from it. The contributor to an Open Source project cannot use Open Source licensing to acquire monopoly rights or to block others from using the contribution made to the project. Lakhani and von Hippel (2003) have identified the three incentives that induce a firm to participate in Open Source projects.

Open Source models are currently being applied and tested in diverse fields like drugs development, biotechnology (Srinivas, 2010; Hope, 2008) and product development in some industries (Balka, 2011; Jasski, 2007). There is a growing interest in applying Open Innovation and Open Source models in the context of climate change. For example, the Clean Energy Group has come out with a comprehensive report on the relevance of 'open and distributed' innovation for climate change (Morey et al., 2011; see also Rattray, 2009 for a discussion of the relevance of Open Source approaches).

## Open innovation and open source: Comparison and differentiation

Both models stress the need for collaboration and for tapping resources outside the boundary of the firm through collaborative processes and networks. This will facilitate flow of ideas and synergies in working and can result in solutions that a single firm or group alone would not have been able to develop. The major difference between them is that, while in Open Innovation efforts are usually made by the firm that is trying to innovate by reaching out to other firms or potential collaborators, in Open Source the problem or opportunity is the central point of focus that connects the people and organisations. In Open Innovation the firm is the centre of collaborative endeavor, while in Open Source the problem or opportunity is the connecting link, not any single firm.

The big difference between Open Source and Open Innovation in terms of handling IPR is that with Open Innovation products can be protected within a proprietary framework that respects the patent rights of the firms involved in Open Innovation, while the Open Source model relies on GPL or similar licenses to protect and enforce IPR. Thus, the major differences are in organizing for innovation and in handling IPR.

## Licensing

Licensing is one method of deriving value from IP, and this can be exercised in many ways. For example, a firm can grant an exclusive license to a single party or can provide non-exclusive licenses to different parties on different terms. Licensing can serve both the purposes of benefiting from IP and controlling its use. Depending upon the considerations for licensing and the rights granted, there can be many different types of license, ranging from exclusive licensing to cross-licensing where parties grant licenses to each other. Licensing can thus be converted into a collaborative practice for mutual benefit.

In collaborative innovation, joint licensing may be desirable when there are different holders of IP rights (e.g., patents) and the technology covered by the patents is necessary for further innovation. Thus, to reduce transaction costs and to benefit from each others' technology, the patent-holders can opt for cross-licensing to each other and/or to third parties. Some of the mechanisms that facilitate such sharing and transfers of technology are discussed below.

### Patent pools

The patent pool is a mechanism is which two or more patent-holders agree to share their IP with each other and/or with third parties through negotiated licenses, which might include cross-licensing. Patent pools can promote TT, facilitate innovation and promote diffusion. The Medicines Patent Pool (http://www.medicinespatentpool.org/) is a recent example enhancing access for medicines for HIV in developing countries through voluntary licensing. In the case of TT in the context of climate change mitigation, patent pools can be formed for different sectors and type of need. For example, the patent pool or patent pools can be formed where access to one technology or group of patents is needed for furthering TT. Thus, a patent pool on renewable energy technologies can combine many patents relevant for an application (e.g., increasing energy conversion efficiency) and license them to encourage TT. Patent-holders also acquire access to necessary technologies that are not owned by them but necessary to commercialise some applications. While patent pools are not panaceas, they have been tested in many contexts in some industries and hence can also be relevant for TT in climate change mitigation. For example, Iliev and Neuhoff (2009) have indicated circumstances under which patent pools will be useful in facilitating TT. An extensive review of patent pools and clearing-house mechanisms in different industries and contexts is available in van Overvalle (ed.) (2009). Patent pools can be classified under Open Innovation Models, as the objective is to combine the specific resources of all parties to form the pool and to license them on mutually agreed terms.

### Patent commons

Under patent commons, patents are made available subject to certain rights and obligations. The commons is thus a collective resource which one can contribute to and draw from, subject to some rules. In 2005, a patent commons was created by Open Source Development Laboratories to enable the open source development community at large to make use of the resources from this Commons for open source development. While all users of this Commons may not be contributors to it, some are likely to be users as well as contributors.

The major difference between a pool and commons is that a pool is a mechanism to aggregate and license, while a commons is a mechanism to aggregate and to share for the purpose of further development and diffusion, subject to some conditions. Usually such commons make use of the General Public License (GPL) or any of the derivatives from GPL to enforce rights and produce certainty about obligations. Thus, resources in such commons are not for free riding because there is also an obligation.

In the context of climate change, the World Business Council for Sustainable Development based in Geneva launched Eco-Patent Commons in 2009. The objective of this is to enable the sharing of patents and to collaborate in furthering eco-innovation. As of now there are about a hundred patents available under this initiative. While for reasons of space I will not provide a detailed analysis of the pros and cons of this approach, such commons may facilitate TT (Boynton, 2011; Hall and Helmers, 2011; Lane, 2011).

A similar initiative drawing upon the principles of Creative Commons is the USA-based GreenXchange. Just as in Creative Commons, here too the holders of IPR, i.e., the patent-holders, permit some uses and give up some rights partially or fully subject to the licensing terms. For example, a patent-holder can permit the unrestricted use of some patents for product development and research by academic institutions, while insisting that any use by commercial firms will be restricted to licensing on commercial terms.

In Eco-Patent commons the patent-holders donate patents to the commons, while in GreenXchange they retain the patents but permit flexibility in using them and license them on specific terms. Both these approaches have their merits and demerits, but what is important is that they provide flexibility in making use of patents without denying IPR.

The Eco-Patent Commons is a typical example of an Open Source Model, as it enables the creation of Commons.

The GreenXChange cannot be considered an example of an Open Source Model or Open Innovation because it is based on the Creative Commons principle, which is derived from copyright. Licenses under Creative Commons grant some rights to users automatically, as indicated in that category of license. Such uses can be relevant for participants in Open Innovation or Open Source projects.

## Alternative licensing mechanisms

Normally licenses are commercial contracts that allow little flexibility. But in the wake of the crisis in access to medicines, the need for flexible licensing mechanisms was felt. So some alternative licenses for the use of patents have been developed. The use of GPL and its derivatives in (open source) software has inspired the use of licenses modeled after GPL or its derivatives in other sectors. Thus, today there are many licenses that offer flexibility in use and facilitate transfers of technology, and most of the alternative licensing mechanisms encourage non-exclusive licensing. One license that can be used with modifications for TT in climate change is EAL (Equitable Access Licensing). Under EAL a university for fair royalty payment will grant a non-exclusive license to use patented technology for production and the sale of research tools in poor countries. The licensee agrees to grant back to the university any improvements it has made and cross-license any other rights owned by it. The idea here is that licensee will not use its rights to block the production. The university can offer the research tool on similar terms to other parties. The objective is to make this licensing applicable to low- and middle-income countries where access at affordable prices is a major issue. A neglected disease license permits the university to license the technology for research into neglected diseases and for commercialisation in poor or low-income countries (Hope 2009). This sort of mechanism would come under Open Source Models, as they are based on Open Source principles and make use of GPL or a license modeled on it.

## Clearing houses

A clearing house is a mechanism for matching the users and providers of goods, services, information and technology (Zimmerman 2009). For example, technology exchange clearing houses offer information services and enable technology providers and seekers to find partners and conclude contracts. Eco-Patent Commons can be considered an open-access clearing house. There is scope for other types of clearing houses in TT in climate change mitigation. The clearing house mechanism under UNFCCC has been more a clearing house for information than for facilitating TT.

From the point of view of patent-holders, engaging in Open Innovation and/or choosing one of the above-mentioned options makes sense only if they are able to derive more advantage out of them when compared to normal licensing practices. For example, it is beneficial to join a patent pool and contribute to it if joining the pool can result in more revenue with lower transaction costs, and/or if it provides access to a technology that is available only to members. For the recipients of technology, accessing a patent pool is preferable to dealing with many patent-holders individually, as the transaction costs will be lower and access to a bundle of technologies is ensured. But if the recipient does not need all the technologies made available through a pool but only some of them, then dealing with patent-holders on a one-to-one basis may be less expensive. It is also likely that receivers of technology may prefer to opt for commercial licensing from a single firm if it provides all the technologies needed than access some from Commons/Patent Pool(s) and opt for commercial licensing for the rest, as the first option reduces legal uncertainties. In the case of licensing practices, while GPL and its derivatives have been used extensively in software contexts, their validity in non-software contexts is not clear, as there is not much case law on this. Some licenses like EAL that are being developed as a solution to a specific problem may not be relevant in other cases.

## Using open source and open innovation for TT in climate change mitigation

In this section, an illustrative example is given of a hypothetical situation in which a climate mitigation technology is the object of an open innovation model. The climate mitigation technology being illustrated here is the development of rice varieties with enhanced nitrogen use efficiency and transfer of technology to breeders and research institutions. Stern (2006) points out that a significant proportion of the greenhouse gases (GHG) produced by agriculture are due to the application of nitrogen fertilizer alone, because a portion of the excess nitrogen not taken up by plants is released into the atmosphere as nitrous oxide, a potent greenhouse gas. Increase in nitrogen use efficiency by plants can result in lower applications of nitrogen fertilizer and thereby contribute substantially to mitigation of climate change.

This is a hypothetical example and not a case study or description of an ongoing project. The three important steps in organizing the development of rice varieties and TT are described below.

**Step 1:** Form a consortium of institutions working on this project and organise it on the basis of Open Innovation. The consortium should cover all activities, from the start to the development of varieties and their transfer through commercialisation by public or private sector. It should also address further research and development activities. Under this project, applying conventional breeding for the development of such varieties and of genetically modified rice with this trait will be undertaken, as both are needed.

**Step 2: This has two components, as below**

The consortium should identify the IPR issues involved in each stage, from development to transfer and diffusion. Normally, germplasm is available under Material Transfer Agreements (MTAs) and as such cannot be patented. The use of research tools and patented genes or gene fragments can become an issue. Thus the mapping of the technologies and tools needed, the issue of respective patents and an analysis of the patenting landscape are necessary. For example, while access to and use of germplam might not be an issue, the relevant processes and research tools might have been patented, as might the genes and gene fragments. The MTAs may have restrictive clauses on usage of the transferred material. Thus the consortium can identify the ways to overcome this by examining: 1) whether research exemptions are applicable, 2) what are the available alternatives, and 3) whether the resources available with the institutions in the consortium can be used to complement or replace the patented research tools, genes or gene fragments.

If IPR is a pressing issue in accessing them, the consortium can find out whether the patentee(s) is/are willing to license them using humanitarian licensing or licensing under EAL or similar licensing on a non-exclusive basis for use in developing countries or LDCs. Since this project envisages identification of the relevant gene from different crops and the development of genetically modified rice, access to the germplasm of crops like barley is important. The freedom to operate, i.e., whether the consortium is free to market the developed product or not, depends on access to and the right to use patented technologies, materials and processes. Therefore, an analysis of the issues in Freedom to Operate is essential.

The complexity in this can be illustrated by the fact that in the development of 'Golden Rice', transgenic rice enhanced with provitamin A, it has been estimated that 40 organisations hold 72 patents on the technology necessary to develop and disseminate this variety. A coordinated international programme resolved this issue by negotiating with the patent-holders by obtaining permissions and licenses (Dunwell, 2010).

In such efforts, organisations like the Public Intellectual Property Resource for Agriculture (PIPRA) or Biological Innovation for Open Society (BIOS) can help in mapping the IPR issues and identifying the options involved in using licenses and accessing alternative resources besides assisting in negotiations on IPR. Once this task has been completed, it is essential to ensure that all institutions have the same understanding of IPR issues and of access to, use of and sharing of resources covered by patents, MTAs and licenses.

2) The consortium should develop a coherent IPR policy for use within the consortium and in dealing with external agents. In this the consortium can make

use of GPL or its derivatives to share its IP assets. For sharing within the consortium, there can be a patent pool. Novel arrangements for sharing knowledge and accessing others' knowledge and technology can be established. The relevant examples of this are the SNP Consortium and the HapMap Project (NAP, 2010).

### Step 3: Collaborative development of varieties and IPR issues

Once the varieties have been developed, it is necessary to seek IPR protection. Not all countries allow the patenting of plant varieties. Many developing countries provide Plant Breeders' Rights (PBR) as IPR for Plant Varieties, while in the USA both patent protection and PBR are available. Often the varieties developed are transferred to seed companies or breeding companies that sell seeds or incorporate the innovation in Open Pollinated Varieties (OPV) or hybrids. Therefore, it is essential that the appropriate mode of Intellectual Property is sought. IPR can be enforced and can be linked with TT to breeders and seed companies. Even also in other cases, obtaining IPR will help prevent misappropriation by others and help assert rights in cases of infringements.

In the above example, if the variety is a GMO, i.e., a genetically modified organism, then there are more issues to be addressed. Even if GM plants cannot be patented, the relevant processes, genes, gene fragments and research tools might be patentable. Hence, while PBR are applicable to plant varieties, IPR protection in terms of patents may be available for relevant processes, etc.

Here too, it is for the consortium to have a definitive IPR policy on patenting and enforcing IP rights. It is a good practice to introduce patent protection as a defensive mechanism. Patents can be used for sharing on a quid pro quo basis, as a defensive mechanism against misappropriation and in bargaining for access to other patented technologies. Moreover, a strong IP portfolio is valuable in terms of income from licenses and in assessing the value of innovations. The consortium should use IPR for the benefit of its members, as well as to facilitate TT.

Open innovation is applicable here in terms of organizing for innovation, developing a structure that engenders open innovation and handling IPR. In open innovation, the core principle is to link with knowledge resources within the organisations and external sources in such a way that knowledge resources are leveraged for a shared objective. Open Source is useful as an alternative mechanism for using IPR in such a way that sharing is encouraged, further development is permitted and access is permitted on some condition, instead of enforcing monopoly rights to prevent others from developing a resource further or to ensure that rent maximisation is made possible by exercising that right.

Thus, as described above, Open Innovation Models and Open Source Models can be used to develop technology and facilitate TT.

## Conclusion

While there is a consensus on the need for TT in climate change mitigation, the role of IPR in facilitating TT is controversial. The debate has moved beyond polarised positions. This has also resulted in a search for alternative models and mechanisms to facilitate TT. The Open Innovation model as an alternative mechanism has much relevance to facilitate TT. Some mechanisms, like Patent Pools and Clearing Houses developed in other contexts, are being applied here, while new initiatives are being developed to build Commons. Although they are not a panacea, they can play an important role and can complement other approaches in facilitating TT.

## About the author

Dr. Krishna Ravi Srinivas is with Research and Information System for Developing Countries, (RIS) New Delhi, India as an Associate Fellow and Managing Editor of Asian Biotechnology & Development Review. His research interests include Intellectual Property Rights, Biotechnology and Biodiversity, regulation and ethical issues in emerging technologies. He has been a Visiting Scholar at the University of Pennsylvania on a Fulbright Fellowship, Visiting Scholar at Indiana University, Bloomington and Post-Doctoral Research Fellow at the South Centre, Geneva.
ravisrinivas@ris.org.in

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