

**Fostering Democratic Innovation as a Means of  
Reducing the 10/90 Gap in Health**

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**1. Summary**

Malnourishment, rather than disease, constitutes the single greatest cause of poor health and untimely death worldwide. Hundreds of millions of people suffer from the chronic lack of adequate food and clean water.

Between regions and cultures the factors in malnutrition vary, even more widely than do the key nutritive crops and the means of growth, harvest, storage and distribution. The appropriate solutions and means of implementing them are also locally diverse; what works well in one area may fail or even exacerbate the problem in another. The most effectual alteration of resource flows to improve health worldwide thus has little to do with new coordination from OECD countries outward for drug production, nor creation of any single new food resource that can be delivered to the developing world. Given the heterogenous nature of this global problem, the best solution is to empower the inventive and committed minds within the developing world to address the root causes locally.

Significant challenges to inventors within the developing world include limitations in technical capabilities, information flow, capital access and continuity, and intellectual property constraints set up to prevent competition with global corporate interests. Our imperative is to foster ways to enable people with ideas to better meet these challenges for local-scale invention and improvement.

BioForge aims to use the communications and data transfer opportunities of the internet to build useful information connections throughout the worldwide community of problem solvers, so that an innovator working on a crop improvement in a developing country can become aware of an advance elsewhere that could be harnessed together with local means of production for use in solving a local problem. A coordinated aim is to build a legally and normative "protected commons" of intellectual property, on a precedent afforded by 'open source' software development, in which differentially motivated individuals, whether in for-profit or non-profit enterprises, can pool ideas and efforts safely and efficiently without any entity having the ability to hijack the whole. Technology owners

have incentives to allow their intellectual property to be used and improved within a protected commons, and those who control capital have the greater certainties to encourage investments in the enterprises that are thus enabled to make use of it.

## II. What are the greatest health problems that can be effectually attacked?

The greatest single greatest cause of poor health and untimely death worldwide is not a particular disease or a constellation of orphan diseases, nor is it the lack of pharmaceuticals to treat disease, nor the lack of research ideas to support new pharmaceutical development. The largest cause of poor health is malnutrition. Estimates vary according to the metric used, but it can be generally agreed that currently at least 842 million people worldwide suffer from the chronic lack of adequate food<sup>1</sup>. Between 20% and 75% of child deaths in a number of Asian and African countries can be attributed to malnourishment; at least six (6) million children under the age of five die each year as a result of hunger<sup>2</sup>.

Undernourishment is not unrelated to disease, however, because deficiencies in protein and certain nutrients greatly weaken the immune system, thereby increasing susceptibility to any disease and the likelihood of death from bouts with diseases that might only temporarily weaken a well-nourished person. Diseases such as measles and cholera are substantially more likely to prove fatal in a person who is not adequately nourished<sup>3</sup>.

The daily effort to obtain enough nourishment to stay alive consumes most of the resources and talents of this population, engulfing any progress toward high goals such as broadly available education, universal suffrage, and gender equality. FAO's report on the State of Food and Insecurity in the World concluded that many of the Millenium Development Goals could be addressed in some way through more resources devoted to providing food for the hungry<sup>4</sup>, but this could be turned around to say that these high goals can never be adequately addressed as long as widespread malnourishment continues to distort the basis of all other measures of well-being.

Why are so many people starving? In some countries, food shortages are systemic, while in others, events such as episodes of harsh weather have contributed to crop failure, or civil strife to food distribution emergencies. In the following section three major factors in food availability are discussed: water, pests, and degraded land.

There isn't any doubt that food security and water availability are closely related, as worldwide 69% of all water is consumed by agriculture. Some of the causes for food crises are listed here in quotes from the FAO report<sup>5</sup>:

- ◆ Drought ranks as the single most common cause of severe food shortages, related to 60% of incidences in developing countries in 2000-2002.
- ◆ Floods are another major cause of food emergencies.

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<sup>1</sup> Are We On Track To End Hunger? Hunger Report 2004. Bread for the World Institute  
[http://www.bread.org/institute/hunger\\_report/index.html](http://www.bread.org/institute/hunger_report/index.html)

<sup>2</sup> State of Food Insecurity in the World 2003. Food and Agriculture Organization of the United Nations.  
<http://www.fao.org/docrep/006/j0083e/j0083e00.htm>

<sup>3</sup> Rice, A., Black, R., Hyder, A., & Sacco, L. 2000. Malnutrition as an underlying cause of childhood deaths associated with infectious diseases in developing countries. *Bulletin of the WHO*, 78(10): 1207-1221.

<sup>4</sup> State of Food Insecurity in the World 2003. FAO, *ibid*.

<sup>5</sup> State of Food Insecurity in the World 2003. FAO, *ibid*.

- ◆ Sharp seasonal differences in water availability, for example in India where 70% of the rain falls in the three-month monsoon period, overwhelming storage capacity, contribute to food supply perturbations.

For this reason, the wider promulgation of water purification and irrigation systems is touted as one major solution to hunger and disease<sup>6</sup>, and on the face of it this makes a lot of sense. However, the implementation has not been a magic bullet. In China, for example, where more than half of the irrigated lands rely on groundwater extraction, water is often pumped out of the ground for irrigation at a rate higher than that by which it is replenished by rainwater percolating through the soil, and as a result water tables have fallen by up to 50 meters in the past 30 years. Poorly managed irrigation has caused degradation of about 10 % of the world's 270 million hectares of irrigated land because of accumulation of salts.<sup>7</sup> Many of the technologies available for remediation of contaminated water in Asia are imported from the U.S. and Europe, and methods of implementation are based on information borrowed from the U.S. and Europe, resulting in troublesome uncertainties when attempts are made to apply them at sites whose characteristics are different.<sup>8</sup> It is estimated that up to 60 percent of the water diverted or pumped for irrigation in Asia is not successfully directed to plant production because of factors such as poor seasonal timing, containment systems that are mismatched to the topography and soil, and the like.<sup>9</sup>

In most developing countries, the incidence of malnutrition is concentrated in regions of degraded environment, and extensive clearing and fertilization of marginal land for food production contributes to exacerbation of the problem. A joint study by FAO, the UN Development Programme (UNDP) and the UN Environment Programme (UNEP) of land degradation in South Asia found that water and wind erosion respectively damage 25 and 18 percent of the sub-region's total land, and that in China and Thailand, water erosion affects 34% of the land area.<sup>10</sup> To get even a little yield in the short term from degraded land tempts the overuse of fertilizers, which in the worsened runoff can further degrade water and land to the detriment of future production. Global fertilizer use has gone up at least nine-fold in the decades since the 1950s, leading to significant contamination of surface and ground water and estuarine environments<sup>11</sup>.

Erosion is accelerated by significant deforestation and clearing of land purposely or through accidental fires; FAO estimates that 140 million ha of high quality soil, mostly in Africa and Asia, will be degraded by 2010 unless better methods of land management

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<sup>6</sup> State of Food Insecurity in the World 2003. FAO, *ibid*.

<sup>7</sup> State of Food Insecurity in the World 2003. FAO, *ibid*.

<sup>8</sup> "DEAR - Vulnerable and Degraded Environments Assessment, Remediation and Management", Australian Research Council, online at <http://www.vdearm.com/articles.php?rc=28>

<sup>9</sup> From a joint study by FAO, the UN Development Programme (UNDP) and the UN Environment Programme (UNEP) of land degradation in South Asia, with details from the results described online at [http://www.fao.or.th/Technical\\_Groups/Agriculture/agriculture.htm](http://www.fao.or.th/Technical_Groups/Agriculture/agriculture.htm)

<sup>10</sup> [http://www.fao.or.th/Technical\\_Groups/Agriculture/agriculture.htm](http://www.fao.or.th/Technical_Groups/Agriculture/agriculture.htm)

<sup>11</sup> Saull, M. 1990. Nitrates in soil and water. *Inside Science* 37. *New Scientist*, Sept. 15.

are adopted<sup>12</sup>. However, compliance failures are often a significant contributing factor in land remediation difficulties. For example, while several Southeast Asian countries have adopted policy frameworks for sustainable forest management (e.g. Malaysia's National Forestry Act of 1984) to decrease deforestation and thus erosion, these are only spottily enforceable. Compliance problems tend to be a symptom of a lack of ownership of laws, policies, regulations and norms, based on failure to understand their personal importance or benefit, or a lack of fit with the local culture.

Outbreaks of pests and crop and livestock diseases can cause highly visible losses that suddenly bring whole sectors to ruin. The percentage of crop losses caused by plant pathogens, insect pests, and weeds was 42% worldwide, accounting for \$500 billion dollars worth of damage in 1993<sup>13</sup>. Insect infestations and viral and fungal diseases can display patterns of incidence and spread that are increasingly predictable with climatic factors and the migration of vectors, or stochastic. In many cases the extent of damage to crops and livestock can be mitigated by early detection of an outbreak, while delayed action can exponentially increase the level of loss and the expense of response.

Inputs such as attractant traps, insecticides, fungicides, alternate host eradication programs, and even identification of diseased individuals can consume significant resources (worldwide, pesticide applications costing \$26 billion dollars annually are applied to manage pest losses<sup>14</sup>), and can be largely ineffectual if applied with the wrong timing. In the Sahel region of Africa this year, to combat locust outbreaks that have resulted in loss of 80% of the grain crop of Senegal, for example, FAO has ordered more than two million litres of pesticides at a total value of \$14.7 million, and contracted 14 spray and survey aircraft for locust control in the region<sup>15</sup>. An expenditure of up to \$60 million is foreseen in order to fight the possibility of famine for hundreds of millions of people in the region, a small expenditure in comparison with a 1987-1989 outbreak that cost more than \$300 million to contain<sup>16</sup>. Local information has helped raise the efficiency of the insecticide application by identifying windows of time when the locusts are least active in the cool of early morning to target spraying. However, because the migration and reproduction patterns of the locusts are largely known, U.N. entomologists estimate that the cost could have been less than a third to fight the outbreak if applied months sooner when the extent of the conditions favoring an outbreak were being noticed.

Thus, a general conclusion that can be drawn is that between regions and cultures the factors in malnutrition vary. What is more, so do the key nutritive crops and the means of growth, harvest, storage and distribution. Some aspects of the Green Revolution have

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<sup>12</sup> "Soil and Sediment Erosion" in Geoinicators, International Union of Geological Sciences, accessible at [http://www.lgt.lt/geoin/doc.php?did=cl\\_soil](http://www.lgt.lt/geoin/doc.php?did=cl_soil)

<sup>13</sup> Oerke, E. -C., Dehne, H. -W., Schonbeck, F., and Weber, A. 1994. "Crop production and crop protection: estimated losses in major food and cash crops." Elsevier, Amsterdam.

<sup>14</sup> "A new era for plant pathology and plant protection." G. A. Fermin-Muñoz, B. Meng, K. Ko, S. Mazumdar-Leighton, A. Gubba, and J. E. Carroll, *Biotechnology*. May 2000.

<sup>15</sup> <http://www.fao.org/newsroom/en/news/2004>

<sup>16</sup> Reuters, "Locusts threaten famine in Senegal, Mali", July 20, 2004.

been criticized because high-yielding varieties that were developed and widely planted were more disease-susceptible, required more water, or were not well-adapted for storage.<sup>17</sup> Thus, particular crops developed at great expense did not necessarily succeed at a local level. In general, the appropriate solutions and means of implementing them are also locally diverse; what works well in one area may fail or even exacerbate the problem in another.

One proverb often used to push sustainable approaches to hunger is the chestnut “Give a man a fish, and he eats for a day; teach a man to fish, and he eats for a lifetime”. What if fish resources in a particular locality are not sufficient to sustain the population, and overfishing results in renewed famine? What if a temporarily well-funded fishing program diverts water resources away from the main cash crop of the region, displacing farmers and resulting in longer-term staple shortages? What if the fish of the area are not safe for consumption because of sanitation or chemical deposition problems that are not being addressed?

The most effectual alteration of resource flows to improve health worldwide thus has little to do with new coordination from OECD countries outward for drug production, nor creation of any single new food resource that can be delivered to the developing world. Given the heterogenous nature of this global problem, the best solution is to empower the inventive and committed minds within the developing world to address the root causes locally.

### **III. Developing the next crop solution**

How can resource flows be directed into such empowerment? One proposal that has appeared in many forms is reform of the intellectual property system to incentivize research or to remove perceived hindrances to research into new drugs and new crops. This approach has the potential to increase the number of ideas that can be patented, an incentive to inventors and research facilities, while setting up a variety of patent infringement exemptions, covenants not to patent in particular markets, compulsory licenses etc. to benefit particular population segments for the public good.

A significant failing of this approach is that it is not the most critical bottleneck in technology development that is thus provided with an incentive. In most patents systems, in order to qualify as patentable an idea must be novel and non-obvious over the prior art, and over combinations of what is known anywhere in the prior art. However, many of the innovations that are needed to convert an idea into useful crop production and distribution to those who need it would not be considered novel. Indeed, the pathway between a novel idea and a useful application may require a large number of critical developmental steps that are not incentivised by the patents system because they are combinations or adaptations of work that has been done elsewhere.

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<sup>17</sup> “The Past 25 Years: Successes, Failures, and Lessons Learned in Feeding the World”, David Gately, International Food Policy Research Institute, online at <http://www.ifpri.org/2020/backgrnd/25years.htm>

For example, let us suppose that an inventor develops a patentable method for making a new type of staple crop propagule that appears to be more water use efficient. A patent may be issued upon a single proof of concept or even upon an enabling prophetic description of the invention, but what are the steps likely to be required before this invention can be deployed?

- Improvements in the method may be necessary to achieve
  - Transfer of the new propagule type, which may require improved breeding methods, into additional varieties that may be more suited to different microclimates or more resistant to diseases
  - Multiplication of the propagule type, which may involve improved propagation methods, to cover the range of tests below
- Training methods for additional operators, efficiencies of scale, and methods for quality control may need to be developed to enable such multiplication.
- The new propagule may need to be field tested
  - in a number of different site types
  - with a variety of different edaphic (soil) conditions, and
  - with varying planting depths and stocking rates (spacing).Such testing may require years and can be very costly to carry out.
- In order to be used economically, the timing of expensive inputs such as
  - planting site preparation
  - irrigation,
  - fertilizers and
  - pesticidesmust be fine-tuned.
- Experimentation will often be required to determine
  - at what times of year and
  - how best to store and propagate the plant,
  - how to scale up production in time to meet seasonal deadlines,
  - rates of sustainable planting and harvest, and
  - how to harvest, store, and package the end product most economically.
- Phenotypic, phonologic and biochemical information may need to be collected and analysed to support regulatory processes
- Investors may require planning and research to determine
  - safety and palatability of the consumed product
  - any phytopathological, erosion, or cost implications of the altered planting practices
  - logistics of getting the product to the markets
  - resilience of the product supply to stochastic hazards such as typhoons
  - best market positioning relative to existing products that may be complementary, such as customary condiments, or competing
  - price-sensitivity

All this adaptation to make an invention usable may require intensive laboratory use and personnel, causing it to be very expensive, much more expensive than developing the original invention, but little of it would be patentable. Accordingly, investment in this

sort of improvement and developmental adaptation would not be incentivised by the patents system.

Other incentives would be required to draw out such investment, primarily a large market pull, for example wealthy and demanding consumers for the prospective product and the possibility of high margins over the cost of goods sold. Under a scenario of low margins, in the absence of a large market pull and the promise of large returns on investment, the developmental investment needed to bring a product to deployment may never occur.

The fact that increasingly, important steps in product development are not self-contained, but instead interdependent, i.e. they may require several key component technologies to function, results in another major disincentive to undertake the downstream investment that must follow the development of a patentable technology. If not all the enabling technologies are assigned to or held by a sole patentee, that patentee may not have freedom to operate. An owner of the rights to only one or a few of these technologies will have to acquire licenses to the rights of many others in order to actually make use of the inventions, and it is within the rights of any one patentee to exercise monopoly rights to deny others use of a patent by refusing to grant licenses. CAMBIA has built a unique dataset of over a million life sciences patents and a number of software tools for making the information in the patents more transparent<sup>18</sup>. Analysis shows many examples of interdependent groups of technologies in which denial of access to any single one technology can and does deny the use of the entire group of technologies by most potential users<sup>19</sup>. Thus, even a brilliant idea for an agricultural innovation that seems perfect to help many farmers will not necessarily do so. Lack of freedom to operate under license for a single aspect of the technology involved, even if all other aspects are available, can block and destroy the worth of the entire innovative process, while the iterative and cooperative shaping and improvement of the technology to meet diverse users' needs is unlikely to bring new patent assets into existence. Investors respond both to cost-benefit scenarios and to the perception of risk. Even if the initial investment costs might in some cases be low, investors are likely to undertake such a risk only if the eventual forecasted returns on that investment are very large. Thus, wherever patents could create a risk to freedom to operate, investment capital is even more unlikely to respond to weak market signals such as a market comprising the poor and the marginalized.

Thus, to foster inventions to respond to the needs of a market that is not wealthy and able to pull such significant investment, providing an incentive through the patents system for starting ideas is not enough.

While we may conclude that facilitating the multi-step improvement and product development process cannot be done solely through the patents system, even if modified to provide incentives and exemptions, there is considerable evidence that valuable invention can be encouraged in its absence. A great example is that historically, even in countries with a long patents tradition such as the USA, patenting has been less available

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<sup>18</sup> [www.bios.net/ip](http://www.bios.net/ip)

<sup>19</sup> For example, see [www.bios.net/agrobacterium](http://www.bios.net/agrobacterium)

for monopolistic protection of innovations in software; nonetheless software development has been greatly encouraged by the formation of “protected commons” for Linux software technology and many other software innovations. In this model, the source code arising from an inventor or technology owner is available to others connected within the commons via “open source” licensing (a license that allows anyone to improve and use the technology for making a profit, as long as they do not prevent others from using it). The protected commons differs from the public domain in that the users are constrained to certain conditions of use, but tens of thousands of users have agreed to these conditions under such license arrangements.

Despite the lack of exclusive protection such as that which would be offered by patents with limited license availability, there has been no obvious hindrance and indeed distinct accelerations are seen in the pace of innovation leading to improvements and commercialization. For example, IBM took in US\$2 billion in revenues from services and innovations based on unpatented Linux code in 2003, more than double the revenues from outlicensing its own patents<sup>20</sup>. Furthermore, far from being discouraged in pursuit of commercial development by the lack of exclusive protection, investors like the lack of risk of being blocked from using the technology and improvements by the IPRs of others.

One reason for the success of the open source protected commons is that the ready availability of the license to use the inventive technology allows for a large number of creative minds to come up with improvements. No one company, not even a giant such as Microsoft, has a monopoly on all the best programmers, so this open source licensing allows improvements, even though they are not patentable, to be developed more quickly than they would in a single company<sup>21</sup>. This open source improvements model, indeed, would be best applied in a situation where the number of potential contributors to improvements is large. In such a case, each participant in the protected commons pool receives not only the benefit of the inventions in the pool, but also a proportionately increasing value in accretive improvements.

The model has also flourished because of the distributive capability of the Internet and the power of informatics to foster transparency of improvements. Indeed, being able to share and display one’s work distributively within the protected commons has developed a community feeling and community norms as a new type of incentive among the participants. In the open-source method, independent programmers around the world contribute, often without pay, to creating and honing better software such as the open-source Web server software Apache, which continues to dominate with 62% market share vs. 27% for Microsoft’s software. The incentive is that the formation of a community feeling within the protected commons is tapping into the true motivation of programmers in a way that corporations often don’t. “Programmers are like artists,” says open-source software consultant Bruce Perens. At most corporations, their best work is hidden behind

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<sup>20</sup> These data were compiled by Yochai Benkler from IBM annual reports and Forbes Magazine, [http://www.forbes.com/forbes/2004/0607/086\\_print.html](http://www.forbes.com/forbes/2004/0607/086_print.html)

<sup>21</sup> Commentary: Tech Outfits Should Take Notes. SPECIAL REPORT -- THE LINUX UPRISING, Robert D. Hof, Business Week, 3. March 2003

locked and guarded doors, when they would rather showcase their best work for their peers, as they can do in the open source protected commons.<sup>22</sup>

#### **IV. A distributive innovation system to attack the problem at its roots**

As described above, the ability to derive benefit from a large number of potential contributors and the more collaborative, connected mode of exploitation of intellectual property were both characteristics of the open source software protected commons model as it developed. The BIOS Initiative aims to build a legally and normative "protected commons" of biological intellectual property, on a precedent similar to that afforded by 'open source' software development, in which differentially motivated individuals, whether in for-profit or non-profit enterprises, can pool ideas and efforts safely and efficiently without any entity having the ability to hijack the whole.

By promoting new institutional mechanisms for licensing new technologies in a protected commons, BIOS will catalyse the empowerment of innovators throughout the region, whether located in rich or poor nations and institutions, to address local, small-margin, small market innovations in food, agriculture, public health, industry and environment. However, while it has its current business and social validation in the Open Source movement in information and communications technology, BIOS traces its roots back to practices of farmer-breeders in the first few thousand years of agricultural development, and finds elements of its motivations in the powerful drive to share the results of scientific endeavour that has characterized the best of science over the last four hundred years.

To encourage this motivation, the timing is perfect to take advantage of the communications and data transfer opportunities of the internet to build useful information connections between problem solvers and technology owners. The ability to build collaborative, license-protected websites has enabled inclusionary, distributive innovation system reform options for software innovation, and it is the aim of the BIOS initiative to adapt the same inclusionary, distributive means to enabling biological innovators.

We will need to use sophisticated informatics to increase transparency and to get around language barriers, but our aim is that the user interfaces not reflect these complications, but instead are readily accessible, with the goal to stimulate mechanisms to incentivise and coalesce creative solving of problems. A scenario is as follows:

Imagine an inventive problem solver in a small regional university, public institute or SME-type company in Bolivia or Vietnam. This individual, usually with modest or no financial resources, may perceive a problem or be charged with solving a problem of localised relevance, perhaps a new disease challenge to crop production or a new public health challenge.

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<sup>22</sup> *ibid.*

An idea about how to approach a solution may already be formed in this person's mind, or perhaps not; perhaps the individual feels overwhelmed by the enormous responsibility and lack of resources. How can he or she find the energy, knowledge, toolkit and capacity to explore potential solutions and adapt and shape them for this local problem? What will be the mechanism for delivery – a problem whether the individual is in public or private enterprise? How can a sustainable contribution to that solution be ensured?

This inventor will almost certainly have access to the internet, as such access is increasing exponentially in the region and will within ten years be virtually ubiquitous with affordable high bandwidth. Thus it will be possible to go to the BioForge website, which will be constructed by CAMBIA's BIOS Initiative, and there to search many categories of problems being tackled by countless groups and individuals. The local researcher can readily find a user group or groups with some synergies to the problem she faces. If such a group doesn't exist, there will be an easy software mechanism to form one, and place a call to the community to help structure such a group.

Without limitations related to time zones, members of the worldwide research community can find opportunities to volunteer an hour, a day, a week of their time, confident that each contribution may have a high probability of making a difference. A graduate student in Europe or the US or a technician in Bangladesh or Australia can access the website in spare time, find this project, and offer some assistance, however small or large, that may be germane to solving the problem.

The website is intended to comprise, as the BIOS IP tools currently do, databases navigable by the neophyte, allowing queries about what worldwide progress in the public or proprietary domain has already been made that could be relevant. Has the idea already been appropriated in the proprietary domain, or otherwise restricted by patents in relevant jurisdictions? Are there ways to manoeuvre within the IP constraints and find technical and legal means forward? Does the ability to solve the problem reside in already published patents that are not filed in the local jurisdiction, or that have been allowed to lapse? Will it be necessary to re-invent the wheel? The ability to interpret and filter this massive information load will have to be provided by a culturally friendly interface, behind which are located powerful informatics aids to guide queries in a way that is helpful to build on the local investigator's knowledge and needs.

If a group with a similar or compatible goal already exists on the website, there will be a simple means to access the expertise, and a guarantee – by the site's operating charter and the license to which all site users must agree – that such access to the fruits of the group's labours can be made without fear that the access will be removed when a product is developed and ready for deployment. It will be possible to surf and work within this site filled with biological innovators, secure in the knowledge that this community is based on a premise of sharing the tools and improvements that are developed, and licenses that guarantee the right to reduce the collective contributions to commercial practice.

This confidence can be shared by local investors – public or private – who can be encouraged that a development based on and leveraging the open-source community can

have real critical mass for improvement and testing, and legal precedent for delivery. This investment will be extremely valuable to ensure a sustainable resource base to implement, test, learn from, revise and ultimately deliver and support the innovation in the local region. Small local enterprise can form around this innovation, not beholden to third-party rights, with the confidence that if it is successful it might later be able to trade the products or services that flow on from its development efforts on a national, regional or even international scale through the freedom to operate offered by the license covenant not to sue.

Perhaps the most significant advantage of the envisioned community is the power of the norms that will be created by the connectivity and collaboration to solve local problems in a locally appropriate way. As previously mentioned, implementation problems with irrigation, compliance problems with erosion control measures etc. were symptomatic of a lack of ownership of laws, policies, regulations and norms, based on failure to understand their personal importance or benefit, or a lack of fit with the local culture. The best way to solve problems like these is to employ the creative minds at the local level who are committed by virtue of their ownership in local problems and local culture. The BIOS initiative aims to use the distributive technology and formation of community norms empowered by the Internet to encourage local ownership in locally appropriate applications of technology.

Though it is not entirely in place as yet, the above-described scenario requires nothing that is fanciful or without precedent. The community of goodwill that exists in the world biological scientific community cannot be doubted. The legal and business precedents are strong, as manifested by the extraordinary success and momentum of the open source software community. The software and informatics that must be created and harnessed are manageable. The communications paradigms and opportunities are in place and growing indisputably even into the most economically neglected communities.

## **V. Summary and policy recommendations**

The most efficacious way to address global health needs is to provide for the continuous generation of long-term stable food sources for the hundreds of millions who suffer from malnourishment. New crops and agricultural innovations to decrease erosion, water supply irregularities, and the impact of pests and plant and livestock diseases would be welcome, but inventors are not always capable of bringing their inventions to effective production and distribution among the hungry, due not only to lack of capital but also to a variety of local factors.

The time is uniquely well set for using the communications and data transfer opportunities of the internet to build useful information connections between problem solvers and technology owners in an inclusionary, distributive innovation system. The open source software protected commons model has been useful for spurring investment and rapid innovation. Similarly the BIOS Initiative aims to build a legally and normative "protected commons" of biological intellectual property in which differentially motivated individuals, whether in for-profit or non-profit enterprises, can pool ideas and efforts

safely and efficiently without any entity having the ability to hijack the whole. This should enable coalescing a creative process of solving problems locally with technology accessed globally.

To empower inventive and committed minds at the local level worldwide to address the market of the poor and marginalized, intellectual investment mechanisms will be needed that are collaborative and distributive rather than capital-intensive. BioForge aims to use the communications and data transfer opportunities of the internet to build useful information connections throughout the worldwide community of problem solvers, so that an innovator working on a crop improvement in a developing country can become aware of an advance elsewhere that could be harnessed together with local means of production for use in solving a local problem. Forming part of the community provides an incentive to innovators that, while small, may attract and reward small innovations in sufficient number to make a big difference. Technology owners have incentives to allow their intellectual property to be used and improved within a protected commons, and those who control capital have the greater certainties to encourage investments in the enterprises that are thus enabled to make use of it.

Any government or intergovernmental agency that desires to support inclusionary and distributive innovation using a paradigm such as this can assist with making patents databases available, commonly formatted and transparent; recognising and encouraging open source licensing and the legal frameworks of protected commons; and facilitating access to the BioForge by individuals in universities and research institutes who can assist with translation and access of the ideas on behalf of their local communities and the micro, small and medium enterprises functioning in those communities. These are much more likely to make the local adaptations to create and maintain sustainable and resilient food supplies.

## **VI. Acknowledgements:**

The preparation of this paper was funded by the Centre for the Application of Molecular Biology to International Agriculture (CAMBIA), Australia, through a consultancy. Funding for the BIOS Initiative is provided by the Rockefeller Foundation. Equipment for website development has been provided by IBM.