One of lead papers presented at: Innovation Asia-Pacific Symposium: 4-7 May, 2009 Kathmandu, Nepal. Paper to be included in an IAPS publication expected to be finalized in 2010

Use of practical examples from CABI, a science based organization, to illustrate how more impact may be gained from research based knowledge

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Abstract

In the current climate of rapid change pressures on researchers to achieve greater impact are increasing. Use of an innovation systems framework is seen as a means of addressing these issues. However, social and biological scientists often conceptualise issues in different ways and biological scientists sometimes find it difficult to relate social science theories to practice. Cases representing practical examples of what it might mean to use innovation systems interventions and recognize key features are presented. Four cases represent actions facilitating uptake of research outputs including; a crop pest bio-control method; post harvest management of coffee; isolation and commercialization of an indigenous seed variety and; a community based system to forecast armyworm plagues. Case 5 addresses an initiative to build capacity to respond to emerging crop health challenges on an on-going basis. Key features influencing project activities and interventions contributing to success are summarized. The project concludes a) innovation systems features and interventions can be recognized in research uptake projects b) a new attitude to failures is needed if we are to learn from failure and c) research organisations may prioritise activities addressing research uptake over innovation capacity d) nevertheless scientists can play an important role in improving innovation capacity directly.

Key words: Innovation capacity; case studies; research uptake; impact

Introduction

In a rapidly changing world, both the developed and developing world are constantly facing new challenges and opportunities caused by factors such as climate change, increasing population and globalization. In recent years there has been considerable debate between aid donors and the international scientific community concerning failure of researchers to achieve impact at livelihood level. A root cause of failure is thought to lie in the approach to generation and use of knowledge. Linear, transfer of technology models where scientists produce ‘new technologies’ which are then ‘delivered’ by intermediaries to beneficiaries such as farmers who then ‘adopt’, although perhaps appropriate in the development scenario of the 1960’s and 70’s are considered to be no longer adequate (Hall et al. 2008).

As a result, researchers are encouraged to re-think their role in development and to consider how they contribute to knowledge generation and use. Systems approaches involving multiple stakeholders are considered to be more likely to lead to impact and the focus has switched from transfer of technology to innovation as a process, defined as the use, adoption, uptake or commercialisation of new and existing knowledge for positive social and economic change. An innovation systems framework has been developed based on what has and hasn't worked in the past, building on a number of academic disciplines. The framework is seen by many as a means of addressing these issues and there is a growing body of literature that describe principles or approaches to guide the way researchers and their partners go about their business (e.g. Hall et al. 2008). Contributors to the DFID funded Research into Use programme developed a set of features emphasised by an innovation systems perspective and a set of interventions to operationalise an approach expected to increase the probability of successful innovation (RIU, 2009) based on work by Arnold and Bell (2001).

Social and biological scientists often conceptualise issues in different ways and biological scientists sometimes find it difficult to apply or relate approaches and/or theories largely developed by social scientists, in this case to innovation, to solve practical problems. The present paper sets out to present a series of cases from CABI, to illustrate some of the ways in which biological scientists have worked to facilitate innovation. The objective is to use practical examples of what it might mean to use the interventions encompassed in an innovation systems approach and to recognize some of the key features.

Case study selection

A set of four cases were chosen representing actions intended to facilitate the use or uptake of specific research outputs or groups of outputs to address specific problems. Case 5 aimed to intervene at a systems level to develop plant healthcare networks in which plant health problems are identified and addressed on an on-going basis.

Table 1: Key features and interventions characterizing an innovation systems approach (RIU, 2009; Andrew Barnett personal communication)

Features	Interventions
• The importance of balancing the power relations between **both the "supply push"** of the research community **and the "demand pull**" of the users of new knowledge. • The importance of **'intermediary functions'** in finding out what producers (and their customers) want, and searching through the range of options within the stocks of existing and new knowledge to find what best meets the need. • The **'framework conditions'** and the **basic 'infrastructure'** are crucial – often the ways of working, aspects of culture, the social value placed on innovation and entrepreneurship, and the banking ethos that best explain successful innovation systems, while weaknesses in the infrastructure often form the major constraint. • Both **"tacit knowledge" and "codified knowledge"** are required for innovation – for example, combining knowledge from manuals and instructional videos with tacit knowledge of local	• **Undertake a diagnosis of the "system"** and the power relations between its elements in order to determine the binding constraints and to identify those parts of the system where intervention is most feasible and most likely to result in successful innovation. The System is defined pragmatically in terms of the whole space in which to innovation is intended or constraints identified. • **Facilitate an interaction between a diverse range of actors** – who are necessary for successful innovation, to build trust-relations between them, to develop the necessary value chains, and to strengthen their capacities to innovate. • **Strengthen the power of the "demand side" of the innovation system** (because poverty is a major constraint to innovation) - by amplifying the "voice" of the potential users of new knowledge and increasing their ability (power) to acquire the tacit and codified knowledge that they need to innovate. This includes supporting the emergence of sustainable knowledge and services markets in the

circumstances. • The importance to successful innovation of **networks and linkages** that provide effective channels for two way flows for communication, resources and knowledge between the various organisations and individuals that make up the system. These can be both formal and informal, with informal links appearing to be particularly important, and relationships can be both collaborative and competitive, with different actors relating to each other as competitors on some issues and collaborators on others.	agricultural and natural recourses sectors. • **Strengthening those organisations and individuals who perform the "intermediary functions"** – linking both the "supply push" of research-based new knowledge and the "demand pull" for that new knowledge and enabling them to interact continuously. • **Increase the incentives and reduce the disincentives -** that motivate people and organisations which do, should or could play a role in innovation. • **Experiment and invest in learning** from this experience –to enable organisations within the innovation system to improve their performance through an evolutionary process over time.

Methodology:

Project documentation and key informant interviews with project staff were used to describe the project focusing on approaches used to facilitate research into use. It should be noted that no case set out to use an innovation systems approach, although understanding of the related debates by those involved may have influenced project design. Interviews focused on three questions, based on the key features and interventions in Table 1.

- In what sense can the case be described as successful innovation (or sequence of innovations)?
- Who were the system actors involved in the innovation process and how did they contribute to the process?
- What were key interventions or features contributing to success?

Case study narratives: Brief descriptions of each case, highlighting some key factors affecting use of knowledge are given below.

Case 1: Quality Coffee in Ethiopia

A project was carried out in Ethiopia, to improve livelihoods of small-scale coffee producers by generating increased income, through demonstrating and popularizing approaches to producing higher quality coffee. Activities responded to increasing sophistication in coffee demand, with higher prices paid for quality. New practices, including selective picking of mature cherries followed by improved sun-drying on raised drying beds or processing to remove the pulp round the coffee bean using simple hand pulpers, were introduced to smallholders. Action learning approaches were used and farmers modified and adapted practices to suit local conditions. At the time of the project, all export coffee had to be sold through central auctions where prices reflecting quality were negotiated. To access the central auction it was necessary to be registered as suppliers (middlemen buying coffee from local collectors or farmers and processing), estates or cooperatives. Farmers in Ethiopia often prefer to operate as individuals and not through cooperatives, following negative experiences of being forced to work in service cooperatives during the communist Derg regime (ending early 1990's). Traditionally they sell small lots (often daily harvests) to local traders mainly to meet immediate cash needs. Traders rarely pay according to quality for such small lots and coffee collected from a number of farmers is generally bulked and sold as aggregated lots.

Initially, it was expected that the project would address technical issues related to coffee quality, while marketing of the product would be a private sector responsibility. However it became increasingly clear as the project progressed that integration of the two components was essential, as farmers would not invest in new machinery or practices unless they profited from the increased quality of the product In other words, economic incentives were needed for farmers to adopt new technologies and practices. A special auction was facilitated enabling project farmers to sell coffee directly to exporters. Thus the high quality project coffee fetched up to 78% more than the average price of conventional coffee. Primary collectors and intermediate traders, frustrated at being unable to access coffee from their regular suppliers (the farmers), started to offer higher prices to lure them back. This demonstrated increased negotiation power of farmers and capacity of local traders to respond to market competition. Mechanisms to give farmers appropriate incentives to invest in improving coffee quality in a sustainable manner were an essential part of the initiative.

Case 2: Community Based Armyworm forecasting (CBAF) in Tanzania

Armyworms are the larvae of moths (*Spodoptera exempta*) which appear suddenly in high density outbreaks with devastating effects on graminaceous crops and pasture. Studies in the 1960s led to the establishment of regional then national forecasting systems in East Africa, with weekly warnings of where outbreaks might occur the following week. The forecasts were based on meteorological information, moth trap data, and reports of outbreaks that could cause subsequent outbreaks. Data were sent to the central forecasting unit, where forecasts were prepared and disseminated. Much research was conducted to improve this system, including the development of pheromone traps for monitoring moths, investigation of remote sensing to detect rainstorms, and methods for locating and controlling early season "critical" outbreaks including those in unpopulated areas.

At the start of a project in 2001 to further improve the forecasting system in Tanzania, a stakeholder workshop analyzed the functioning of the forecasting service and proposed a new, community based approach, where villages are provided with moth traps and make forecasts for their own communities. The community decides how to communicate forecasts, so farmers know when to check their crops for the tiny armyworms, before they cause serious damage. Facilitating interactions between different stakeholders at community level was essential since early attempts failed when local authorities were not involved. Pesticide dealers and district authorities are also alerted, so that control supplies and activities can be organized. Forecast accuracy is good and in villages where no external support was provided after the first season (other than providing baits for the pheromone trip), forecasting continued 2 years later, with arrangements made in some villages to 'pay' farmer forecasters for their services. Farmer forecasters have acquired status within the community, and nationally the approach has been supported as a complement to the existing centralized system, which still has value for longer term forecasts to support higher level decision making. A key factor considered to have contributed to success was the general shift towards state decentralization in Tanzania, establishing framework conditions that were conducive to greater community involvement in responding to armyworm outbreaks.

Case 3: Kale seed

Brassicas are grown by over 90% of Kenyan smallholders with kale the most important providing food and income generation opportunities through sales to urban centres. Researchers from CABI and the Kenyan Agricultural Research Institute (KARI), aiming to work with farmers to design appropriate Integrated Pest Management (IPM) approaches for kale, discovered farmers in one area were already using kale tolerant to a major disease. The variety flowered easily in one part of Kenya and farmers from elsewhere came to seek seed, although availability was limited. Activities shifted to addressing how to facilitate farmers' access to these landraces. At the same time growing and selling seed was identified as a potential income generation activity for farmers in the area where the variety flowered. Work took place with farmer groups to identify potential varieties and develop a clean landrace. Five distinct, uniform lines were developed, and enough clean seed produced to allow a thousand smallholder farmers in different kale growing regions in Kenya to evaluate them. Farmer groups were trained in clean seed production, learning how to prepare and maintain disease free plots and about safe packaging and storage. However, training was not enough for them to profit from seed production as a business and it soon became clear that the farmer / research / extension coalition could not solve the problem alone.

To a large extent, policies determined how seed is marketed and a number of issues were identified. In Kenya it is illegal to sell seed uncertified unregistered seed and farmers also need to be registered to operate a business. Although farmers were interested in commercializing seed production they did not necessarily have the skills and capacity to operate independently or the necessary networks or distribution capability. The project started to partner with other organizations and bodies to address these issues. The project engaged with KEPHIS (Kenya Plant Health Inspectorate Services), responsible for seed certification. KEPHIS provided inputs on seed regulatory procedures in training sessions showing farmers how seed plots are inspected, describing standards to be met and practical ways of achieving them. They also worked closely with the original partners to develop seed characterization procedures for kale, and implement multi-locational trials. Two out of 5 lines are currently being registered so they can be traded legally. Community development authorities. Ministry of Culture and Social Services were engaged to register the groups growing the kale. To become a registered seed merchant in Kenya is expensive and demanding and the project engaged with an existing private sector company to explore options. The private company saw an opportunity to commercialise varieties expected to find a ready market. Farmers would generate income by bulking seed and selling to the private company that would distribute and sell seeds commercially.

Case 4: Bio-control of Asian corn-borer in DPRK

Agriculture is of high importance in DPR Korea with 90% of production generated through a cooperative farming approach. The Ministry of Agriculture defines crops and yields expected of the cooperatives in annual work plans and provide inputs and services needed to deliver the targets. However, farmer work teams responsible for production find it increasingly difficult to deliver targets due to declining soil fertility and the exacerbating cause of insect damage, together with limited access and poor quality of fertilisers and pesticides. The Asian corn borer causes the most extensive damage, resulting in yield losses generally ranging from 10-30% and occasionally up to 80%. Since maize is one of the most important staple cereal crops in DPRK, efforts to reduce pest damage and ensure food security are vital.

The present case covers an initiative responding to a major drive to increase National food production and improve food security in DPRK focused on long term improvement in maize production using IPM. IPM combines cultural, chemical and biological control methods to provide long term prevention and reduction in pesticide use. Biological control of the Asian corn borer was a key part of the IPM strategy and involved mass production of a parasitic wasp *Trichogramma*.

The IPM approach was tested in country and showed 28% increase in yield, 65% decrease in borer larvae and increased plant material for use as livestock fodder. Eight facilities for mass production of the parasitic wasp have now been established at county level, following adaptation of Chinese equipment and facility design to cope with poor infrastructure and limited access to electricity. These facilities rear wasps for up to 40 cooperative farms, predicted to increase total production by 6200 tons per year. Wasp eggs are provided in exchange for materials needed to rear them.

Capacity building of actors contributing to wide-scale use of IPM measures was key. An experimental rearing facility was established in the Plant Protection Institute and a *Trichogramma* Production Manual produced to give scientists hands-on experience and prepare them to train county staff working in the rearing facilities as well as farmers. A jointly developed knowledge transfer concept together with the introduction of new training methodologies and didactic approaches formed the basis for successful IPM implementation and farm level. A general ability of trainers to transfer scientific knowledge into practice-oriented farmer support further strengthened the results. Central Plant Protection Station (CPPS) staff of the Ministry of Agriculture were trained to manufacture and maintain local rearing facilities and assisted to develop a business plan that recognised the inappropriateness of profit in the socialist economy. University lecturers at Pyongyang University were supported to develop an IPM course, now part of the University syllabus. Policy workshops with the Ministry of Agriculture to develop National IPM guidelines led to maize IPM, particularly the use of *Trichogramma* wasps, being set as a high priority area by the government.

The culture and institutional framework comprising the socialist system in DPRK represented a special set of circumstances the project had to deal with and capacity building efforts needed to adapt to social norms and account for diverse and often conflicting interests. At the farm level, incentives to improve productivity (benefits from higher yields) are counterbalanced by the fact that production targets may be raised if higher yields are achieved in consecutive years. However, purely ideological incentives such as increasing the contributions to national food supply appeared to affect farmers' motivation to raise production. Furthermore, the government takes responsibility for ensuring the population is fed and given the difficulties, pressure on the government for increased food production is high. A driving force behind government policy is the aim of self-sufficiency which means that there is a reluctance to import pesticides and other inputs. Locally produced agro-chemicals are of poor quality so alternative methods to control pests that can be managed internally are attractive. In Europe, bio-control may cost a bit more than chemical solutions whereas in DPRK the reverse is true.

Case 5: Plant healthcare networks

The case describes activities led by CABI scientists in the "Global Plant Clinic" (GPC). Conceptualisation of plant healthcare networks evolved over time as scientists explored ways of providing direct support to farmers seeking advice on crop health problems. The initial idea was to hold regular 'plant health clinics' in which 'plant doctors' set up a 'clinic' in a public place farmers frequent, often agricultural market places. Now, clinic doctors operate within in a heterogeneous network of actors including technical experts, diagnostic laboratories and input suppliers. Doctors request advice and alternative control options from experts, and in some cases research projects have emerged to address problems with no known solution. Samples can be sent for diagnosis to National diagnostic laboratories and where further advice is needed, or laboratories lack equipment and materials for tests, samples are sent to GPC laboratories in the UK. Linkages with local input suppliers ensure plant doctors know availability of products and in Bangladesh certification of suppliers following training courses has encouraged reduced sales of fake products. Training programmes for plant doctors teach them to look carefully at symptoms, interview farmers and visit farms where necessary. Doctors are taught only to make a diagnosis and give advice if confident they are right and only recommend inputs available locally. Fact sheets are used to convert tacit to codified knowledge which can be shared more widely. A condition of GPC support for clinics (training and materials) is that doctors record and share data related to clients, symptoms, diagnoses and recommendations. The records provide the basis of a quality control system in which data are shared at monthly meetings of clusters of clinic doctors and associated technical experts. They also provide the basis of a community surveillance system.

Clinics have now been run in 4 countries in Asia; 9 in Africa and 5 in Latin America and there have been efforts to learn about key factors affecting success through a learning by doing approach. For example, it was observed that organisations with an existing mandate to carry out extension and those that were well run, assigning clear roles and responsibilities for staff, and with direct accountability to farmers, were more likely to run clinics effectively and maintain a regular service. Interaction at all levels within organizations was essential for the clinics to become integrated with their daily activities. In some cases facilitating greater understanding between actors was needed to encourage attitudinal change. For example, plant doctors were taught not to be dismissive of farmer explanations and laboratory staff encouraged to change patronizing attitude to extension staff through better understanding how clinics worked and the farmer needs. Experiences also showed the importance of understanding local contexts. For example, there were differential attitudes amongst men and women farmers and plant doctors and how they perceived, used and interacted with plant health services in Bangladesh; in Africa, economic incentives to motivate staff to run clinics or undertake farmer outreach activities were often needed, in contrast to Asia where many took independent initiatives; capacity of individuals is often lower in countries emerging from long term conflict where skilled staff had been killed or fled from the country.

Summary of findings

Table 2 compares each case against the set of features and interventions summarized in table 1, indicating whether a particular feature was fundamental to the nature of the initiative or that an intervention was used and contributed to the success of the initiative. The greater number of X indicates higher level of relevance or importance. Detailed observations are given below.

Observation of key features

Relations between "suppliers" and "users" of knowledge were altered in all cases. In cases 1 to 4 shifts occurred where National actors were trained to use participatory approaches allowing users to adapt and influence how knowledge was used. In the GPC case mechanisms were developed allowing regular communication between the two enabling farmers to demand knowledge and excluding promotion of specific knowledge unless it directly responding to farmers' problems.

Table 2: Overview of relative importance of features and interventions in contributing to success

Key features	**1 Coffee**	**2 CBAF**	**3 Seed**	**4 IPM**	**5 GPC – plant healthcare networks**
Balance supplier/user relations	X	X	X	XX	XXX
Intermediary functions' key to identify needs and find solutions	XX	X	XX	X	XXX
Framework conditions crucially impact on knowledge use	XXX Policy and culture	XXX Communication networks	XXX Policy	XXX Culture	XXX Culture and Ways of working
Tacit and codified knowledge combined	XXX	X	XX	XXX	XXX
Networks and linkages key to innovation	XXX	XXX	XXX	XXX	XXX
Key interventions					
Undertake system diagnosis	iterative	systematic / iterative	iterative	iterative	iterative
Facilitate actor interactions	XXX	XXX	XXX	XXX	XXX
Strengthen "demand side"	XX	X	X	X	XXX
Strengthening "intermediary functions"	X	X	XXX	XX	XXX
Increase incentives /reduce disincentives	XXX	X	XX	X	XX
Experiment and invest in learning about processes	XXX	XXX	XX	XX	XX

Intermediary functions were also key in all cases. The GPC case focused on the role of plant doctors in brokering knowledge, seeking support where diagnosis and solutions were not clear and ensuring recommended inputs were available locally. In the remaining cases intermediary actors were key in building capacity to use specific knowledge. For example, ministry extension training coffee farmers; village and district extension officers participating in communication networks in armyworm forecasting; extension and KEPHIS training seed producers and; the Plant Protection Institute supporting farmer capacity building in IPM.

Framework conditions were a fundamental feature of all five cases. In cases 1 and 4 current or previous socialist regimes had a major influence on stakeholder behaviour e.g. farmers views on coffee cooperatives and farmers organization in DPRK. In case 1 and 3 policies related to regulation of coffee and seed marketing influenced market actor behaviour and determined ways in which appropriate incentives could be put in place. In GPC country context influenced how networks functioned. In the case of CBAF existing interactions between actors determined the communication mechanisms that formed part of the approach. In all cases it proved important to work across organisational hierarchies as well as ensuring all relevant actors were considered. Gender and caste issues were observed to be important in case 5, but not in other cases, though this may be partly because gender considerations were not evaluated critically during the course of the initiatives.

Tacit and codified knowledge were combined in all cases. In case 5, the plant healthcare networks use a process of developing fact sheets share tacit knowledge. In other cases capacity of stakeholders to translate tacit to codified knowledge was built while preparing materials related to specific outputs.

Networks and linkages were important in all cases, those needed to facilitate use of specific knowledge in cases 1-4 and those needed to identify and address emerging challenges in case 5.

Use of key interventions

System diagnosis was only undertaken systematically at the start of the initiative in case 2, where a stakeholder workshop analysed the forecasting system looking at the actor roles, patterns of interaction and reasons for different behaviors. From this a community based model was developed. In the remaining cases understanding of the system emerged as the initiatives progressed. Staff in cases 1 and 5 felt that although a more systematic analysis at the start of an initiative would have been useful and may have provided a short cut to learning lessons as activities unfolded, real learning comes from practical application and implementation. In other words, theoretical analysis is useful but needs to be integrated with longer term learning about behaviour.

Facilitating interaction between actors took place in all cases. Interactions included meetings, workshops, group training, site visits and formal visits. In case 5 a written agreement was used to formalize interactions between plant healthcare networks in Nicaragua and monthly meetings between clinic doctors were key to establishing a quality assurance system. In the CBAF case agreement of communication processes in the event of predicted outbreaks were a fundamental part of the initiative.

Strengthening the demand side and intermediary functions were, as mentioned above key features of the GPC case, but less fundamental to cases 1-4. Nevertheless, participatory processes were used to allow users to express their needs and influence the way knowledge was used and intermediaries were taught to train farmers in using practices to improve coffee quality, forecasting armyworm attacks, seed management and use of IPM measures.

Increase the incentives and reduce the disincentives In all cases understanding the incentives or disincentives influencing actor behaviour were key to promoting the sustainable use of knowledge. For coffee and seed there needed to be economic incentives for farmers to invest in practices, while in the GPC non-monetary incentives were more important. In DPRK socialist culture meant conventional economic incentives at farmer level were not feasible and appropriate incentives at government level were more important. In case 2, the risk to crop production caused by the armyworm was so serious that it acted as a fundamental incentive encouraging individuals to engage in ways to deal with it.

Experiment and invest in learning Learning was fundamental in cases 1-4 related to technical aspects of the project and impact of successful innovation. Learning about processes and how they contributed to innovation was strongest in case 5 but documentation reflecting on the processes was observed in all cases and interviews with staff involved revealed a deep understanding of the issues, where they had gone wrong and how they had gone about correcting misconceptions etc.

Conclusions

Successful initiative were selected as cases, however all initiatives encountered problems, made mistakes, learnt from them and as a result tried alternative approaches. Some key lessons from the case studies about the kinds of impact you can expect, the role for scientific organisations, and how to strengthen learning are given below.

A fundamental difference between the cases was that success for the first four was measured in terms of the extent of adoption and use of research outputs, while success of the fifth was measured in terms of the capacity of plant healthcare networks to respond to emerging problems that could reasonably be considered innovation capacity. This explains why the features and interventions figured more prominently in the fifth case compared to the others as success is more closely related to that defined in innovation systems terms. However, it should be noted that the first four gave rise to behavioural changes also expected to increase innovation capacity. This was because capacity building interventions (e.g. addressing individual skills, interactions between actors, organisational strengthening and policy change), though implemented to facilitate uptake and use of specific knowledge, had broader impacts on those involved. Examples include: new or changed relations between private sector and farmers in the seed case or traders and farmers in the quality coffee case; training of trainers and teaching codification of tacit knowledge in the DPRK case and; training in participatory approaches across cases.

Learning emerging from the cases could be strengthened from in depth analysis of additional cases of activities that were not successful, although a shift in the way donors and peers view failure is needed before failures are widely and freely examined in public. Although learning was fundamental in all cases, a primary focus was sometimes on technical impacts. Biological and social scientists need to continue to strive to work together to systematically learn about research approahcces and to use innovation theory to be more successful in the future.

In fact, it is more likely that scientific organisations are best placed to contribute to innovation capacity indirectly through research into use initiatives. Activities such as those in case 5 do not always fulfil the mandate of research organisations that take responsibility primarily for new knowledge they are involved in generating and direct impacts on livelihoods are longer term. Both types of initiative are important if scientists are to contribute more directly to livelihoods.

Acknowledgements

The idea for the present paper arose from work contracted to ODI and CABI by the DFID funded RIU programme. However any views or opinions expressed are solely those of the authors.

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