The Discussion Forum on development of IAS management tools and guidance finished with an August 2019 discussion of *Risk analysis on the potential consequences of the introduction of invasive alien species on social, economic and cultural values*.

By the end of the month, it received 36 contributions from around the world, providing commentary and examples. The discussion was structured into three threads asking for views and evidence on different aspects of this issue. This report summarises the contributions received by 31 August 2019 (09:00 GMT)

The three threads in this forum were:

4a) Qualitative and quantitative existing cases of the impacts of invasive alien species on socio-economic and cultural values and the wellbeing of indigenous and local communities that capture a diversity of impacts?

4b) What actual and potential risk analysis and other relevant methods are available or are being or could be developed that can be used for preventing/limiting the impacts of invasive alien species on socio-economic and cultural values and the well being of indigenous and local communities?

4c) Can the knowledge gained so far on the impacts of invasive alien species on socio-economic and cultural values and the well being of indigenous and local communities provide a basis for better ways of defining, measuring and quantifying such impacts in the future?

Overarching summary discussion:

While plants provide 80% of global food supply and produce 98% of the planetary oxygen, each year an estimated 10–16% of global harvest and up to 40%t of global food crops are lost to plant pests. Three-fold increase in the value of trade in agricultural products over the last decade to US$1.7 trillion, this is matched by plant pest losses to agricultural trade of more than US$220 billion annually (Savary et al. 2019). These are massive socio-economic impacts. Invasive plant pests like fall army worm are spreading more quickly around the globe. Pests are appearing earlier and in places where they were never seen before influenced by climate change, threatening to reduce both the quality and quantity of crops, reducing yields. Rising temperatures are also exacerbating water scarcity, and changing the relationship between pests, plants and pathogens.

The International Plant Protection Convention (IPPC) develops international standards for phytosanitary measures (ISPM), Commission on Phytosanitary Measures (CPM) recommendations, implementation and capacity building activities of the 183 IPPC member countries (= contracting parties). The IPPC has over 100 standards many of which are relevant for the protection of cultivated plants, but also extends to encompass natural flora and plant products (https://www.ippc.int/en/core-activities/standards-setting/ispms/#publications). Relevant standards include:

- Phytosanitary treatments and diagnostic protocols for specific pests (https://www.ippc.int/en/core-activities/standards-setting/ispms).
- ISPM 2 on framework pest risk analysis available at: https://www.ippc.int/en/publications/592/).
- ISPM 5: Glossary of phytosanitary terms; Supplement 2: Guidelines on the understanding of "potential economic importance" and related terms including reference to environmental considerations.

- ISPM 11 on pest risk analysis for quarantine pests (https://www.ippc.int/en/publications/639/), which also considers in its supplements pest risk analysis for LMOs and determining the potential for a LMO to be a pest
- ISPM 15: Regulation of wood packaging material in international trade.
- ISPM 27: diagnostic protocol for *Xylella fastidiosa* as regulated pest and guidelines for the prevention, eradication and containment
- CPM recommendation (CPM =) on "Threats to biodiversity posed by alien species: actions within the framework of the IPPC" (https://www.ippc.int/en/publications/84229/).
- Fruit fly standards, over 23 international standards that provide guidance to establish areas pest free of fruit flies, to determine fruit or vegetable hosts, to effectively carry out disinfestation through irradiation and cold treatments.
- Avocado phytosanitary measures to minimize the risk of international movement of three weevils and a moth, adopted as international standards
- Fall armyworm. FAO is taking an active role in coordinating partners' activities, plans and approaches to provide sustainable solutions to the FAW challenge

IPPC has a newly endorsed Strategic Framework for 2020-2030, in which there is a Strategic Objective – "Protect the environment from the impacts of plant pests". This objective is targeted at plant pests which are invasive alien species and which can and do have a significant and devastating impact on the terrestrial, marine and freshwater environments, agriculture and forests. This framework is hightly relevant for the Convention of Biological Diversity Global Biodiversity Framework (GBF) 2020-2030 development. From this recommendations to a post-2020 global biodiversity framework are:

- A robust framework that considers plant health as a key component.
- A framework that highlights invasive alien species that are plant pests.
- A framework supported by a coherent, comprehensive and innovative communication

Summary of the Discussion – 4a) Qualitative and quantitative existing cases of the impacts of invasive alien species on socio-economic and cultural values and the wellbeing of indigenous and local communities that capture a diversity of impacts?

Key reviews:

A special issue on "The human and social dimensions of invasion science and management" has recently been published in the Journal of Environmental Management vol 229, including 18 articles covering existing research and case studies from all over the world: Nepal, Chile, Guam, Madagascar, indigenous Australia, South Africa, La Reunion (see https://www.sciencedirect.com/journal/journal-of-environmental-management/vol/229/suppl/C). Pfeiffer and Voeks (2008) also broadly reviewed this issue across the world.

This issue includes a review paper (Shackleton et al. 2019) which concludes invasive alien species are a well-recognised driver of social-ecological change globally, however impacts on livelihoods and human well-being is less well understood in terms of effects (benefits and costs) and yet this is important for guiding policy formulation and management. "Slightly less than half (48%) of species studied had both substantial positive and negative impacts on local livelihoods (e.g. Australian *Acacia* spp. species; *Camelus dromedaries*; *Lantana camara*; *Prosopis* spp.), with 37% inducing mainly costs (*Chromolaena odorata; Lissachatina fulica; Opuntia stricta*) and 16% producing mainly benefits (*Opuntia ficus-indica; Acacia* spp.). Some species, such as *Acacia dealbata*, fell into different categories depending on the social-ecological context."

"Key benefits or services included the provision of fuelwood, fodder, timber and food products for local households communities and to a lesser extent supporting and regulating services such as soil

improvement and shade. A number of species also provided cultural services such as recreation and spiritual values and provided many with an opportunity to earn a cash income. However, invasive species also harm livelihoods and increase vulnerability through encroaching on land and reducing mobility or access. They can also decrease the supply of natural resources used by households and reduce agricultural production (livestock and/or crops) which can result in losses of income and increased vulnerability. Furthermore, some invasive species were seen to have negative implications for human health and safety and reduce the cultural value of landscapes. Economic impacts on livelihoods as a result of invasive species were highly variable and very dependent on the social-ecological contexts. These negative implications can reduce resilience and adaptive capacity of households and communities thus increasing their vulnerability to change"

Regional examples:
Sweden, IAS like *Lupinus polyphyllus, Rosa rugosa, Heracleum mantegazzianum* and *Impatiens glandulifera* have impacts on significantly biologically (contain half the nationally important threatened species) and culturally important (called “kulturlandskap” “cultural landscape”) meadows and pastures that have a special flora and fauna from traditional agricultural practices that are increasingly abandoned. They form the traditional Swedish countryside, scenery that is homely and picturesque. Some socioeconomical impacts of biodiversity loss are recognised and honey producers lose quality and value from the modified pastures. Plant invasions form monocultures replacing the diversity of natural, less pretentious flora which will totally change the scenery. The general cultural impact of changing scenery on average member of the population is hard to measure.

Australian aborigines: Social and cultural impacts of weeds on aboriginal land impacts on indigenous foods and other cultural values. Aboriginal rangers are tackling the problem (https://ictv.com.au/video/item/1610). Grasses brought in for grazing agriculture where they are considered of value are significantly affecting native food sources and species through dense vegetation and altered fire regimes. "Storylines" and "Songlines" in indigenous culture can be relevant for understanding of the socio-economic impacts of IAS in local communities and indigenous livelihoods. E.g. dingo spread thousands of years ago leading to loss of some native species or contemporary introduction of feral cats. Indigenous communities adapt to use some IAS as novel food source including pigs and water buffalo (and more recently feral cattle). Both negative and positive cultural importance needs to be understood and quantified (Urry 1979, Symanski 1994, Trigger 2008, Robinson and Wallington 2012). Many studies have also focussed on the National feral camel culling program in central Australia (Vaarzon-Morel and Edwards 2012, Kaethner et al. 2016, Vaarzon-Morel 2017).

South Africa: The constitution ensures everyone has the right to an environment that is not harmful to their health or wellbeing, providing a basis for socio-economic consideration. The National Environment Management Biodiversity Act- Alien Invasive Species Regulations state that risk assessment should include key economic, social and ecological considerations (without defined modalities) to guide a decision for import permits for exotic species. Some studies suggest environmental and socioeconomic impacts are significantly correlated e.g. water hyacinth (Nentwig et al. 2016, Rumlerová et al. 2016).

IAS examples:
Bamboo (*Bambusa vulgaris*) hinders the regeneration of native wet montane vegetation in the Blue and John Crow Mountains National Park in Jamaica, as well as other forested areas across the island. There is however a thriving bamboo industry for its construction value as a relatively cheap and accessible material (Rashford 1995) and for soil conservation (commonly bordering riverbanks to

stabilize the soil), and important for a traditional musical instrument called "Benta" (Seniors 2003). Bamboo has also found its way into Jamaican superstition (Bengry 1950). The longstanding and common acceptance of bamboo as a part of the Jamaican cultural landscape has presented resistance to evidence it is an invasive species in Jamaica.

Prosopis & Acacia (in Africa and India): cause major socio-economic impacts on rural indigenous communities but have also led to adaptation in these communities in the use of these plants to create new industries. This shows how local communities will find ways themselves of finding value in intractable IAS, but this can lead to greater IAS environmental impacts and ecosystem degradation in the longer term. For understanding how best to manage IAS it is important to understand these local community adaptations (Fagg & Stewart 1994, Berhanu and Tesfaye 2006, Cunningham et al. 2008, Maundu et al. 2009, Sato 2013, Baka 2014, Bekele et al. 2018)

Water hyacinth (West African countries) heavily impacts water navigation for local fishermen and reduces local fish harvests and hence food insecurity for the already financially-stressed families. A Nigerian, Achenyo Idachaba, established a local company that harvests water hyacinth and uses the dried stalks to make local crafts, which have been displayed in international galleries. She also won the 2014 Carter Women's initiative global prize for her work. You can read more about her work here: https://www.cartierwomensinitiative.com/candidate/achenyo-idachaba (Borokini and Babalola 2012).

Typha grass (Typha latifolia - northern Nigeria). The government use of heavy machinery to control its growth was counterproductive and interviewed community leaders complained they were not involved. Now, the Nigeria Conservation Foundation (a non-profit) is spearheading projects to encourage harvesting the plants and its use in making charcoal, an alternative income source and control method (Borokini and Babalola 2012).

Freshwater crayfish (*Procambarus clarkii* – eastern China). Popular food in eastern China farmed over 92, 000 km2, the output was more than 110, 000 tons, the annual total output value was 45 billion Yuan, and employment of 500, 000 in Jiangsu Province in 2017. While not a pest in this region in Yunnan Province in southwestern China, this crayfish caused damage rice terraces in the Honghe Hani Rice Terraces, a world cultural heritage and local people who do not like to eat it have no effective control strategy. Assessing the potential economic, environmental and cultural risks of invasive alien species should take into account the special local production and lifestyle.

Summary of the Discussion - Session 4b) What actual and potential risk analysis and other relevant methods are available or are being or could be developed that can be used for preventing/limiting the impacts of invasive alien species on socio-economic and cultural values and the wellbeing of indigenous and local communities?

Risk analysis needs to consider both the socio-economic impacts posed by a species and considerations arising from its management separately when prioritising species for management. Bacher et al (2017) conclude that attempts to quantify socio-economic impacts in monetary terms are unlikely to provide a useful basis for evaluating and comparing impacts of invasive alien taxa because they are notoriously difficult to measure, they are often context-dependent, and important aspects of human well-being are ignored. They identify different constituents of human wellbeing may be affected: security; material and immaterial assets; health; and social, spiritual and cultural relationships. They go on to propose the Socio-economic impact classification of alien taxa SEICAT process, which provides a mechanism to assess each of these in turn (Bacher et al 2017).

A different approach is needed to assess the sociological impacts of management. Booy et al (2017) propose a method to assess the overall feasibility of management, with separate sub-categories covering effectiveness, practicality, social acceptability, wider environmental impact, and cost. This combination of methods, assessing the social implications of a species as part of wider risk assessment, and the social acceptability of management as part of risk management, can be combined in a process of risk analysis. This combined approach allows the prioritisation of species and their management based on a rapid assessment in non-monetary terms. While more detailed economic cost-benefit analyses can be used to assess individual cases, we need rapid methods to prioritise action given the large number of species and invasions that we are currently experiencing.

There is also social impact assessment which offers a structured process of identifying, evaluating and addressing social costs and benefits. It has potential value for enabling meaningful public participation in planning and as a key component of integrated assessments of management options (Crowley et al. 2017).

What is still lacking is well documented socio-economic, cultural and community wellbeing semi-quantitative criteria on which to, not only, evaluate impact but also to evaluate effectiveness of applied risk management options. For example, if a weed invades and suppresses an culturally important indigenous food plant or iconic species how does this reduce the capacity of that community to be self-sustaining or lead to loss of community cultural values? Also, what are the target invader or site-based management thresholds needed to be achieved to adequately suppress that threat?

Risk assessment tools have also been developed by the GIASIPartnership (http://giasipartnership.myspecies.info/en/simpletaxonomy/term/14701), and the IUCN Invasive Species Specialist Group (http://www.issg.org/risk_assessment_resources.htm). The standard IPPC Pest Risk Analysis process can also be found at (https://www.ippc.int/en/core-activities/capacity-development/guides-and-training-materials/guides-and-training-materials/pest-risk-analysis/) .

See also (Anderson et al. 2004). There are also approaches for assessing many species at the same time in terms of understanding the threats they pose to new regions based on community similarity and probability of arrival e.g. based on level of trade (Paini et al. 2016).

Summary of Discussion - Session 4c) Can the knowledge gained so far on the impacts of invasive alien species on socio-economic and cultural values and the well being of indigenous and local communities provide a basis for better ways of defining, measuring and quantifying such impacts in the future?

The extensive accumulated knowledge and data over the past 30 years can be used to 'define', 'measure' and 'quantify' accurately the impacts of alien invasive plants on 'socio-economic and cultural values and the wellbeing of indigenous and local communities. However implementable and successful control solutions are lacking. Significant progress has been made in biological control, however maintaining sustainable biocontrol agent populations over time can be challenging. Chemical control is still expensive and environmentally harmful, though new molecules show better ecotoxicological profiles. There are several key questions for better management:

- *How can we guide and prioritise actions to better focus on achievable management goals?* Too often the priorities for species listing or management are based on the scale and likelihood of the impact, without considering the feasibility of management. The feasibility of management depends on political will, availability of techniques/knowledge for implementing control, availability of well-trained teams in order to perform the control, and financial resources

allocated to management. Inevitably decision-makers and even scientists want to see results rapidly, but realistic and efficient control programs of IAS require long-term investment.

- *What is the best model to invest resources in prevention, eradication or long-term management?* Prevention can of course be highly cost-effective but is often ineffective. Although prevention is cost-effective many prevention programs fail due to weak enforcement systems due to lack of motivation or commitment by national or local authorities. Preventing a problem that has not yet occurred requires a strong self-motivation at all levels.
- *All three management approaches need resources, but how do we optimise this process in different environments and for different taxa?* Investments on long-term management often lead to poor outcomes. More rigorous methodology in the monitoring and evaluation of control programs would improve learning and lead to better long-term the control efficiency.
- *What are the ecological criteria to switch species management goals from prevention to eradication to long-term management?* Too often we see programmes that misapply these objectives, failing to prevent and eradicate when it is still feasible, while investing in long-term species management.
- *How can the science community support the production of new and refined tools for management?* Practitioners need more species-specific control methods, more cost-effective ones and new technologies to achieve this. For invasive plants, biological control has been the most effective solution, making great progress in the past 20 years, reducing the problems of non-target effects. Concerns remain for indirect effects of biocontrol agents on local food webs. Greater investment in biopesticide development may be merited.
- *How can the science community help practitioners manage effectively at large scales?* There are numerous examples of successful eradications or removals, but most are based on very small areas. Species-specific cost-effective control methods and new technologies are needed.
- *How do we use our understanding of ecology and species dynamics to guide more effective management at scale?* Future research should focus on developing appropriate effective tools for managing IAS and informing effective management policy.

Information on impacts, be they economic, biodiversity or social are needed together with science that combines this with information on management feasibility and economics to guide effective management strategies. There is also an urgent need of many countries to carry out studies immediately to identify first which species are invasive then the impact of each on the local livelihood. Efforts made by the local communities for managing IAS have not always been well informed by scientific research. In summary, future research should focus on generating knowledge to inform management.

Cultural values:

It is important to understand the role of cultural values and perspectives in the management of IAS. In New Zealand, Māori-sourced IK, referred to as mātauranga Māori, has an increasingly important role in environmental management, including protection of biological heritage from invasive alien species. The New Zealand government is actively exploring with Maori how to include mātauranga Māori into our work on IAS management. This is signalled as a clear priority in our Conservation and Environment Science Roadmap (https://www.mfe.govt.nz/about-us/our-policy-and-evidence-focus/conservation-and-environment-science-roadmap) and mātauranga Māori approaches are central to several of our research programmes focussed on fighting IAS, such as the pathogens causing kauri dieback and myrtle rust. It is now also commonplace for Māori to be involved in governance of IAS management programmes where taonga (treasured, sacred) species are at risk (Lambert et al 2018).

IAS examples:

Prosopis (mesquite) in Western Asia, Africa and in India. Dense stands of mesquite, often deliberately introduced for fodder, spreads all over and totally changes the ecosystem in many areas, severely lowering the water table in the soil causing the collapse of the grass that creates the pastures. The pods can be used as source of fodder for the goats and the wood is used as a fuel depending on the context of each region and local livelihoods. Within few years there is no fodder left and pastoralists who have to move becoming nomads. This inevitably creates conflict and dismay for local communities. process, the causes and the consequences are well understood, however no solution has been proposed for solving this problem. At best spread is mapped.

Pine wood nematode (PWN - *Bursaphelenchus xylophilus*) causing the economically and environmentally significant 'pine wilt disease' in species of pine (*Pinus* spp.). PWN is native to North America and is vectored through parallel introductions of the wood-inhabiting North American longhorn beetle *Monochamus*, it has spread to Japan China and Korea and then Europe (Portugal) in 1999 and now threatens the rest of Europe. Local species of *Monochamus* can also vector the disease. PWN is not only an important pest for forestry production, but also alpine forests causing increased erosion. In Korea, the disease has cost over US$600 million in 20 years with additional ecological and social impact. IPPC ISPM 15 (wood packaging) has helped stem the spread. This example helps understand how future impacts from forestry pests can be risk assessment quantified and managed.

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