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6 Five challenges to reconcile agricultural land use and forest ecosystem services in Southeast

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16 Abstract

- 17 Southeast Asia possesses the highest rates of tropical deforestation globally and exceptional
- levels of species richness and endemism. Many countries in the region are also recognized for
- 19 their food insecurity and poverty, making the reconciliation of agricultural production and forest
- 20 conservation a particular priority. This reconciliation requires recognition of the trade-offs
- 21 between competing land-use values and the subsequent incorporation of this information into
- 22 policy making. To date, such reconciliation has been relatively unsuccessful across much of
- 23 Southeast Asia.
- We propose an ecosystem services (ES) value internalization framework which identifies key
- 25 challenges for such reconciliation: (i) lack of accessible ES valuation techniques; (ii) limited
- 26 knowledge of the links between forests, food security and well-being; (iii) weak demand and
- political will for the integration of ES in economic activities and environmental regulation; (iii)
- disconnection between decision-makers and ES valuation; and (v) lack of transparent discussion
- 29 platforms where stakeholders can work towards consensus on negotiated land-use management
- 30 decisions.

- 31 Key research priorities to overcome these challenges are developing easy to use ES valuation
- techniques, quantifying links between forests and well-being that go beyond economic values,
- 33 understanding factors that prevent the incorporation of ES into markets, regulations and
- environmental certification schemes, understanding how to integrate ES valuation into policy
- making processes, and how to reduce corruption and power plays in land-use planning processes.
- 37 **Key words**: forest economics; landscape conservation planning; wellbeing; payment for
- 38 ecosystem services.

Introduction

39

- 40 Land conversion to agricultural use is the leading global cause of biodiversity loss and a major
- driver of deforestation in Southeast Asia (Sodhi et al. 2004), a region that experiences greater
- deforestation rates than other tropical regions (Margono et al. 2014). This rapid habitat loss is
- alarming because of Southeast Asia's (SE Asia) high species richness and endemism, including
- four of the twenty most important global biodiversity hotspots: Indo-Burma, Sundaland,
- Wallacea and The Philippines (Myers et al. 2000) (Fig. 1).
- 46 Deforestation in SE Asia is driven by economic forces that respond to increasing demand for
- agricultural products, timber, fiber and mining (Abood et al. 2014). Due to rapid population
- 48 growth, poverty, weak governance, and lack of conservation expertise and resources, reconciling
- 49 conflicts between economic development and the environment remains a leading challenge for
- 50 policy and practice in SE Asia (Sodhi et al. 2004) (Fig. 2). Therefore, there is a need for options
- 51 that decouple increasing demand for agricultural land and negative impacts on tropical
- 52 biodiversity. Economic options include land-use planning that recognizes the trade-offs between
- forest ecosystem services (ES) and agriculture (e.g. Runting et al. 2015). Related alternatives to
- reconcile economic development and biodiversity conservation are those which limit the demand
- of the products with the highest environmental footprint (e.g. oil palm, cattle production)
- 56 (Nghiem & Carrasco 2016); changing product sources and consumer consumption patterns
- 57 through certification schemes; and alternative diets with lower environmental footprints in high-
- income importing countries (Bateman et al. 2015; Tilman & Clark 2014).
- 59 Economic returns of agricultural conversion often outweigh the economic value of ES provided
- by standing forests if ES are not recognized by both markets and decision-makers, potentially
- leading to unsustainable land-use decisions (Balmford et al. 2002) (Fig. 2). A market failure
- 62 (inefficient allocation of resources) occurs then when forests are converted to agriculture even if
- 63 the value of ES is greater than the value of agriculture. To correct the market failure it is
- necessary as a first step to integrate the environmental costs of forest conversion into decision
- 65 making, which requires valuation of ES. In addition, because tropical forests in SE Asia provide
- a wide range of goods and services that are highly valued by human populations in the region
- 67 (Abram et al. 2014), it is important to consider the value of ES provided by forests, and compare
- these with agricultural benefits when planning the conversion of forests into agriculture
- 69 (Bateman et al. 2015; Runting et al. 2015) (Fig. 2).
- 70 The practicalities of incorporating forest ES values, food security and well-being considerations
- 71 into land-use planning pose significant challenges in SE Asia. Identifying these challenges is a
- first step towards reconciling forest ES and agriculture. The objectives of this essay are: (i) to
- develop an ES value internalization framework to identify the main challenges for reconciling
- agricultural land-use and forest ES in SE Asia; and (ii) to identify key research priorities to
- 75 overcome these challenges.

- 77 An ES value internalization framework to identify challenges for the reconciliation of
- 78 agriculture and forest ES

79 Potential emerging challenges were identified at the symposium "Reconciliation of biodiversity 80 conservation, ecosystem service provision and food security in the tropics" at the Society of Conservation Biology Asia Chapter held in Malacca (Malaysia) in August 2014. The symposium 81 82 organizers (L.R.C. and T.S.) identified and selected experts working on biodiversity conservation, ES valuation, food security, and conservation interventions (e.g. payment for 83 ecosystem services, PES) in SE Asia. The symposium participants were asked to identify the 84 main challenges faced in their areas of research with respect to the reconciliation of forest ES 85 86 and agricultural production in SE Asia. To identify and select the main ongoing challenges that emerged from the symposium we developed a forest ES internalization framework (Fig. 2, Table 87 88 1, (Cowling et al. 2008)). We developed a valuation-knowledge-demand-engagement-consensus framework that describes the factors and processes (where their lack or malfunctioning represent 89 challenges) necessary to internalize ES into policy for application on the ground (Fig. 2, Table 90 1). Internalization of ES into policy is contingent on three necessary conditions: (i) adequate 91 tools to value ES; (ii) adequate understanding of the links between forests, food security and 92 people's well-being; and (iii) sufficient demand for ES integration in economic activities, and 93 political will to integrate ES in regulatory frameworks. Once these conditions are met, the further 94 two key processes are: (iv) integration of ES valuation within policy making processes; and (v) 95 consensus building with all stakeholders to derive policy influence and change. 96

97 Challenge 1. Do we have the right tools to value ES in SE Asia?

Over the last few decades, ES academic studies applied to forest management have increased 98 dramatically. Their inclusion in planning and decision-making processes is, however, very low, 99 highlighting a distinct gap between theory and actual implementation. There remain a number of 100 data and technical barriers to measuring ES values accurately and cost-effectively, particularly in 101 102 Southeast Asia where environmental research has lagged behind other regions (Sodhi et al. 2004). For example, existing software packages for assessing ES, such as 'Integrated Valuation 103 of ES and Trade-offs' (InVest; http://www.naturalcapitalproject.org/InVEST.html) require 104 105 advanced modelling and geographic information systems (GIS) skills. This may hinder the inclusion of ES as part of regular planning and policy-making procedures in SE Asia, due to a 106 general lack of expertise in these areas. Hence, a SE Asian ES framework should be underpinned 107 with practical approaches that support and build on current planning capacity in SE Asia. One 108 possibility is the application of these tools by external agencies with funding from outside SE 109 Asia or using benefit transfer statistical approaches (Carrasco et al. 2014). Although these 110 approaches offer valuable spatial information, they do not empower local people to carry out 111 analyses and develop ownership, which is key for long-term success (Ruckelshaus et al. 2013). 112

Other alternatives are simple rapid assessment protocols that can be locally applied. For instance, 113 the 'Toolkit for Ecosystem Service Site-based Assessment' (TESSA; http://tessa.tools/) can help 114 understand the impact of actual and potential ES changes at individual sites (Peh et al. 2013). 115 These fit-for-purpose toolkits—which provide guidance on how to identify important ES and a 116 series of standardized protocols for measuring them-focus on site-scale assessments, and so are 117 relevant for local decision-making. These characteristics make protocols such as TESSA highly 118 relevant in SE Asia, where land-use decisions occur rapidly, and resources (budget, manpower, 119 120 capacity) are limited (Sodhi et al. 2004).

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Measuring the economic benefits from forests, however, is insufficient for effective forest management. We also need to quantify the linkages between ES, well-being and development

- opportunities. These challenges can be potentially addressed by integrating a suite of complex
- models (e.g. ARIES, InVest), or through benefit transfer approaches which use robust data from
- toolkits like TESSA. This integration, which should be a future research priority (Table 2), could
- capture dynamic stocks, flows of ES and beneficiaries to identify diverse development
- alternatives at the local level.

- 129 Challenge 2. Poor knowledge of the link between forests ES, food security and well-being
- Efforts to value ES can focus narrowly on economic values (e.g., in PES). A restricted approach
- might, for example, seek to reconcile agricultural production and forest ES by identifying
- scenarios that yield greatest profits. This can overlook diverse social equity considerations that
- shape decision-making (McDermott et al. 2013), as well as a diversity of cultural and social
- values that fail to make it into policy (Chan et al. 2012). These issues are particularly salient for
- decision-making across much of SE Asia where there are concerns with food security, poverty
- alleviation, indigenous rights and, from a broader perspective, human well-being.
- Because economic valuation of ES fails to incorporate the relative importance of ES to people
- and societal levels of dependence on ES, ES valuation that considers well-being instead of only
- economic values is increasingly proposed (Stiglitz et al. 2010). The links between forest ES and
- well-being—which includes material needs, social relations, health, security and freedom of
- choice—are however difficult to monetize or even quantify, leading to large knowledge, and thus
- implementation gaps (Ruckelshaus et al. 2013). Nevertheless, characterizing these poorly
- understood links is fundamental for conservation interventions such as PES in tropical low-
- income regions where culture and community structure play important roles (Milner-Gulland *et*
- al. 2014). One key aspect of well-being is health, which is intimately linked to provisioning ES
- that fulfil basic nutritional needs. Increasing efforts to characterize the role of forests for food
- security and health can capture important links between forest ES and well-being through food
- security (Ickowitz et al. 2014).
- Food security means ensuring people consume enough food and have access to diets that meet
- their nutritional requirements. Globally, micronutrient deficiencies are estimated to cause 12% of
- deaths in children under five (Black et al. 2003). The micronutrients most commonly missing
- from diets in Southeast Asia are iron, vitamin A, iodine, and zinc (FAO 1997). Typically, forest
- foods are rich sources of micronutrients; animal source foods are high in bioavailable iron and
- zinc, and forest fruits and vegetables can be rich sources of vitamin A and iron (Powell et al.
- 155 2015).
- These micronutrient-rich foods can be collected from 'natural' wild forests, but the crop and
- species diversity of some types of agriculture practiced in forested landscapes, particularly
- swidden agriculture and agroforestry (where staple crops are intercropped with legumes and also
- managed for hunting), can also result in high quality diverse diets (Padoch & Sunderland 2014).
- Although the relationship between forests and nutrition is gaining increasing attention
- 161 (Sunderland et al. 2013), empirical evidence documenting these contributions remains scarce. In
- SE Asia there has been very little quantitative nutrition research investigating such relationships
- 163 (Powell et al. 2015). To our knowledge, there have been only five studies, and only one that

- reports nutrient level information. This single study finds wild foods make an important
- 165 contribution to vitamin A intake in the Tiruray region of the Philippines (Schlegel & Guthrie
- 166 1973). Other studies from Papua New Guinea (Dwyer 1985), Indonesia (Colfer & Soedjito
- 167 1996), Timor-Leste (Erskine et al. 2015) and Vietnam (Ogle et al. 2001) all document extensive
- use of wild products. However, sample sizes are small and research methods vary considerably.
- Since many tropical forests are cleared for agriculture, it is imperative to understand the true
- costs of clearing forests for peoples' diets and compare this with other changes in well-being.
- 171 After forest landscapes are displaced by agriculture, agriculture may increase calories from
- staple crops, but at the potential loss of nutritious foods from parts of the landscape. To
- investigate this, more rigorous nutrition research with substantial sample sizes, clear selection
- criteria for study sites, and attention to ecological context is necessary (Table 2).
- As exemplified with food security and nutrition, our current limited understanding of the links
- between forest ES, food security and well-being hinders the evaluation of trade-offs between
- agriculture and forest ES. Further research quantifying those links is thus necessary to support
- ES valuation from a broader well-being perspective (Table 2, Fig. 2). Such research would need
- to collect well-being and environmental information, together with data on potential
- confounders, before and after forest conversion. Matched pairs or the use of spatial statistical
- models, combined with household surveys can help overcome these knowledge challenges.
- 182
- 183 Challenge 3. Weak demand for ES integration in economic activities and regulatory frameworks
- ES can be internalized into economic activities, *inter alia*, through international and local ES
- markets, environmental certification schemes, corporate social responsibility, environmental
- impact assessment (EIA) and direct government regulation (e.g. taxation and subsidies).
- 187 Developing strong and self-sustaining local and international ES deals remains however a
- 188 fundamental challenge. The two main existing ES sets of contracts in SE Asia are in carbon and
- water. Carbon markets have greater potential for attracting international buyers due to the links
- between tropical deforestation and climate change. The potential of carbon markets has not been
- 191 fully realized however, as political issues prevented forest conservation projects from joining the
- 192 Kyoto protocol as clean development mechanisms. Nevertheless, the United Nations Programme
- on Reducing Emissions from Deforestation and Forest Degradation (REDD+) has been slowly
- growing, and the central role of forests on the 21 Conference of the Parties Paris agreement in
- 195 2015 may signify a takeoff for REDD+.
- Water contracts attract mostly local buyers in the form of hydropower companies, e.g. \$50M
- were spent in 2013 (Forest Trends 2015), chiefly associated with watershed services in Asia. The
- number of watershed programs has however slowed since 2009 (Forest Trends 2015), making
- the identification of ways to foster ES contract creation research priorities (Table 2).
- 200 Environmental certification schemes such as High Conservation Value Area and Certified
- Sustainable Palm Oil (CSPO) also offer potential to integrate forest ES into certification of
- agricultural products in SE Asia. The certification of forest ES could internalize the value of ES,
- but suffers from the noted problem of limited demand which, in this case, is exacerbated with the
- 204 high transactions and monitoring costs of certification of forest ES (Meijaard et al. 2014).

- 205 EIA is another way to incorporate ES into decision making through regulatory frameworks.
- Although EIAs are increasingly carried out in SE Asian countries, the quality of the standard, its
- implementation in the field and the interpretation afterwards are many times not adequate. In
- addition, in most cases, ES and biodiversity are not part of the EIAs or are poorly enforced
- 209 (Phillips et al. 2009). Another alternative to incorporate ES is through direct government
- regulation through command-and-control policies (e.g. via sanctions). Although this is very rare
- in SE Asia, the smoke pollution episodes ("haze") due to forest fires in Indonesia have led to
- environmental laws aimed to sanction responsible agri-business companies (Lee et al. 2016). The
- very low use of regulation to incorporate ES denotes, however, a lack of political will to make
- ES an integral part of regulatory frameworks in the region. Future research should thus focus on
- 215 identifying ways to scaling-up forest ES certification and enhancing the integration of ES
- valuation in EIAs (Table 2).

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Challenge 4. Failed integration of ES valuation within policy-making

- 219 While ES valuation is widely discussed as helpful for informing policy, there is limited
- documented evidence of its actual operationalization (Laurans et al. 2013; Ruckelshaus et al.
- 2013). This can be attributed to numerous technical limitations, including low engagement
- between environmental economists and policy makers, and a lack of accessible decision-support
- 223 platforms. Equally, however, ES valuation is part of a process-based approach to decision-
- making (Laurans & Mermet 2014). This views valuation as part of broader governance processes
- 225 to ensure ES frameworks are meaningfully operationalized to inform policy. This broadened line
- of enquiry recognizes that valuation should engage diverse stakeholders (Laurans et al. 2013).
- How valuation data are created and used, and whose interests are represented in decision-making
- processes should be actively considered (Phelps et al. 2014). This includes, for example, how
- and whether formal processes recognize the diverse uses and values of ES for local actors.
- As valuation initiatives to inform decision-making emerge across SE Asia, they should be part of
- broader decision-making processes. ES valuation should not be restricted to environmental
- benefits and costs, but consider also social aspects and the well-being of local people. The divide
- between the theory of environmental economics and the actual application of ES valuation and
- 234 how this will influence land-use on-the-ground must be carefully studied if forest ES and
- agricultural production are to be reconciled (Table 2).

- 237 Challenge 5. Lack of strong consensus building platforms to reconcile competing land-uses
- Bringing together policy makers and stakeholders can facilitate consensus for land management.
- One potential framework to reconcile competing land uses in SE Asia are "landscape"
- approaches" which improve understanding and recognize interconnections between different
- land uses and the stakeholders who derive benefits from them (Sayer et al. 2013). Such
- landscape approaches also aim to reconcile competing land uses and achieve conservation,
- production and socio-economic outcomes (Sayer et al. 2013).
- Despite the utility of landscape approaches for both sustainable agriculture and forest ES
- conservation, they should not be seen as prescriptive approaches to spatial planning. Published

principles for landscape approaches (Sayer et al. 2013) are not a set of boxes to be ticked in

- search for an agreed spatial plan, but a framework of approaches which practitioners can draw on
- to solve real problems on the ground. There are fundamental difficulties in identifying and
- agreeing on metrics to measure progress in solving "wicked" problems (Game et al. 2014; Sayer
- et al. 2013). If opinions differ on optimal solutions then no single metric can measure, or even
- define, "success", particularly when trade-offs are the norm, as in SE Asia. The application of
- landscape principles might eventually lead to a spatial plan accepted by stakeholders, but
- landscapes are constantly changing under the influence of multiple drivers, and end points in the
- form of long-term plans appear to be the exception rather than the rule.
- 255 Much of the theory and practice of landscape approaches is underpinned by the assumption that
- facilitation and negotiation will eventually allow consensus. However, in reality there are often
- entrenched views, conflicts of interest and power plays. Conflict between agriculture,
- conservation and other competing land uses is often the subject of strongly contested activism
- with highly polarized positions (Sunderland et al. 2008). Advocates of landscape approaches
- sometimes appear to assume that conflict can be avoided by resolving these fundamental
- differences. In reality, any intervention will bring 'winners' and 'losers' in any rural
- community—including 'traditional societies' living in or on the edge of forest habitats—and will
- be heterogeneous and characterized by various internal conflicts. Ignoring this heterogeneity and
- 264 these internal conflicts may weaken local communities against the influence of new powerful
- stakeholders in SE Asia such as logging, agro-businesses and mining companies, challenging the
- internalization of ES.
- 267 With increasing anthropogenic and biophysical pressures on forest ES across many landscapes in
- SE Asia, choices have to be made about what is desirable and how landscapes should be
- 269 managed. Management regimes can optimize trade-offs and synergies among different outcomes,
- but there are always likely to be some trade-offs and opportunity costs (Leader-Williams et al.
- 271 2010). Bearing in mind that it may be impossible to reach consensus despite negotiation and
- 272 facilitation, future research needs to focus on understanding the negotiation and institutional
- 273 dynamics that hinder the adoption of sustainable strategies (Table 2).

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Discussion

- 276 Through an ES value internalization framework, we have identified five main challenges to
- 277 reconcile forest ES and agricultural production in SE Asia (Table 1, Fig. 2). Technical challenges
- arise because most methods to estimate the value of ES require detailed data or expertise that
- 279 may not be available (Table 1, challenge 1). Even if economic value maps are produced
- exogenously, rapidly changing conditions and the fact that ES values change in space and time
- (Renard et al. 2015) mean policy makers need tools to evaluate and adapt to the dynamic nature
- of local environments. In addition, valuation tools would ideally empower local people to
- participate in the estimation of benefits provided by forests and agriculture (Ruckelshaus et al.
- 284 2013). Although considering the temporal and spatial dimensions of ES and the heterogeneity
- among local communities would be ideal, in reality, however, a trade-off exists between the level
- of detail that policies can attain and how practical and implementable these policies are. This
- trade-off would be determined by the knowledge of the socio-ecological system where benefits
- from forests versus agriculture occur and how amenable it is to value the ES dynamically and

spatially. Translating this knowledge into policies would thus require a balance between capturing the realities of the system and the practicality and simplicity of the policies.

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291 Even though valuation analyses that reveal the environmental costs of forest conversion are necessary to reconcile forest ES and agriculture, they are only the first step. Valuation alone is 292 unlikely to lead to change as it needs to be further integrated into decision-making through the 293 294 engagement of environmental economists with policy making processes. Such engagement between environmental economists and policy makers seems, however, to be low, leading to 295 scarce application of ES approaches that lead to improved outcomes for ES and well-being 296 297 (Ruckelshaus et al. 2013). There is thus a need to create platforms where environmental economists can interact with policy makers in an iterative science-policy process (Table 1, 298 challenge 4). This may even require reforming institutions and changing practices to consider 299 society's long-term goals (Guerry et al. 2015). This lack of engagement with policy makers 300 echoes the low inclusion of ES in regulatory frameworks and political will to enforce 301 environmental protection in processes such as EIA. For instance, although EIAs in Indonesia are 302 compulsory prior to the establishment of plantations on peatlands, the carbon emissions and loss 303 of ES which result from conversion have very little weight over economic development 304 considerations (Lee et al. 2016). Companies typically pay independent consultants to get the 305 desired result from the EIA, making it a mere formality (McCarthy & Zen 2010). Alternatively, 306 to avoid conflicts of interests, payments for EIAs could be funded by the government or 307 international agencies. Voluntary alternatives such as international and local contracts of ES, 308 voluntary adoption of zero deforestation through corporate social responsibility and forest ES 309 310 certification, though promising, suffer, on the other hand, from weak demand for ES (Meijaard et al. 2014). Given this situation, research identifying ways to enhance demand and political will 311 towards ES should be a priority (Table 2). 312

Internalization of ES needs to consider the multiple dimensions of ES on human well-being, 313 beyond economic values (Stiglitz et al. 2010), i.e. the social and cultural implications of land use 314 315 allocations, and adoption of well-being and food security as outcomes to compare against agricultural benefits. We know little, however, about these links. For instance, because most 316 studies have focused on income from non-timber forest products, little is known on how forests 317 provide essential nutrients (Ickowitz et al. 2014). Expanding our knowledge about the 318 relationship between local communities' well-being and forest needs to be executed before forest 319 ES can be integrated in trade-off analyses (Table 1, challenge 2 and Fig. 2). This knowledge 320 should be acquired through solid data-driven research where all the plausible development 321 options and their well-being implications are considered for local stakeholders. Such research 322 should evaluate the economic realities and livelihoods of people living in and around forests and 323 the availability of alternative livelihoods (and how to provide them) need to be taken into 324 account. Access to health systems, education, cultural preferences and general well-being will 325 thus be needed to complement the economic valuation of ES and agricultural outputs. Who 326 benefits, who loses and the social implications for, for instance, indigenous communities, need to 327 328 be part of ES valuation in SE Asia if it is to effectively engage policy makers and society at 329 large.

Although the importance of forests for poor people in low-income countries is clear (Foli et al. 2014; Nasi et al. 2008), deforestation brought about by large agribusiness companies can provide

opportunities in the form of labor, schooling and health services. But they also create conflict by

competing with local land ownership rights. Development that empowers local people to own

and manage their own agricultural land, while offering alternative sources of income (e.g.

ecotourism, PES), and determining the role of the forest to complement their income, may

represent a more effective way to alleviate poverty than large agribusiness land conversion

(indeed this form of development was preferred by local people in Borneo (Abram et al. 2014).

Future research would thus need to evaluate the well-being implications of land conversion by

large companies versus other forms of development with different levels of forest conservation

340 (Table 2).

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Building on solid valuation methods and land-use socio-ecological systems knowledge,

consensus between the key stakeholders involved in land-use decisions, e.g. using landscape

approaches, should be attempted through facilitation and negotiation, even if consensus is

impossible to reach in many instances. The reality however is that weak governance and

inequitable power relations prevail above negotiation and consensus (Table 1, challenge 5).

346 These inequitable power relationships explain also the gap between economic theory and failed

ES policy implementation. This is because the economic value of ES is often not received by the

providers of the services. Elite capture of PES program benefits has extensively been document

in SE Asian countries (Howson & Kindon 2015; To et al. 2012). For instance, in the carbon

350 finance project of Sungai Lamandau in Indonesia, the ability to secure benefits was obstructed by

351 government licensing and a function of social relationships and access to local markets (Howson

& Kindon 2015). Similarly, an analysis of PES projects in Vietnam showed how monopolization

of access to forestland and existing state forestry prevented the poor from receiving benefits (To

et al. 2012). Adequate land tenure regimes, mapping of ES providers and allowing different

actors to negotiate on a level playing field could contribute to mitigate elite capture and

356 consensus to be translated into policies.

357 Given the challenges identified, research efforts that could produce the greatest contributions to

ES internalization in SE Asia can be summed up as: developing easy to use dynamic ES

valuation tools that can capture the relationship between forest ES and well-being; identifying

ways to foster local and global ES markets, contracts and the incorporation of ES in properly

enforced EIA; understanding factors hindering the inclusion of ES into policy making; and

362 strategies to reduce factors that facilitate power plays and corruption in platforms for negotiation

among key stakeholders (Table 2). Research focusing on these challenges and how they

interrelate would facilitate the reconciliation of agriculture and forests ES in SE Asia, a region

where imperative economic development goals overlap with extraordinary biodiversity riches.

- Abood, S. A., J. S. H. Lee, Z. Burivalova, J. Garcia-Ulloa, and L. P. Koh. 2014. Relative contributions of the logging, fiber, oil palm, and mining industries to forest loss in Indonesia. Conservation Letters.
- Abram, N. K., E. Meijaard, M. Ancrenaz, R. K. Runting, J. A. Wells, D. Gaveau, A.-S. Pellier, and K. Mengersen. 2014. Spatially explicit perceptions of ecosystem services and land cover change in forested regions of Borneo. Ecosystem Services 7:116-127.
- Balmford, A., A. Bruner, P. Cooper, R. Costanza, S. Farber, R. E. Green, M. Jenkins, P. Jefferiss, V. Jessamy, J. Madden, K. Munro, N. Myers, S. Naeem, J. Paavola, M. Rayment, S. Rosendo, J. Roughgarden, K. Trumper, and R. K. Turner. 2002. Economic Reasons for Conserving Wild Nature. Science **297**:950-953.
- Bateman, I. J., E. Coombes, E. Fitzherbert, A. Binner, T. Bad'ura, C. Carbone, B. Fisher, R. Naidoo, and A. R. Watkinson. 2015. Conserving tropical biodiversity via market forces and spatial targeting. Proceedings of the National Academy of Sciences 112:7408-7413.
- Black, R. E., S. S. Morris, and J. Bryce. 2003. Where and why are 10 million children dying every year? The Lancet **361**:2226-2234.
- Carrasco, L. R., T. P. L. Nghiem, T. Sunderland, and L. P. Koh. 2014. Economic valuation of ecosystem services fails to capture biodiversity value of tropical forests. Biological Conservation **178**:163-170.
- Chan, K. M., A. D. Guerry, P. Balvanera, S. Klain, T. Satterfield, X. Basurto, A. Bostrom, R. Chuenpagdee, R. Gould, and B. S. Halpern. 2012. Where are cultural and social in ecosystem services? A framework for constructive engagement. Bioscience **62**:744-756.
- Colfer, C. J. P., and H. Soedjito. 1996. Food, forests and fields in a Bornean rain forest: towards appropriate agroforestry development in C. Padoch, and N. L. Peluso, editors. Borneo in transition: people, forests, conservation, and development. CIFOR.
- Cowling, R. M., B. Egoh, A. T. Knight, P. J. O'Farrell, B. Reyers, M. Rouget, D. J. Roux, A. Welz, and A. Wilhelm-Rechman. 2008. An operational model for mainstreaming ecosystem services for implementation. Proceedings of the National Academy of Sciences **105**:9483-9488.
- Dwyer, P. D. 1985. The contribution of non-domesticated animals to the diet of Etolo, southern highlands province, Papua New Guinea. Ecology of Food and Nutrition **17**:101-115.
- Erskine, W., A. Ximenes, D. Glazebrook, M. da Costa, M. Lopes, L. Spyckerelle, R. Williams, and H. Nesbitt. 2015. The role of wild foods in food security: the example of Timor-Leste. Food Security **7**:55-65.
- FAO. 1997. Chapter 8 Malnutrition and micronutrient deficiencies Accessed at:

 http://www.fao.org/docrep/w0078e/w0078e09.htm. Agriculture food and nutrition for Africa A resource book for teachers of agriculture. Food and Agricultural Organization of the United Nations, Rome.
- Foli, S., J. Reed, J. Clendenning, G. Petrokofsky, C. Padoch, and T. Sunderland. 2014. To what extent does the presence of forests and trees contribute to food production in humid and dry forest landscapes?: a systematic review protocol. Environmental Evidence 3:15.
- Forest Trends. 2015. Ecosystem MarketPlace. Marketwatch. Water Markets. Watershed Investment in Asia. Forest Trends. Available at: http://www.ecosystemmarketplace.com/marketwatch/.
- Game, E. T., E. Meijaard, D. Sheil, and E. McDonald-Madden. 2014. Conservation in a wicked complex world; challenges and solutions. Conservation Letters **7**:271-277.
- Guerry, A. D., S. Polasky, J. Lubchenco, R. Chaplin-Kramer, G. C. Daily, R. Griffin, M. Ruckelshaus, I. J. Bateman, A. Duraiappah, T. Elmqvist, M. W. Feldman, C. Folke, J. Hoekstra, P. M. Kareiva, B. L. Keeler, S. Li, E. McKenzie, Z. Ouyang, B. Reyers, T. H. Ricketts, J. Rockström, H. Tallis, and B. Vira. 2015. Natural capital and ecosystem services informing decisions: From promise to practice. Proceedings of the National Academy of Sciences 112:7348-7355.
- Howson, P., and S. Kindon. 2015. Analysing access to the local REDD+ benefits of Sungai Lamandau, Central Kalimantan, Indonesia. Asia Pacific Viewpoint **56**:96-110.
- Ickowitz, A., B. Powell, M. A. Salim, and T. C. Sunderland. 2014. Dietary quality and tree cover in Africa. Global Environmental Change.
- International Institute for Applied Systems Analysis. 2014. GAEZ v3.0 Global Agro-ecological Zones. IIASA.

 Accessed at: http://webarchive.iiasa.ac.at/Research/LUC/GAEZv3.0/.
- 418 Laurans, Y., and L. Mermet. 2014. Ecosystem services economic valuation, decision-support system or advocacy?
 419 Ecosystem Services 7:98-105.

- Laurans, Y., A. Rankovic, R. Billé, R. Pirard, and L. Mermet. 2013. Use of ecosystem services economic valuation for decision making: Questioning a literature blindspot. Journal of Environmental Management 119:208-219.
- Leader-Williams, N., W. M. Adams, and R. J. Smith 2010. Trade-offs in conservation: deciding what to save. John Wiley & Sons.

- Lee, J. S. H., Z. Jaafar, A. K. J. Tan, L. R. Carrasco, J. J. Ewing, D. P. Bickford, E. L. Webb, and L. P. Koh. 2016. Toward clearer skies: Challenges in regulating transboundary haze in Southeast Asia. Environmental Science & Policy **55**, **Part 1**:87-95.
- Margono, B. A., P. V. Potapov, S. Turubanova, F. Stolle, and M. C. Hansen. 2014. Primary forest cover loss in Indonesia over 2000-2012. Nature Climate Change.
- McCarthy, J., and Z. Zen. 2010. Regulating the Oil Palm Boom: Assessing the Effectiveness of Environmental Governance Approaches to Agro-industrial Pollution in Indonesia. Law & Policy **32**:153-179.
- McDermott, M., S. Mahanty, and K. Schreckenberg. 2013. Examining equity: a multidimensional framework for assessing equity in payments for ecosystem services. Environmental Science & Policy **33**:416-427.
- Meijaard, E., S. Wunder, M. R. Guariguata, and D. Sheil. 2014. What scope for certifying forest ecosystem services? Ecosystem Services 7:160-166.
- Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. B. da Fonseca, and J. Kent. 2000. Biodiversity hotspots for conservation priorities. Nature **403**:853-858.
- Nasi, R., D. Brown, D. Wilkie, E. Bennett, C. Tutin, G. Van Tol, and T. Christophersen. 2008. Conservation and use of wildlife-based resources: the bushmeat crisis. Secretariat of the Convention on Biological Diversity, Montreal. and Center for International Forestry Research (CIFOR), Bogor. Technical Series **50**.
- Nghiem, T., and L. Carrasco. 2016. Mobile Applications to Link Sustainable Consumption with Impacts on the Environment and Biodiversity. Bioscience:biw016.
- Ogle, B. M., P. H. Hung, and H. T. Tuyet. 2001. Significance of wild vegetables in micronutrient intakes of women in Vietnam: an analysis of food variety. Asia Pacific Journal of Clinical Nutrition 10:21-30.
- Padoch, C., and T. Sunderland. 2014. Managing landscapes for greater food security and improved livelihoods. unasylva **64**.
- Peh, K. S.-H., A. Balmford, R. B. Bradbury, C. Brown, S. H. Butchart, F. M. Hughes, A. Stattersfield, D. H. Thomas, M. Walpole, and J. Bayliss. 2013. TESSA: a toolkit for rapid assessment of ecosystem services at sites of biodiversity conservation importance. Ecosystem Services 5:51-57.
- Phelps, J., B. Hariyanti, A. C. Sinaga, and A. Dermawan. 2014. Environmental Valuation in Indonesia: Implication for forest policy, legal liability and state losses estimates. Center for International Forestry Research (CIFOR), Bogor, Indonesia.
- Phillips, M., F. Enyuan, F. Gavine, T. Hooi, M. Kutty, N. Lopez, R. Mungkung, T. Ngan, P. White, and K. Yamamoto. 2009. Review of environmental impact assessment and monitoring in aquaculture in Asia-Pacific. FAO, Rome(Italy).
- Powell, B., S. H. Thilsted, A. Ickowitz, C. Termote, T. Sunderland, and A. Herforth. 2015. Improving diets with wild and cultivated biodiversity from across the landscape. Food Security:1-20.
- Renard, D., J. M. Rhemtulla, and E. M. Bennett. 2015. Historical dynamics in ecosystem service bundles.

 Proceedings of the National Academy of Sciences 112:13411-13416.
- Ruckelshaus, M., E. McKenzie, H. Tallis, A. Guerry, G. Daily, P. Kareiva, S. Polasky, T. Ricketts, N. Bhagabati, and S. A. Wood. 2013. Notes from the field: lessons learned from using ecosystem service approaches to inform real-world decisions. Ecological Economics 115:11-21.
- Runting, R. K., E. Meijaard, N. K. Abram, J. A. Wells, D. L. A. Gaveau, M. Ancrenaz, H. P. Posssingham, S. A. Wich, F. Ardiansyah, M. T. Gumal, L. N. Ambu, and K. A. Wilson. 2015. Alternative futures for Borneo show the value of integrating economic and conservation targets across borders. Nat Commun 6.
- Sayer, J., T. Sunderland, J. Ghazoul, J.-L. Pfund, D. Sheil, E. Meijaard, M. Venter, A. Boedhihartono, M. Day, C. Garcia, C. van Oosten, and L. Buck. 2013. Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. Proc Natl Acad Sci 110:8349 8356.
- Schlegel, S. A., and H. A. Guthrie. 1973. Diet and the Tiruray shift from swidden to plow farming. Ecology of Food and Nutrition 2:181-191.
- Sodhi, N., L. Koh, B. Brook, and P. Ng. 2004. Southeast Asian biodiversity: an impending disaster. Trends in Ecology & Evolution **19**:654-714.
- 473 Stiglitz, J. E., A. Sen, and J.-P. Fitoussi. 2010. Report by the commission on the measurement of economic performance and social progress. Paris: Commission on the Measurement of Economic Performance and Social Progress.

- Sunderland, T., C. Ehringhaus, and B. Campbell. 2008. Conservation and development in tropical forest landscapes: a time to face the trade-offs? Environmental Conservation **34**.
- Sunderland, T., B. Powell, A. Ickowitz, S. Foli, M. Pinedo-Vasquez, R. Nasi, and C. Padoch. 2013. Food security
 and nutrition: The role of forests. Discussion paper. Center for International Forestry Research (CIFOR),
 Bogor, Indonesia.
 Tilman, D., and M. Clark. 2014. Global diets link environmental sustainability and human health. Nature 515:518-
 - Tilman, D., and M. Clark. 2014. Global diets link environmental sustainability and human health. Nature **515**:518-522.
 - To, P. X., W. H. Dressler, S. Mahanty, T. T. Pham, and C. Zingerli. 2012. The Prospects for Payment for Ecosystem Services (PES) in Vietnam: A Look at Three Payment Schemes. Human Ecology **40**:237-249.

Tables and figures

Table 1. Five challenges for the reconciliation of agricultural production and forest ES in Southeast Asia.

Challenge	Description
1	Scarcity of easy to use on-the-ground tools for rapid ES valuation.
2	Poor understanding and quantification of forest ES benefits with regards to food security and well-being.
3	Weak demand for ES by economic activities and weak political will to integrate and enforce ES into regulatory frameworks.
4	Poor engagement of environmental economists and ES valuation with policy makers.
5	Lack of transparent discussion platforms with which stakeholders can reach consensus on competing land uses to avoid power plays and corruption.

Table 2. Research priorities to overcome the five challenges to reconcile agricultural production and forest ES in Southeast Asia.

Challenge	Research priorities
1	—Developing on-the-ground, easy to use tools that allow local communities to
	value ES dynamically as land-use changes, e.g. TESSA.
	—Developing integrated suites of complex models (e.g. ARIES, InVest) with on-
	the-ground toolkits to understand linkages between ES, well-being and food
	security.
2	—Quantifying the relationship between well-being, food security and forest ES at
	different scales.
	—Evaluating the well-being implications of land conversion by large companies
	versus other forms of development with different levels of forest conservation.
3	—Identifying ways to foster ES market demand and linking them to buyers, such as
	through REDD+ and forest ES certification schemes.
	—Identifying strategies to internalize and enforce ES in EIA and regulatory
	frameworks.

4	—Identifying factors that hinder the engagement of the ES valuation process with
	policy makers and stakeholders.
	—Analysis of the cognitive and institutional dynamics of policy makers and
	institutions and how these hinder the implementation of ES into policy.
5	—Identifying the barriers that prevent discussion platforms and the engagement of
	all stakeholders.
	—Identifying the most effective ways to counter and reduce corruption and power
	plays in consensus platforms

Fig. 1. Spatial conflicts between agricultural production and forest ES in Southeast Asia. A: ES economic value of tropical forests based on a spatial regression meta-analysis (Carrasco et al. 2014) and biodiversity hotspots in Southeast Asia (Myers et al. 2000). B: distribution of oil palm yield potential, one of the main cash crops in the region (International Institute for Applied

499 Systems Analysis 2014).

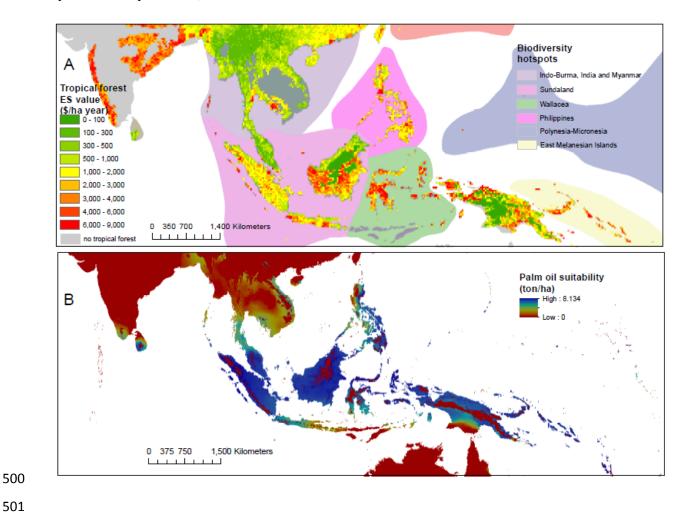


Fig. 2. Conceptual framework for the reconciliation of tropical forest ES and agricultural production through the internalization of forest ES values. The top panel describes the land-use system where deforestation drivers arising from the demand of agricultural products pose a land-use decision-making problem in Southeast Asia. The bottom panel describes the process to internalize ES into land-use planning. The necessary processes for internalization of ES are: quantifying the value of forest ES that is not captured by markets; understand the links between forest ES, food security and well-being; and sufficient demand for ES (markets and certification schemes) and political will to integrate them into regulatory frameworks. Once these processes are in place, the engagement of ES valuation with policy makers (that feeds back into political will and demand for ES) and the development of consensus building platforms for all stakeholders are needed to reconcile the trade-offs between competing land uses.

