A novel approach to the sustainable financing of the global restoration of degraded agricultural land

Bruce Chapman and David B Lindenmayer

1 Sustainable Farms, College of Business and Economics, The Australian National University, Canberra, Australian Capital Territory 2601, Australia
2 Sustainable Farms, Fenner School of Environment and Society, The Australian National University, Canberra, Australian Capital Territory 2601, Australia
3 National Environmental Science Program Threatened Species Recovery Hub, Fenner School of Environment and Society, The Australian National University, Canberra, Australian Capital Territory 2601, Australia

E-mail: david.lindenmayer@anu.edu.au

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Abstract

Humanity must find ways to feed an expanding human population. This requires maintaining the productivity of agricultural land, although much of it is increasingly degraded. Many trillions of dollars will be needed to address land degradation globally, but there has been little discussion about how to sustainably finance major global initiatives such as the UN Decade of ecosystem restoration. We suggest that existing financing instruments (government grants and commercial loans) have two limitations. First, the size of the problem is so substantial that contemporary approaches have no real prospects of adequately addressing the issue. Second, even if grants and loans had the potential in terms of prospective magnitude, in many instances they would be inequitable, regressive and/or have high risks for farm properties. We examine an alternate financing instrument, revenue-contingent loans (RCL), which potentially has subsidy-reducing properties for government budgets, and thus the capacity for more broadly-based public sector engagement with agricultural land remediation. RCL can substantially diminish borrowing risks and hardship for farm properties. Unlike commercial debt, repayments under RCL are not time-based but instead occur when a farm business can afford to make them. This is important as remediation of farmland degradation can be a medium to long-term process, and hence loan repayments need to parallel the time that it takes for the benefits of restoration to accrue to a farm business. Using income data from Australian agriculture, we illustrate empirically the repayment effects of a hypothetical RCL, focusing on the consequences for a government’s budget, the time stream of repayments for farms differing in revenue streams, and the benefits of income-smoothing. Our results underscore the potential benefits of RCL for the financing of land restoration investments, for both farmers and taxpayers. RCL could be made operational without significant costs to government budgets and within acceptable time frames.

1. Introduction

The world is facing a global agricultural land degradation crisis (Tilman et al. 2012, IPBES 2018). An estimated 29% of the earth’s arable land is degraded, directly affecting 3.2 billion people (IPBES 2018). This equates to 2 billion ha, an area the size of Russia although, depending on definitions, some researchers suggest the global extent of degraded land might be at least twice this amount (Gibbs and Salmon 2015). The issue is accorded international formal status: tackling arable land degradation is UN Sustainable Development Goal 15.5, which aims to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, reverse land degradation, and halt biodiversity loss.
Poon agricultural practices leading to degraded farmland pose a significant challenge for humanity. That is: *How to grow more food for an expanding population whilst at the same time reducing land degradation?* An additional challenge is an economic one: *What is the best way to finance the remediation of degraded land?* Indeed, the challenges of resolving these problems are immense. The cost of land remediation has been estimated to exceed $US12 trillion (Crouzeilles et al. 2019) in 2019 dollars or approximately 10% of total annual world GDP. To achieve such vast investment a new and sustainable policy approach to financing land remediation is needed. Yet, to date, there has been little discussion about how to sustainably finance major global initiatives such as the UN Decade of ecosystem restoration.

Here we argue that current government and private sector financing arrangements are not well-suited to addressing large-scale land degradation problems. We then provide an alternative approach to sustainable financing known as revenue-contingent loans (RCL). With RCL, a government would provide loans to farm properties to tackle land degradation and, ultimately, boost not only productivity but also profitability. Many studies have shown that improved management of the natural assets on a farm has a high probability of increased agricultural production and profitability (Thorburn et al. 2013, Francis et al. 2015, Pezo Quevedo et al. 2018), reduced costs (such as those associated with erosion and flood control) (Ribaudo 1986, Colombo et al. 2003, Jones et al. 2008), and enhanced biodiversity conservation (reviewed by Kremen and Merenlender 2018). For instance, establishing shelterbelts of planted trees between adjacent paddocks can depress wind-speeds and wind-chill and boost pasture production for livestock (Lindenmayer et al. 2018), sometimes by as much as 8% (Cleugh 2003). In other examples: (i) restored riparian vegetation can improve dry matter production in adjacent paddocks (Walpole 1999), leading to greater milk production in dairy herds and up to ~5% boost in farm income (DELWP 2016); and (ii) re-established native vegetation can increase the land value of farms (Polyakov et al. 2015).

Critically, and unlike with normal bank loans, debts under a RCL approach are repaid depending on a farm property’s future financial circumstances. Our contribution to the conceptual discussion involves drawing parallels to the international emergence of income-contingent loans (ICL) for higher education financing (student loans). The most recent developments in this literature is presented in a Special Issue of the journal *Economics of Education Review* on student loans (edited by Chapman and Doan 2019).

We provide an illustrative example of a hypothesised RCL applied in an Australian agricultural context as an approach to what we term ecologically sustainable agricultural investment (ESAI). We use modelling to illustrate two things: what such a policy might mean with respect to the timing of loan repayments to the government; and the insurance benefits of RCL compared to a normal commercial bank loan. While the data and results are from Australian livestock and cropping production, the lessons drawn can be considered to be generic because there are broad similarities to the issue of the remediation of degraded land in arable lands elsewhere around the world.

2. Limitations of conventional financial approaches

Numerous funding initiatives worldwide have been established in an attempt to restore degraded land (Menz et al. 2013). As examples, over 47 commitments to date have been pledged to restore 350 million ha of deforested agricultural areas by 2030 under international initiatives such as the Initiative 20 × 20 in Latin America, the Bonn Challenge, AFR100 in Africa, and the New York Declaration on Forests (Chazdon et al. 2017). Such activities will require an estimated US$18-300 billion per year to be implemented (Menz et al. 2013, Ding et al. 2017). However, these financing investments still fall well short of the many trillions of dollars estimated to be needed to reverse land degradation problems globally (Crouzeilles et al. 2019). Thus, a fundamental policy question is: *How can investments to restore arable land be appropriately and sustainably financed in an equitable way?* That is: *Where is the money coming from, and how can adequate funding streams be maintained?* Traditional sources of finance for farm-based restoration and related management activities include government outlays (primarily direct taxpayer grants), and farm businesses borrowing from commercial banks. Below, we suggest that both approaches have significant, although distinctly different, problems.

2.1. Limitations of grants

Grants sometimes do not produce good outcomes or effective integration of agricultural production and environmental objectives. For example, between 2007 and 2013, 23 billion Euros was spent on schemes to improve agricultural environments across Europe (European Commission 2015). However, many programmes were of mixed effectiveness in achieving key objectives such as conserving farmland biodiversity or remediating riparian environments (Morandi et al. 2014, Batary et al. 2015, Nilsson et al. 2015) and/or were expensive relative to outcomes. In North America, Europe, and Australia, billions of dollars of grants have been spent in agricultural areas to restore waterways, protect and improve remnant native vegetation, and to repair saline soils. However, success has often been limited as many programmes have been ad hoc,
ineffectually targeted, inadequately managed, short-term, or poorly monitored (if monitored at all) (Bernhardt et al 2005, Hajkowicz 2009, Pannell and Roberts 2010, Robins and Kanowski 2011).

More astute government oversight of such programmes is critical. Yet, even if such leadership were present, there are economic reasons for ESAI to not take the form of only taxpayer subsidies and grants. Economic principles suggest that efficient investments require sharing of costs to reflect the benefits accruing to both the private and public sectors (Stiglitz and Rosengard 2015). This is the case for farm financial contributions when, as is likely, ESAI result in the improved condition of natural assets that increase productivity and profitability of farms (e.g. see figure 1).

Another significant point concerning sharing of funding costs with farms is that since ESAI grants are often provided to asset-rich (albeit sometimes income-poor) farm properties, this form of financing can be seen to be inequitable and hence ‘regressive’ economic policy. This is because budget outlays are funded by all taxpayers, the majority of whom are typically less advantaged over their lifetimes than the owners of farm properties benefitting from public sector ESAI largesse. This equity argument, coupled with the fact that farms benefit financially from well-designed interventions (Kremen and Merenlender 2018), leads us to conclude that financing of ESAI should be shared between property owners and government. We emphasise that this is not a general argument against all grants programmes such as public funding of endangered species conservation in agricultural landscapes.

2.2. Limitations of commercial loans

An additional important economic policy question is: Should governments leave the process to the market, including the use by farm businesses of commercial loans to underwrite ESAI? A problem with commercial loans is the risk to a borrower of a future incapacity to repay the debt, which suggests that conventional bank loans can be associated with repayment hardships and are unlikely to create efficacious market outcomes for agricultural land restoration. We illustrate below an important aspect of this through the presentation of modelling results concerned with the proportion of a farm’s annual revenue required to repay a commercial debt over periods of both healthy and poor financial situations.

A fundamental issue is that ESAI are characterized by lag times until improvements in productivity are realized. They are also associated with uncertain returns. To minimize potential losses for a lender (a bank), these risks are offset through the use of the collateral of a farm property in the event of default. However, for many farms, the prospect of foreclosure and property forfeiture comes with high psychological costs. Potential loss of a farm, which may have been in a family for several generations, may create a rational aversion to commercial borrowing, particularly the financing of investment projects such as land restoration that can have long time frames.

3. Sustainable financing for the restoration of degraded agricultural land: an alternative funding instrument

The potential limitations of large grants, subsidies and conventional commercial loans indicate a need for alternative financing instruments and policy responses. We propose RCL, which are subset of ICLs (Chapman et al 2014). These are instruments involving financial assistance in the form of loans provided by governments for individuals or businesses. However, and a critical point is that, unlike bank loans, ICL are repaid not on the basis of time, but instead on the future capacity of a borrower to repay. In the remainder of this section we examine briefly the basic economics underpinning such an arrangement, and
explore first the question of why this financing approach is consistent with an emerging economics and finance theoretical literature. Second, we highlight the considerable potential of the approach for policies addressing land degradation.

3.1. Contingent debt: economic theory
We start with the basic question: What is the purpose of lending? Part of the answer is that without borrowing, many citizens and businesses would be unable to find money to finance investments. Institutions such as banks exist to provide finance to allow investments, or consumption purchases (e.g. a house), that would otherwise not happen. A well-known principle of economics is that there are major benefits to agents (individuals and businesses) from lifecycle income and consumption-smoothing (Quiggin 2014). That is, people are better off if they are able to organize their finances to have more disposable income than would otherwise be available to them in tough times, and less disposable income than would otherwise be when times are propitious.

Consumption-smoothing allows borrowers to repay debt when their financial circumstances allow them to do so without incurring hardships. If consumption-smoothing from borrowing is highly imperfect—as it is with a commercial loan—financial hardships from repaying debt are unexceptional and in a period when finances are particularly poor can lead to default, with the consequences being severe (e.g. bankruptcy). These adverse outcomes take the form of the loss of credit reputation and, in the case of farm debt, default and loss of the property.

Commercial lending institutions are aware of the benefits of consumption-smoothing to both borrowers and lenders which is why large bank loans always involve a long period for repayment. However, and critically, banks are unable to properly target debt collection to ensure the minimization of repayment difficulties. This is because they cannot enforce debt contracts to ensure full consumption-smoothing, which would be the case if loan collections reflected capacity to pay. The time-based design feature of bank debt collection means that bank loans can achieve consumption-smoothing only very imperfectly.

Consumption-smoothing aspects of debt are critical to the motivation for RCL for the financing of land degradation remediation. This is because a RCL is able to deliver extremely high levels of income-smoothing because the collection contingency is based on realized actual future income/revenue streams instead of being conditioned by time. Moreover, governments are in a unique situation with respect to the collection of loans to deliver much more targeted and efficient consumption-smoothing for borrowers than is available through the commercial banking market. This is because governments have two key advantages. First, unlike the private sector, governments have the legal jurisdiction to know the actual incomes of citizens, and the revenue of businesses. Second, in most countries, because of the comprehensive coverage of the taxation system, governments are able to collect revenues extremely efficiently—including for loans. However, we recognize that the parameters and administrative issues associated with the implementation of a RCL scheme will have important country-specific dimensions.

The advantages of contingent debt collection are now part of mainstream economics and finance theory, and are best explained in Stiglitz (2014), Quiggin (2003) and van Long (2014). The essential theoretical contribution of these developments is that financing contracts to deliver income-smoothing have to be able to be enforced, and that contingent debt administered through the taxation system has this valuable attribute. Based on economic theory, Quiggin (2014) argued that where there are different approaches to financing and all loans are repaid, contingent-debt is superior to all other forms of financing. Thus, as long as ICLs can be designed to be collected efficiently, they have superior qualities in the delivery of benefits to borrowers and without incurring commensurately higher costs for lenders. In Stiglitz (2016) it is argued that: ‘Income-contingent loan programmes run by governments represent an important social innovation, an improvement over previous mechanisms for funding investment’.

We suggest that ICL is particularly important in agriculture because investment returns following the restoration of degraded land will potentially take a long time. Since bank loans require repayment of interest without delay after a loan is first provided, this could mean financial hardship for a farm before investment returns are realized. The benefits and efficacy of a contingent debt approach have been demonstrated globally in another sector—the financing of higher education in the form of student ICL (Chapman and Doan 2019) (see supplementary methods 1, available online at stacks.iop.org/ERL/14/124084/mmedia).

3.2. RCL collection of debt
For a government, a prospective financing instrument for ESAI must be both affordable and administratively feasible. With respect to a RCL, this means: (1) the vast majority of debt is collected and not open to avoidance strategies; and, (2) debts are collected in time frames acceptable for a government’s budget. In addition, it is important that there are vetting procedures to ensure ESAI projects are appropriate. Simple and widely available forms of remotely-sensed (satellite-derived) data (e.g. Furby 2002; http: //wald.anu.edu.au/ australias-environment/) can be gathered to determine whether the loans made to property owners have been employed to improve natural assets such as by planting shelterbelts and renovating farm dams (Ikin et al 2019). This can be readily supplemented with
on-the-ground assessments to calibrate and verify temporal changes on farms such as in types, amounts and spatial patterns of native vegetation and replanted vegetation cover (e.g. see Geddes et al 2011, Lindenmayer et al 2019). If an RCL is well designed, potentially the only costs to government are from monitoring/ensuring loans are used for reversing land degradation; while we believe that these will be quite small, further analysis is necessary to justify this view.

A critical issue is the effects of an RCL on a government’s budget, and we model this for Australian farms as an example to quantify the likely time stream of loan repayments. We emphasise that the modelling is of the financial consequences of RCL used for investments in the mediation of land degradation, and not of the actual processes involved in the restoration of degraded land.

For our analyses we sourced information on farm property annual revenues from 1990 to 2015 (see supplementary methods 2, and supplementary table 1 for data). For a fairly representative sample of the properties most likely to use an RCL for ESAI, we restricted the sample to mixed livestock grazing and cropping farms. Loan repayment estimates are sensitive to the distribution of farm revenues, and we therefore provide the results of our simulations of annual farm revenues by quintile (figure 2).

We found that farm properties in the highest quintile of the revenue distribution (Q5) generate annual revenues 3–4 fold higher than farms at the median of revenues (figure 2). Those in the bottom 20% of the revenue distribution (Q1) received revenues ~10% of those experienced by Q5. Thus, there is a wide distribution of Australian farm property annual revenues, which is critical information for estimates of RCL repayments. Repayments of contingent debt will vary considerably over the revenue distribution, and this has been taken into account in our calculations of farm revenue by quintile medians (figure 2) (see supplementary methods 2 for discussion of the background to the data).

We chose two policy design features for the illustrative estimates. The first is the debt per property, and we use two levels: $A50 000 and $A100 000 (which corresponds to a plausible range of values for land restoration projects). Our modelling is a simple approximation and we accept that it would be sensible budgetary policy to cap debts in a way to reflect the capacity of a farm property to pay. That is, eligibility for maxima should be determined, in part, by past farm revenues. This is an important and straightforward extension that needs to be accommodated in future modelling.

Second, a collection rate as a percentage of annual revenue has to be determined, and we modelled both 3% and 6% (equivalent to rates for an ICL for Australian student loans; see supplementary methods 1). We found that the 3% collection rate did not deliver time streams of debt repayment likely to be acceptable to governments and consequently focus on the results using the 6% collection rate (figure 3). These analyses revealed: (1) a wide range of repayment streams of the total debt, from around one year for the highest revenue quintile of farm properties, to around 13 years for the lowest quintile; (2) that median revenue properties will repay their debts in four years; and, (3) that all debts will be repaid. This means that because there are no interest rate subsidies, the costs to a government budget would be zero.

We repeated the exercise for a debt level of $A100 000 and found evidence of broadly similar patterns (see figure 4). That is: (1) there is an even wider range of repayment streams of the total debt than was the case for a $A50 000 loan from around two years for the highest revenue quintile of farm properties, to over 25 years for the lowest quintile; (2) median revenue properties will repay their debts in seven years; and, (3) not all debts will be repaid in full within 25 years, although around 80% of properties will have done so within 12 years (figure 4).

Our modelling approach also can illustrate the total cumulative amount of loan repayments, which is a critical issue for the budgetary sustainability of a RCL
proposal (figure 5). Our analyses indicated that: (1) ~94% and 79% of the $A50 000 and $A100 000 debts, respectively, would be repaid within ten years; and, (2) the cumulative debt repayments are very rapid, with over 60% of total loans being repaid within five years (figure 5). Such short time frames for repayment of RCL finance should appeal to many governments internationally. We would expect similar findings to those reported here for the agricultural sectors of many OECD countries with comparable
agricultural revenues, although this would need to be explored with respect to specific country applications.

3.3. The insurance benefits of RCL: a simple illustration

In the conceptual discussion above, we highlighted the risk management implications of RCL, and ICL in general. There is an extensive literature on this issue with respect to student loans. The Special Issue of the *Economics of Education Review*, edited by Chapman and Doan (2019), presents 10 papers on this topic and canvasses many more. In this literature ICL repayments are compared to the alternative to RCL (normal time-based repayment loans) in terms of the difficulty of making loan repayments, using the concept of a ‘repayment burden’ (RB) which is the proportion of a graduate’s annual income that is required to sustain repayments for these types of loans. A major issue is that RBs with an ICL are set by law within the policy design, and at least in the international student loan policy experience, are always low (never more than 10% of incomes in all countries which currently use ICLs).

The student loan literature illustrates compellingly that time-based repayment loans are associated with very significant differences in RBs for individuals. This is because they depend on graduates’ annual incomes which differ very markedly both between countries and over time. High RBs are very important for student debtors because they lead inevitably to defaults, with the research showing clearly that the RBs from these types of loans can be extremely high for debtors with low future incomes. The international comparative evidence is documented extensively in Chapman and Doan (2019).

To demonstrate these issues for RCL, we follow the methodological approach suggested in Chapman and Dearden (2017) and have used some extreme assumptions to illustrate the insurance benefits of the RCL. We have placed a hypothetical farm in a very low revenue situation for 2006–2008: receiving revenue equal to only half of the bottom decile of farm property revenues for these three years. Between 2009 and 2012, the property received the median farm revenue, and for the years 2013–2015 received farm revenue in the 90th percentile (see figure 6). We acknowledge that RCL is not the best indicator of a farm’s capacity to pay, but it is certainly the best administrative way to proceed. That is, our results are indicative, and not definitive, of concerns for farms with commercial loans.

The results shown in figure 6 are compelling, with the major findings being: (1) the repayment burdens for our hypothetical commercial loan scenarios are generally above what is required for the RCL. And (2), in several of the years that the RBs are higher for the bank loans, they are very much higher than is the constant 6% RB case for the RCL: 57%, 28% and 32% of annual farm revenues.

Our analyses demonstrate quite clearly that commercial debt repayment obligations under plausible assumptions and with the use of actual farm revenue data can have a very high variance, which needs to be compared to the constant repayment proportions of annual farm revenue associated by design with a RCL. This means that consumption-smoothing is achieved with the use of an RCL, as demonstrated in the plethora of analogous research related to student loan comparisons for many countries. We contend that the highest RBs found for commercial loans in our example of 57% (see figure 6) would generate considerable financial problems for farmers.

4. Conclusions

Land degradation is a major problem globally and various UN initiatives (such as the Decade of Land Restoration) underscore its public policy importance. Yet, there have been few discussions about how to sustainably finance global ecosystem restoration. We argue that conventional financial approaches, such as the use of government grants and time-based government or commercial loans, are likely to have
significant limitations in tackling agricultural land degradation problems.

We propose the use of RCL for agricultural investments in the mitigation of agricultural land degradation. The economics of RCL suggests that our approach has major advantages over grants, such as improved equity for taxpayers, and critical consumption smoothing and default insurance advantages for farm property owners relative to other financing options. The temporal patterns of loan repayments also can be matched to the amount of time required to remediate many land degradation problems and to return some areas of farmland to profitability.

Using loan levels and parameters apposite to this agricultural and institutional context from Australia, we have modelled an illustrative example of a hypothetical RCL. Our analyses suggest propitious outcomes for both the funding agency (the government) and borrowers (farm properties). For RCL, desirable outcomes for both the lender (relative rapid repayment of debt) and the borrower (achievement of significant consumption-smoothing) are clear.

Critical points are that RCL are able to achieve both administrative simplicity and collection efficiency, and the parameters of a scheme need to satisfy government budgetary needs and consumption smoothing for borrowers. We have illustrated a suggested RCL design can satisfy these criteria. While specific institutional features must mean that different approaches will be needed for the contingent debt arrangements of particular nations, our approach appears to be workable, at the very least for Australia, but likely also for other OECD member countries.

We recognize that the parameters and administrative issues associated with the implementation of a RCL scheme will have important country-specific dimensions. Consequently, design choices are important for understanding operational efficacy and budgets.

In summary, several key ingredients are required to begin an alternative journey to a fair and efficient policy approach to the financing of investments involving RCL for the mitigation of degraded land. The approach needs to be conceptually compelling, empirically sound, and demonstrably viable in public policy administrative terms and with respect to the implications for farm borrowers. Our analysis suggests RCL is able to achieve these needs.

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Data availability statement

Any data that support the findings of this study are included within the article.

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