THE UNIVERSITY OF SYDNEY

The Henry Halloran Trust

GDP Growth Versus Sustainability

Authored by Dodo J Thampapillai

For the

Henry Halloran Trust

August 2020

Commissioned Research
Final Report 2020

ISBN: 978-0-6484296-9-2

THE UNIVERSITY OF SYDNEY

GDP GROWTH VERSUS SUSTAINABILITY

Dodo J Thampapillai

Introduction

More often than not, economic growth is deemed vital for the survival of any economy. The popular belief is that economic growth will deliver amongst many things, growth in employment and wages. Hence the dominant perception is that absence of growth will usher in periods of gloom and doom. During 2018-19, the Australian economy, strictly speaking, did not recede. But its economic performance was well below the 30-year average growth rate of 3 per cent. Hence, the Australian government, like many other governments faced with similar predicament, believed it pertinent to stimulate the economy. So in April 2019, the Commonwealth of Australia reduced taxes by nearly $160 Billion, giving an average tax payer on an annual income of $80,000 an additional disposable income ranging between $1000 to $1200 per year; that is, $19-23 per week. Further, the Commonwealth did also announce its plans for infrastructure spending to the tune of $4 Billion for expanding and improving the rail and road networks across Australia in the expectation of employment creation. These actions of the Commonwealth sat comfortably with those of the Reserve Bank of Australia (RBA), which reduced the interest rate to one per cent in April 2019, and then to an all-time low of three quarters of one per cent in October 2019. There was also speculation, if the economy did not show signs of recovery, of further reductions into the domain of negative rates[1] - as in the European Union and Japan. But, before any of these measures could hardly take effect, the summer of 2019-20 brought in catastrophic bush fires, unleashing unprecedented damages involving loss of life, property and a multitude of resources on the Australian landscape.

Whilst the damaging fires are all not fully contained as yet (at the time of writing this narrative), a massive task of reconstruction awaits Australia. No doubt the stimulus measures of 2019 are now outdated and would have to be redirected towards the reconstruction efforts. And the RBA has to remain undeterred in its commitment to a domain of low interest rates.

1 Such negative interest rates – described fashionably as Quantitative Easing – are primarily intended to deter trading banks from depositing their profits with relevant Central Banks and instead expand their lending portfolio.

It is widely acknowledged that the catastrophic fires of 2019/20 were mainly the result of climate change and global warming, the drivers of which are distributed over time and space across the world. However, it would be unwise to ignore the actions within Australia that would certainly have played a contributory role. That is, the fires can also be seen as a cumulus of outcomes stemming from Australia's persistent mismanagement of her natural resource endowments. The dominant source of such mismanagement is the misguided responses to sluggish economic activity (or even the perception of it), whenever it appeared over past several decades in the past. Misguided – because the primary focus of these responses has always been to expand the size of gross domestic product (GDP) - the commonly used indicator of economic performance. However, it is widely acknowledged that GDP is an ineffective indicator. This is because as indicated below, the definition of GDP does not adequately account for various items that offer *foundational support* for the economy. It is these foundational items that have been severely depleted and neglected over the years and hence constituting the mismanagement. Moreover, expansion of the commonly targeted components of GDP such as Consumption and Investment can in fact exacerbate the strains on these foundational elements. Important amongst these items are two types of largely unpriced capital, namely Environmental Capital (KN) and Social Capital (KS). Yet, decisions by governments and firms often follow the changes in the estimates of GDP without recognising the changes in KN and KS that could unfold. In fact a grossly mistaken notion within the economics profession is that KN and KS fall outside the realm of macroeconomic policy – the basis of which rests on GDP.

The aim of this paper is to clearly demonstrate the case for KN-KS occupying an important place in macroeconomic policy and hence the assessment of economic performance. The paper begins with an explanation of KN and KS. This is followed by revisions to the basis for assessing economic performance beyond GDP. Such revisions then pave the way for identifying target areas which must occupy an important place in the reconstruction and recovery process.

Environmental Capital (KN)

KN can be conceptualised as the aggregate stock of all natural endowments of an economy. The argument is that KN stock is analogous to the stock of manufactured capital (KM), which is presented in the national accounts. The size of KM stock is indeed an essential ingredient of standard macroeconomic policy. This stock is the aggregate of diverse items of KM such as buildings, infrastructure, machinery and factories, and is presented as a single number denoting stock size. Therefore Environmental Economists argue that it should be possible, to

at least conceptualize, the presence of an aggregate of diverse KN endowments as a similar numerical measure. Such diverse items of KN include: forests, air sheds, surface and ground water resources, and biodiversity. Whilst economists readily recognize the expansion of KM stock as a primary determinant of economic growth, they fail to appreciate that the depletion of KN is an equally important determinant of such growth.

Critics of the KN concept argue that unlike the components of KM, the items that make up KN do not have a "price". However, the newly developed field of Environmental Macroeconomics demonstrates that despite difficulties, the size of KN can be measured in the same metric as that of KM; for example, see Thampapillai (2014), Thampapillai and Ruth (2019).

Strictly speaking KN does not have national boundaries as sovereign states do. KN endowments are part of a global KN ecosystem. For example, the smoke and haze from the Australian bushfires had drifted even as far as Chile in South America. The annual haze that originates in Indonesia and Malaysia, from the mismanagement of the waterlogged peat soils, blankets a fair portion of South and Southeast Asia. The summer of 2019 in the Northern hemisphere witnessed the smoke and haze from the Siberian forest fires stretch as far as Western Europe, the Arctic Circle, Canada, United States and Kazakhstan to the South.

The asset nature of KN and its global linkages are not clear to most economists – especially those who occupy centre stage in the teaching of economics. For example, Mankiw (2004, p. 246) states:

> "*Although natural resources can be important, they are not necessary for an economy to be highly productive in producing goods and services. Japan, for instance, is one of the richest countries in the world, despite having few natural resources. International trade makes Japan's success possible. Japan imports many of the natural resources it needs, such as oil, and exports its manufactured goods to economies rich in natural resources."*

Clearly, Mankiw fails to realise that – besides the existence of global ecosystems –Japan, for example, exports environmental damage in the form of asset depreciation to Australia when she imports from Australia the natural resources that she does not have[2]. Further, the asset is not simply a resource – but rather the entire ecosystem within which the resource is found. An extractable natural resource, regardless of whether it is beneath or above the ground, when extracted, creates significant disturbance to the ecosystem in which it is housed and given the broader linkages, even beyond the local ecosystem.

[2] This is clearly a fallacy of the framework outlined in the System of National Accounts by the United Nations Statistical Office (2008)

Take the case of wood chipping in Eden – a coastal township in Southern NSW and a serious casualty of 2019-20 summer bush fires. Since 1977, Harris-Daishowa, a Japanese wood-chip exporter has been logging old-growth forests on the escarpment around Eden. This activity, spanning in excess of 80,000 hectares of virgin forest, has been carried out under leaseholds that were formally approved by the Commonwealth as well as the State of NSW. Periodic opposition by conservation groups to this activity could not overcome the premise that wood chipping in Eden contributes to Australia's GDP as well as local and regional employment. But the long term damages caused by forest logging – especially of old-growth forests far exceed the monetary benefits of wood chipping. Wheeling (2019) reports recent scientific research from the University of Michigan revealing how canopy changes become important drivers of drought and reductions in soil moisture through changes to the hydrologic cycle. Had such research evidence been overwhelmingly available in the 1970s and 80s, then it is possible that the logging leases might have been denied. The chip mill in Eden and significant areas of surrounding forests have been destroyed in the fires of 2019-20, and would unlikely be a source of income and employment for a considerable length of time.

Besides forest clearing, several other activities also alter the hydrologic cycle that can lead to drought. Important among these is the excessive depletion of water from river systems right across the Australian continent. The abstractions of water are primarily made for agriculture and mining. Over a time period exceeding 100 years, the Murray-Darling Basin (MDB) has been transformed from robust to a fragile KN asset. The main reasons for this transformation are, amongst others, both regulated as well unregulated withdrawals of water. The MDB Authority reports show that in just the four-year period from 2015 to 2018, some 68 Billion litres of water had been abstracted, under licences, and that too, from just a small section of the basin in Queensland's Barwon-Darling tributaries. Annual withdrawals from the entire MDB, for irrigation could add up to a mammoth volume of 3.8 Trillion litres. If one is searching for the drivers of the Australian drought and climate change – they are also right here in Australia.

Mining is another activity that causes disturbances to both the surface as well as sub-surface ecosystems. Besides, mining is water intensive. For example, the Adani mine with an intended to extraction volume some 60 million tons of coal per year from the Galilee Basin in Central Queensland, would withdraw 12 billion litres of water per year from the Carmichael River. Such an abstraction volume will undoubtedly and adversely affect the Great Artesian Basin – largest ground water basin in the world. Some mistakenly argue that the withdrawal of water is from the river and not the ground water basin. The reality is that the river is nature's own recharge mechanism for the ground water resource system. Australia does have

efficient technologies for recouping water from mining. However, the adoption these technologies may not be as widespread as they should be. Further, the clearing of vegetation for mining and the scarring of the landscape would inevitably alter the hydrologic cycle.

Sand mining is an important contributor to housing and urban development. Sand volumes, in excess of 70 Million tons, has been removed from the sand dunes in Kurnell Peninsula to support mainly building activity in Sydney. Sand mining activity is widespread across coastal regions of Australia. North Stradbroke Island in Queensland, which generates roughly 500,000 tonnes of sand annually, has been the source of controversy due to the severe ecological impacts. Important among such impacts is the loss of mangroves from coastal and river systems where sand mining occurs. Mangroves are nature's filters for air and water and important players in the hydrologic system.

Practically every economic activity utilizes KN. It is for this reason that Alfred Marshall (1891)[3] deemed nature to be ultimate capital. That is, if one were to take any item and disaggregate into its components until one can disaggregate no more, the ultimate components come from nature. It is therefore essential that decisions pertaining to economic growth must not be confined to GDP alone – but must equally consider changes to KN. Stewardship towards KN must become an important economic activity and must enter the portfolio for employment creation.

Social Capital (KS)

KS is generally a collection of cohesive social networks and organizations that achieve social stability. The presence of a high degree of KS in any society is manifested in the display of a diverse array of attributes consisting of items such as: happiness, peace, law and order, absence of corruption and good health. Singapore achieves a higher of KS by ensuring that no one could speak ill of another race or religion. The legal enforcement of tolerance and respect has, over the years, grown into a virtue. KS is quickly lost in the context of religious and ethnic chauvinism. Although Australia has laws against hate speech, parliamentary privilege has not prevented some members to make hurtful statements such as 'Islam is a disease'. Nevertheless KS is deeply rooted in the Australian Psyche. The bush fires of 2019-20 and many others of the years gone by in the past, have displayed the gallantry and dedication to society of the volunteer fire fighters. These volunteers have relentlessly given up their time to protect lives and property of others. Some of them have – most sadly – lost their lives. The

[3] Alfred Marshall's *Principles of Economics* is perhaps the first concise text book in Economics and outlines natural endowments as assets

Australian community at large rallied around to help those who were rendered virtually destitute. This is one of many examples where Australian altruism has been at its best.

Across the Tasman on 15 March 2019 at Christchurch in New Zealand, a lone extremist killed 51 people who were partaking in the Islamic traditional Friday Prayers at a Mosque. The tragedy was extreme. But the overwhelming outpouring of solidarity and support from fellow New Zealanders starting with the New Zealand's Prime Minister was a clear manifestation of high KS in New Zealand. Some four weeks later, on Easter Sunday 21 April 2019, the city of Colombo in Sri Lanka witnessed another extreme tragedy inflicted on Christian worshippers at a landmark Church and innocent tourists by three Islamic extremists. Again there was a rallying of solidarity with the victims from people of different faiths and ethnicity.

The Late Professor Lynn Stout (2011) in her book on Social Conscience – an important attribute of KS – illustrates how the media often overlooks acts of stewardship and kinship by the community during times of crises. She gives the example of Hurricane Katrina that caused widespread destruction and havoc in the city of New Orleans in 2005. Whilst the media reported the damage and scenes of looting, it failed to show how members of the community rallied around to help each other. Stout's (2011) thesis rests on the need for cultivating social conscience through various avenues – something, which economics and economists fail to encompass in the formulation of economic policies.

Yet, any economy depends on a high degree of KS for its survival. Investors and entrepreneurs would rather locate their activities in places where KS is high rather than low. The loss of social conscience and hence KS is often manifested in corruption. The level of KS can be gauged by recourse to the "Corruption Perceptions Index" published by Transparency International, despite the criticisms surrounding the methodology. Denmark and New Zealand have consistently been ranked as the top two countries for having the lowest level corruption between 2010 and 2018. In these rankings out of 180 Countries, Australia had slipped from 8th in 2010 to 13th position in 2018.

A high level of KS would also mean that the economy enjoys the services quality labour (L) and other social malaise such as inequality, crime, suicide, spread of drug use, social - ethnic conflicts and homelessness would be low. According to the overall Human Development Index for 2019 published by UNDP, Australia occupies a respectable 7th place with reference to the multiple criteria overall. Nevertheless, aberrations in individual attributes can result in very adverse outcomes

Environmental and Social Capital (KN-KS)

There is indeed a very close association between KN and KS. The destruction KS will inevitably involve the destruction of KN. For example, corrupt practices in water trading permitting excessive abstraction from surface and ground water systems have rendered KN fragile, and in turn, soil surfaces dry. Aberrations also appear in the form of rent seeking lobby groups exerting pressure for permitting mining and building licences and relaxing regulatory restrictions zoning. As indicated above, mining, besides excavation and extraction, is intensive in water usage. Land clearing for new buildings, as also indicated above, can induce hydrologic changes – especially via canopy changes. When one considers these changes over a time period exceeding 100 years, it is not surprising that the Australian landscape has been rendered vulnerable to extreme climate events – notwithstanding the fact that climate change is a global event.

It is not difficult to envisage how social and ethnic conflicts involving indiscriminate acts of shelling would lead to severe damage of KN. For example, the prolonged civil war in Sri Lanka had resulted in conservation groups establishing elephant orphanages. Significant extents of land area in Vietnam and Cambodia are still uninhabitable owing to the presence of explosive mines.

Similarly, destruction of KN can drive KS into disarray. For example, consider a leaked memorandum from Lawrence Summers in 1991 as chief economist of the World Bank:

> "*I think the economic logic behind dumping a load of toxic waste in the lowest-wage country is impeccable and we should face up to that." ….."I've always thought that under-populated countries in Africa are vastly under polluted*."

Summers a professor of economics at Harvard was Presidential Advisor to Bill Clinton and later became the President of Harvard. The misguided rationality in the memo, based on the theory of comparative advantage in trade theory, has provided credence for the exporting of toxics from Europe and North America to Africa. One of the first destinations for these toxics was Liberia and Guinea Bissau in West Africa – countries that later became laden with the outbreak of the Ebola virus. One possible and plausible theory is that given the lack of safeguards to contain the toxics in underground repositories, their seepage into the subterranean ecosystems would have contaminated soil and water, and in turn contaminated food and water consumed by society. The result of all this could have been reductions in human immunity levels and infiltration of viruses that would have otherwise not crossed the human barrier. So here we have the misuse of KN leading to the destruction of KS in the form of death and human misery.

However, many mainstream economists reject the need to integrate KN and KS into macroeconomics. They argue that two conceptual tools of microeconomics, namely externalities and public goods can accommodate them. Externalities are unpriced effects that emerge from economic activities of production and consumption. For example, pollution is an externality for which markets do not exist – but for which markets can be improvised. Emission and toxics trading schemes are examples of such improvisation. Pure public goods are those, which anyone can consume as much as he/she wants without any rivalry. Such goods are rare but there are several resources both environmental and social that possess public good characteristics up to a certain point. Examples are beaches, forests and social tolerance. For example an open beach can tolerate many visitors/tourists until congestion sets in and from whereon limits, entry fees and regulations are imposed. Similarly a society could accommodate a flow of refugees up to a certain point, from whereon tolerance and empathy fail to survive.

The reasoning of relying on the microeconomic frameworks of externalities and public goods to regulate damages to KN and KS has a serious flaw. As explained in Thampapillai and Ruth (2019) and Chindarkar and Thampapillai (2018), externalities like pollution and other forms of degradation are never fully controlled and residual effects do always remain. Not only do these effects remain, they also accumulate. So, even if emissions trading and other legislations could reduce the volume of pollution, over time, cumulative loads will continue to increase.

At this juncture, an analogy presented in Thampapillai and Ruth (2019) is worth reiterating. That is, the case of a prisoner in a torture chamber, who receives one hundred, lashes a day. The prisoner's torso is one massive flesh wound. The prison warden takes pity and decides to halve the number of daily lashes. This action would certainly not heal the wound. In fact, for any healing to occur, the lashes must stop. KN and KS sinks are stressed and stretched to the limit. We need actions that would heal the sinks and not those which would further inflame them. There are several examples to illustrate the cumulative damage on the KN sinks and include: the permanent and growing brown cloud in Asia, polar ice melts, disappearance of mangroves and wetlands, and the extinction of species. With reference to KS, when homelessness is not fully controlled, crime waves and extremism begin to emerge. Homelessness by itself is a product of aberrations in the housing market. It is possible to argue that Al Qaida is an uncontrolled social externality that had gone berserk.
The extreme weather events – fires, floods, earthquakes and storms – anywhere in the world could very well be the outcomes of un-internalised residual externalities that continue to accumulate in various sinks. It is for this reason that Nobel Laureate Nordhaus – who studies

the link between economic growth and cyclones – recommends a slower rate of economic growth. But, such slow rates of growth could continue to add to the cumulative burden. Herein, the premise is that no harm could befall, if we have no growth and permit the sinks to recover. Peter Victor's (2019) argument for *Managing without Growth* would imply that avenues for reclaiming the resilience of KN-KS are in fact important sources of employment creation.

KN-KS as the Foundation Stone of an Economy

To illustrate the foundational role of KN-KS as the basic support structure for any economy, one can conceptualize the economy as a building with several rooms or floors where each room/floor is a market. In the first place, the building should never be plainly erected on a parcel of land. A solid foundation must first be laid, and the building has to be then erected on that foundation. So the premise is that KN-KS is the foundation on which the economy sits. One can conceptualise economic growth as the process whereby the building gets bigger/higher with more floors and more rooms than before. That is, more markets are added and/or existing markets expand. Therefore, it is imperative that proper maintenance and reinforcements are implemented with reference to the foundation. If not, cracks can begin to appear and eventually the foundation could crumble. And together with the foundation the building collapses. The evidence of cracks in KN-KS is a plenty. With reference to KN and natural hazards, one would observe sharp increases in not only their frequency, but also their intensity. This is indeed true of bush fires not only in Australia, but also in several parts the world. But consider Japan, where earthquakes are a common occurrence. Earthquake data on Japan shows that the frequency of earthquakes exceeding 4 on the Richter scale has increased significantly in just the past 20 years compared to observations contained in the 100 years that have preceded the year 2000. Further, the intensity of earthquakes that exceed 4 on the Richter scale has also significantly increased in the past 20 years. These increases in both frequency and intensity of earthquakes are perhaps not uncorrelated with increases in the intensity of mining activities in the near neighbourhood (China, Mongolia and Siberia) that could induce earthquakes has also significantly increased in the past 20 years.

To reiterate, the frequency and intensity of hazards such as floods, droughts and bushfires have increased in Australia and of course the world all over. The drivers of these observations are indeed the persistent focus on economic growth alongside the continued mismanagement of land and water resources. Globally, the evidence of breakdown in KS is overwhelming. Refugees fleeing from their homes, civil unrest, acts of war, drug lords spreading substance abuse among children, acts of extreme terror, mass shootings and gun related violence, and the list goes on. Australia has not been immune to these with the exception of perhaps

Australians wanting to flee Australia – rather than perhaps several thousands of persons wanting a refuge in Australia. This context might change if the neglect of KN-KS continues and corrective measures are not adopted.

The role of KN-KS as a foundation is illustrated in Figure-1. As explained in Thampapillai and Ruth (2019), the foundation performs a dual role as a *source* as well as a *sink*. For example, KN provides the resources, which an economy needs. Note that these are not only the extractive resources, but also basic needs such as the air we breathe, the water we drink and the ground we stand on. The very same stock of KN does also act as a sink. For example, the rivers that supply water are sinks for run-off from farm properties carrying chemicals and various residues. The air-shed that provides air to breathe is also the sink for various industrial and agricultural emissions.
(Figure-1 About here)

It is not difficult to envisage how the quest for economic growth accompanied by various actions that degrade KN can lead to a diminution in the size of KN. In a study of the Australian economy spanning 1970 – 2015 (Thampapillai and Chen 2018, Thampapillai and Ruth 2019), it was shown that Australia's air shed had shrunk by nearly two-thirds. Although these methods are fraught with assumptions and methodological difficulties, it is evident that KN as both a source and a sink is shrinking in size. The diminution of several other KN assets were referred to above.

KS provides quality L for the work force. High level of KS is manifested in peaceful and caring neighbour-hoods. When economic activity intensifies and L has to spend extended hours away from home, connected and cohesive family and societal networks can assist households to maintain their integrity. However, these networks break down in contexts amongst many others such as: hate speech, rivalry, quest for higher incomes and the spread of substance abuse. The last mentioned has been identified as a clear driver of mental illness, which in turn exerts significant pressure on family harmony. Rivalry and the search for higher incomes are also associated with risky borrowing and debt exposure and these in turn have been important drivers of homelessness.

Revisions to Assessment of Economic Performance

When the litany of woes with KN-KS is on the rise, then such woes would in themselves be the causes for the slowdown in economic activity. That is, the slowdown could very well be centred on the inability of the KN-KS foundation to support further expansion. Therefore, the expansion of KN-KS is an important consideration for assessment of performance and

subsequent planning for recovery and reconstruction. That is, one must also navigate expenditures towards improving the resilience of KN-KS, rather than prompting people to spend in the expectation that the economy would expand. However, in current practice, assessment of economic performance is confined to changes in GDP.

As in most standard economics text books (Mankiw 2009), GDP is the aggregate of value added expenditures pertaining to Household Consumption (C), Investment (I), Government Spending (G) and Exports (X) net of Imports (M). That is, [GDP = C + I + G + X – M]. These components of GDP are reported in the Expenditure Accounts of a country's national accounts and economic performance is assessed by recourse to changes in real (inflation adjusted) values. The Income Accounts of a country reports the aggregates of value added earnings that contribute to National Income (Y), namely Compensation of Employees (CE), Gross Operating Surplus (GOS) and Taxes (T) earned by government. That is, [Y = CE + GOS + T]. When the foundational capital KN-KS is ignored, assessment of economic performance and macroeconomic policy formulation, proceeds on the basis of on the state of balance between GDP and National Income; that is [GDP ≡ Y]. It is within this overall balance that other balances within the economy operate, namely Fiscal Balance (G ≡ T), Savings (S) – Investment balance (S ≡ I) and Trade Balance (X ≡ M).
But when, the foundational capital is recognized, it becomes imperative that some portion of income, labelled D_{KNS} in Figure-1, is ploughed back into KN-KS to offset its wear and tear and strengthen its foundational role. Therefore the basis for assessing economic performance has to be revised to [GDP ≡ Y – D_{KNS}]. D_{KNS} is at the core of methods dealing Environmental and Social Accounting. Suffice to note here that these include costs associated with items such as mitigating pollution, reforestation, adopting soil and water conservation, maintaining law and order and enhancing ethnic and religious harmony. Proxy methods for their estimation can be found in Ruggles (1987), Crowther (2000) and Thampapillai and Ruth (2019). Very often GDP is overstated because expenditures pertaining to D_{KNS} are included in GDP. Further, D_{KNS} is understated because some items such as species extinction are omitted owing to difficulties with quantification.

Whenever a slowdown of GDP is experienced, it seems common for governments to leap towards Keynesian type non-specific general expenditure stimulus, as was the case with Australia in April 2019. Such generalized stimulatory actions are expected to prompt producers to expand production in anticipation of enhanced spending behaviour by consumers. However, stimulus towards increasing consumption spending has been generally ineffective in most developed countries including Australia. It is possible that most consumers have reached a point of satiation with consumption choices available to them. For example,

how many brands of lip-gloss or designer shoes could an avid consumer test? Further, most consumer goods in retail outlets are produced in developing countries – notably China. Hence any stimulus aimed at, for example, increasing Australian consumer spending, is less likely to stimulate production in Australia.

Nevertheless, the thesis advanced here is that the time for non-specific generalised stimuli are now well past. Whenever an economy shows signs of a slow-down, then the first port of call is to review the KN-KS foundations and strengthen them. In Australia, these foundations, especially those pertaining to KN, have been rendered fragile. These need to be restored in the first instance.

The Way Forward

As of January 2020, more than fifty percent of all Australians have been adversely affected by the catastrophic fires – some terribly more so than others losing lives of dear ones and property. Nearly 15 Million hectares have been burnt out destroying precious flora and fauna. Danielle Celermajer, a Professor of Sociology at the University of Sydney, describes the catastrophic events as "Omnicide" – the destruction of everything – and the gravest of all crimes for which, many are accountable. Yet, Dateline 28 January 2020: Peter Martin reports on survey of a panel of 20 prominent (perhaps not that prominent) economists. These economists lament that following a record history of 30 years of growth, this year will be the second year in a row for Australia to underperform in terms of GDP and wages growth. Little do these economists realise that, the so called record period of sustained growth with little stewardship for nature was accompanied by the depletion of KN and underlies the Professor Celermajer's description of Omnicide. Right now there is a confluence of priorities. These include action plans to enable persons affected by the catastrophic fires to regain normalcy in their lives. Such actions might even lift the perverse indicator of economic performance, namely GDP above the 30-year average.

In the meantime, it is vital **to establish a governance regime that would have just one solitary aim – that is, the prevention of Australia from becoming an uninhabitable continent driving Australians into climate refugees**. Towards this end, specific areas of policy intervention are presented in Table-1 and discussed briefly below. With respect to the first three areas, in Table-1, it would be pertinent to deem the KN endowments to be the property of the Commonwealth. With rivers, mines and forests, a management approach based on a "whole of asset-endowment" basis, justifies ownership by the whole of nation, namely the commonwealth. To safeguard the health of these endowments, it is pertinent to consider the establishment of autonomous institutions – analogous to the RBA – so that they

could act independently without the influence of lobby groups – but on the basis of scientific information alongside socio-economic analyses.

(Table -1 about here)

Revitalisation of River Systems

Control and Regulation of Water Abstraction and Returns

Backtrack a little over 200 years. Alfred Deakin's vision for Australia was a land of prosperity for generations to come. It was with the best of intentions that Deakin travelled to the United States and then introduced into the Murray Basin in Victoria, the Californian type of irrigation scheme. As historian Dr Hamilton-McKenzie (2011) writes, this type of irrigation was most unsuited for Australia because the Australian river flows stemmed from rainfall as opposed to the Californian ones which originated in snowmelt. The foray into a mistaken type of irrigation over two centuries ago was followed by several years of grossly inadequate water governance that witnessed the abstraction of excessive volumes of water for irrigation and private storage reservoirs both upstream and downstream in various river systems – especially on the Murray Darling Basin. Some notable abstractions include the Cubbie Station on the Queensland – New South Wales border, using between 200,000 to 500,000 mega litres of water abstracted from the Darling River for growing cotton. A review of real estate pages of farm properties - especially in the river basin areas - indicate significant volumes of water storage as positive attributes that would enhance the sale.
In some properties, the storage areas display a distant horizon! A fair proportion of these waters must be returned to regain natural flows. The attempts to achieve these returns by recourse to water trading and specially improvised markets for government buy-backs of were not only unsuccessful but also wasteful of public funds. Markets are inherently perverse. For example, one agribusiness firm was able to sell the rights to overland flow to the Commonwealth for $80 Million in 2017.
As Vinoli Thampapillai (2011, 2014) argues there needs to be legal reform and that certain principles from International Water Law need to be introduced into the Water Acts of 2007 and 2008. These legal arguments would guide water sharing agreements between States and Territories. But such arguments have to be guided by science. Professor Sivapalan from the University of Illinois presents a persuasive case for adopting the principles of socio-hydrology for managing the needs of the natural environment alongside those of humans. In fact, Sivapalan et.al (2011) preface their narrative with tensions in the Murrumbidgee Irrigation Area, when environmental flows became an added entity in the water markets.

In the current context, the return of certain volumes of water needs to be mandatory and a regulatory framework needs to be quickly established. Water markets must be removed. All unlicensed withdrawals need to be returned and the quantum of return from licensed withdrawals be guided by the principles of socio-hydrology and conservation biology. Further, given that the abstractions have involved the destruction of mangroves and wetlands, their re-establishment becomes a priority activity. Such activity too has to be guided conservation biologists and socio-hydrologists.

From an institutional perspective, the Murray-Darling Basin Authority (MDBA) could be expanded to oversee all river systems and perhaps renamed the Australian River Basin Authority. This is because all river systems are invariably interconnected in hydro-geological terms and some threshold level of river health must be maintained.

Methods to Reduce Reliance on River Systems

Agriculture and Natural Sequence Farming

This is a clear way of relieving the pressure on river systems. Peter Andrews – an Australian farmer – offers Natural Sequence Farming (NSF) as a solution to persistent periods of drought. As explained in Andrews (2006, 2008) and Williams (2010), NSF is a collection of structural and non-structural methods that aim to minimize soil erosion and increase groundwater recharge. The methods also involve reintroducing some native species of flora mistakenly deemed as weeds by mistaken experts. Such reintroduction could enable soils to recoup their original properties in terms of organic matter. There is of course evidence that farm properties that adopted NSF have survived the drought. Yet, critics seek evidence from science – perhaps overlooking the very science that explains the primary cause of the drought. Questions have been also raised about the reintroduction of native species of flora despite evidence of such species being favourable to local soils. Some have suggested that farms that adopt NSF could serve as exemplary models for others in the farming community. If farm properties could be guided towards NSF – then the potential for relying heavily on river flows and returning stored water to the river systems could be enhanced and river health restored. Adoption of NSF could entail significant costs because it is based on infrastructural changes on farm properties. Given the importance of farming and agriculture to the economy, the Commonwealth may consider redirecting at least part of the infrastructure funding announced in April 2019 towards NSF. The other incentives might take the form of tax incentives and expenditure write-offs for tax purposes.

Related to the need to change the nature of landscape in agriculture is also the search for measures and technologies that conserve soil moisture. These are considered below.

Airdrop Irrigation and Drip Irrigation

Airdrop irrigation method was developed by a scientist from Swinburne University in response to events associated with long millenium drought. This scientist – Edward Linacre – had lost several of his friends, who were farmers, to suicide because of financial strains caused by the millennium drought and the inflexibility displayed by the banks. This is a low level technology that primarily mimics desert insects to combine hydrogen and oxygen in the air to create moisture. This innovation won the James Dyson award[4] in 2011. Primarily this device enables moisture from the air to be trapped in soils in the vicinity of the roots of plants thereby minimise loss of moisture due to evaporation. Apart from alleviating the demand for drawing water from natural flows such as rivers and creeks, it is possible to create pockets of green in broad-acre properties for giving relief to livestock during periods of drought.

Drip Irrigation, as practiced now, is an evolution of ancient techniques for conserving water in sub-surface soils. Primarily the method involves running irrigation pipes either close to or below soil surface to prevent loss moisture due to evaporation. Although initial systems employed perforated clay pipes, current usage involves plastic pipes. Israel is a distinct success story for transforming the desert into an oasis of orange groves and the like. But Israel's success also depends on urban waste water recycling to minimize tapping into water sources such as in the Galilee Basin.

Again these two methods could be incentivised by recourse to tax concessions, subsides and grants

Streamlining Mining

Dateline September 2013: The Liberal Party takes office and Tony Abbot becomes Prime Minister. Within 4 months, the Resource Rent Tax (RRT) – otherwise also known as the mining tax, was abolished. So was the Carbon tax. In April 2013 – there were nearly 114 mining projects awaiting approval and many of these were subsequently approved including the infamous Adani mine. Mining is without any doubt a major contributor to Australia's GDP and export revenue. In an address to a federal campaign rally on 29 June 2013, this what Tony Abbott said (quoted in Quiggin 2013): *"Just to get the regulatory approvals [to start a mine] takes more than three years. Six years ago it took less than 12 months… Australian investors are fleeing this country to invest in more stable countries like Mongolia and Angola"*. Leave alone the tenuous notion that Angola and Mongolia are stable nations, the intention was (and still is) to attract investors to mine highly demanded resources, especially for the export market. However, this export revenue and expanded GDP are not without

4 **https://newatlas.com/airdrop-wins-james-dyson-award/20471/**

significant damage to KN – especially the depletion of water resources. It is estimated that the extraction of one tonne of coal requires 250 litres of *fresh* water – without counting the amount of recycled water. Given that in 2016-17, some 880 Million tonnes of coal was produced, the amount of fresh water withdrawal would have been 220 Billion Litres. Mining is also not without land clearing. As indicated land clearing and canopy changes would seriously disturb the hydrologic cycle. So, in exchange for export revenue, Australia inherits an irreversibly scarred landscape, depleted stocks of water and a disturbed hydrologic cycle. As Trenberth (2008) explains a disturbed hydrologic cycle is invariably one where prolonged periods of drought are followed by intense precipitation, floods and storms. Given that the precipitation is lost from the earth's surface normalcy cannot be gained without remedial measures. As indicated, the system of national accounts, worldwide, does not recognize these effects. Therefore, the contribution to export revenue needs to be significantly diluted, and it is imperative that mining decisions are stream lined with emphasis on domestic needs.

Conventional logic dictates that a mineral is a non-performing asset as long as it remains beneath the ground. But, when some part of this asset is extracted and sold in exchange for income, the asset has depreciated by the value of the amount removed. So, in fact, the income from the resource equals the value of its depreciation, and if this amount is deducted from GDP, then the net addition to GDP is zero. It is for this reason, that Professor John Hartwick from Queens University in Canada has made the case reinvesting the income from mining into the creation of new sources of income. This logic has been established in Natural Resource Economics as the Hartwick-Rule (Hartwick 1977), and surprisingly unknown to many economists. The RRT was a vehicle for the Commonwealth to recoup at least part of the income from mining activities – especially those conducted by foreign investors.

Therefore, there is a case for deeming that all mineral resources are the property of the Commonwealth and hence liable for the RRT. Federal – State divides can only confound the issue of ownership, and in this confusion, many mining entities mistakenly regard the mine and mineral as their own. Hence, from an institutional perspective, it is important clarify the ownership issue in law, and thereby establish an autonomous statutory body that would oversee the approval processes. Various government ministries and agencies could liaise with this body.

There is yet another reason for streamlining mining, namely the stability of the earth surface. The literature on seismic sciences (Yerkes and Castle, 1976; Van Eijs et al., 2006), indicates that the extraction of oil and coal from layers beneath the Earth prompts significant pressure reduction, which in turn induces seismic activity. It is noteworthy that the United States Geological Survey has constructed earthquake contours on the basis mining projects.

But, the overwhelming reason for streamlining mining is the depletion of water, which in turn renders the landscape dry and hence vulnerable to extreme fire hazards. That is, mining is a driver of bush fires. It is ironic that BHP, which is perhaps the largest mining entity in Australia, complained in January 2020, the mining output was being constrained by the bush fires[5]. Equally ironic that the former Prime Minister Tony Abbott, donned the fire fighters' uniform and joined the frontline with the Rural Fire Service of NSW.

Revitalize Forest Systems

The latest '(2018) State of the Forest Report' issued by the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) indicates that Australia's a forest cover in 2016 was 134 Million hectares. However, the 2008 Report by ABARES, reveals Australia's forest coverage in 2003 was some 149 Million hectares. This means that during the period 2003 to 2016, which was part of the so called record 30-year sustained growth, Australia lost 15 Million hectares of forest. Somewhere close to that amount was lost in just one summer alone, namely the 2019-20 summer. There are two important points worthy of mention here.

- First, the loss of forests – 15 Million hectares during 2003 to 2016 and much more counting the preceding years – is lost on those who lament on the end of the record period of growth.
- Second, the catastrophic fire events of 2019-20 themselves could have been driven at least partially, by the deforestation of the preceding years. The rate of deforestation was significantly higher during the decade following the year 2000, than other years during the post-1990 period.

The main drivers of deforestation in Australia have been agriculture, mining and urban expansion in the form of housing development. Besides land clearing, housing development does also impose additional demands on forestry in terms of forest products – mainly timber and related forest products.

Although some 20 Million hectares could be designated as old growth, only some 5 million hectares had been confirmed and mapped. Some of these – especially those around Eden in NSW – could have been destroyed by the catastrophic fires. Old growth forests are those with the highest canopy density and their contribution to the hydrologic cycle is therefore the highest amongst forests. Hence, a legislation calling for the absolute preservation of old growth forests is vital. If such legislation were present, then the current (February 2020) tensions in Tasmania over preservation of the Tarkine Que River forests.

5 New York Times 21 January 2020 - report by Isabella Kwai

As reforestation with native species begins, it may be pertinent – if forest specialists see fit – to install air-drop irrigation units wherever feasible. This might be a way of preventing further damage if and when the fires return and permit reforestation take a firm grip on the landscape. Further, as suggested by the World Resources Institute (2014), it may be possible to commence restoration in highly degraded and marginalised lands with Bamboo plantations. As Qiu et al. (2019) and Bystriakova et al. (2003) suggest, bamboo can become an important resource in the building industry and be a substitute for hardwood materials. Reducing the reliance on forests also requires the search for innovative building designs such as those offered by the renowned architect Shigeru Ban from Japan[6]. He is well-known for constructing innovative homes and shelters with cardboard for disaster victims and one of his notable achievements is the reconstruction of a cathedral with cardboard in Christ Church, New Zealand after the earthquake of 2011.

The rationale advanced here is that the search and adoption of substitutes for timber products could facilitate active reforestation efforts. The case studies reported in the Asia Pacific Network (20011) and the works of Shigeru Ban suggest that this may be viable.

Closed Loop Production Systems

Status quo in terms of commercial and industrial organization can only exacerbate the difficulties with emissions and the release of other forms of pollutants. As indicated earlier by recourse to the prisoner analogy, the challenge here is to protect KN sinks and permit them to regain resilience by reducing the growth of cumulative pollution loads. It is in this context that closed production systems become important policy initiatives. A closed loop system is one where waste is either recycled as an input into another process or returned to nature as harmless material. A few examples considered here are: Industrial Symbiosis, Waste to Value Methods including Sewerage Treatment Systems; Air-conditioning and Heating Systems; and Innovative Methods of Commodity Development.

Industrial Ecology:
The most cited example of Industrial Symbiosis is the industrial park in the Kalundborg District of Denmark on the shores of Lake Tissø. As explained by Grann (1997) and Valentine (2016), this is a constellation of plants involving an oil-refinery, coal power station, cement and gyprock making facility, fish farms, green houses and neighboring farms. The entities are so arranged such that the wastes and byproducts from one entity can enter the other entities as inputs. The end result is minimum strain of the KN sinks – especially the lake and the air-shed. Although examples of this type might deepen the path dependency on fossil fuels, the potential

6 (**http://www.shigerubanarchitects.com/works.html**)

for refineries to transition towards renewable biofuels does exist. Another example provided by Khatri (2009) is from closer to home in Fiji. A catholic priest in charge of Boys' Town has prevented the deterioration of a creek into which a brewery was discharging its wastes. Using bamboo pipes, these waste discharges were routed to an animal husbandry unit as animal feed. The animal wastes were then used as composts on a barley field from where the grains were sold to the brewery.

At greater aggregate (sectoral) level, Ellen MacArthur Foundation (2017) provides how the farm sector can be connected to the urban sector through waste recovery facilities. The aim is to deconstruct the prevailing linear model in agriculture. The premise adopted here is that nutrients extracted from soils through agriculture are returned at least partially to urban waste repositories. The circular (closed-loop) system involves connecting the urban waste repositories to nutrient management facilities that recover phosphorous and other important nutrients, which in turn are then returned to agriculture.

Waste to Value

Sanitation and hygiene are not the only issues that surround sewerage treatment. Because this activity eventually relies on a variety of environmental sinks – oceans, lakes, rivers and subterranean ecosystems – efficient methods of sewerage treatment have far reaching implications for sustainability. Singapore's Public Utilities Board (PUB) offers a framework which other cities can/must emulate. In this city state, every single dwelling is connected to a system where the treatment is so advanced that the recovered water is reusable for both industrial and potable purposes. But besides the issue of water conservation, it is equally important to note that the extent of treatment renders the residues that get deposited into the ocean sink to be inert. Most coastal cities in the world deposit either untreated or semi-treated sewage into ocean sinks on the grossly mistaken assumption that the ocean is an infinite sink capable of assimilating wastes. For example, Sydney (Australia) pumps out each day at least 12 million litres of semi-treated sewage into the Pacific Ocean[7]. Imagine the cumulative load of pathogenic material that would be accumulating, if one tallies all other coastal pumping stations in Australia and the number of years of this activity. Skeptics would of course argue that the ocean is not a static body of water and that wave actions and oceanic movements will render the deposits harmless. This may be true if the loads of deposition are small and not continuous over time. Scientific evidence from the University of New South Wales now indicates that the quality of the Pacific Ocean on the Eastern sea board of Australia could be seriously compromised. It is this type of practice (amongst others) that had rendered nearly half the Baltic Sea (below a certain depth) to be lifeless. It is plausible to argue that the sink capacity of all oceans in all continents is compromised owing to improper methods of sewerage

7 **http://www.environment.nsw.gov.au/resources/beach/bwsob0304/bwar03042.pdf**.

treatment. If all cities in the world were to replicate the Singapore model, then the implications for global warming are immensely significant. The oceans are the world's largest naturally occurring carbon sink owing to the presence of phytoplankton. The sink capacity of the oceans when restored could in turn restore balance to the carbon cycle. In fact the Paris targets could be met sooner than later through proper sewerage treatment and the phytoplankton recovery in the ocean.

Compared to 20 years ago, every dwelling and building in almost every city is now equipped with either an air-conditioner (in tropical countries) or a heat pump (in temperate countries) or a reverse-cycle unit (mainly in temperate countries). Air conditioners generally pump out hot air – depending on the indoor temperature setting – and hence raise the outdoor ambient temperature. Heat pumps in winter gush out colder air and thereby lower the external ambient temperature. The skeptics' response would be that the change in temperature prompted by each unit is miniscule relative to the volume of the earth's troposphere. However, if one were to take a tally of the number of dwellings across the globe and the time continuum, then the cumulative effect is quite unlikely to be insignificant. Closing the loop (at least partially) on this type of system would be to search for dwelling/building designs that would reduce the demand for external heating and cooling and at the same time enable the capture of the heat/cold emission for reuse within the dwelling/building. For example, in a shopping centre complex, the design aspects could be construed such that dry-cleaning establishments receive the hot air exhausts (in tropical countries) and cold rooms for refrigeration receive the cold air exhausts (in temperate countries). In both cases, the partial loop closure reduces the energy demand imposed on the grid.

Alternative Energy Sources

The greenhouse gas concerns have already ushered in several alternative energy initiatives. As of now nearly fifty per cent of electricity is powered by renewable sources[8]. This is despite the dominance of coal power, which makes it difficult for innovative energy producers to compete. For example the Australian firm Oceanlinx had developed a device that would convert wave energy into electrical energy and had in place about six urban energy supply projects each to deliver between 5MW to 15 MW of peak capacity. Unfortunately the firm went into receivership in 2014. And this was about the same time as mining projects received significant boost by the removal of carbon and rent taxes. Even now in January 2020, the Commonwealth is fixated with the need to lower energy prices by promoting coal power plants. Such unwise efforts could stifle new projects such as those started in January 2020 by AgBioEn – A Melbourne based firm. This firm has launched a near $2 Billion dollar project, in Katunga

8 https://www.straitstimes.com/asia/australianz/aussie-states-take-lead-in-push-towards-clean-energy-future

Victoria, to deliver value from farm organic waste. The project will harness materials such as cereal straw and convert it to electricity, renewable diesel and jet fuel, and fertilizer[9].

Bio-Mimicry
Bio-mimicry involves methods of commodity development that embrace closed-loop production involve attempts to replicate nature's methods of dealing with waste. It is defined as:

"A new science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems".

Janine Benyhus (1997) and Vanderbilt (2012) illustrate several examples of how the physiological processes of various organisms in nature can come up with processes for the manufacture of various items without polluting nature. For example, abalone makes it shell – a durable product, which could serve as a container without polluting the surrounding environs. The manufacture of durable containers such as glass is the result of sand mining and heating at excessively high temperatures. Similarly plants can produce flowers with a dazzling array of colours without chemical dyes that contaminate KN sinks. Note that manufacture of desired colours for fabrics has been very polluting activity. Hence the challenge is for industrial processes to mimic physiological processes of biological organisms so the pressure exerted KN endowments would be minimal.

Strengthening KN-KS

The primary tool for strengthening KN-KS is education. An anecdote offered in Thampapillai and Ruth (2019) illustrates this very well. A mother was wheeling her shopping trolley in a busy suburban super market in Singapore, with her child of primary school age tagging along. The mother was hurriedly throwing items into the trolley and this made the child visibly upset and vocal – the child wanted the mother to read the label first and ascertain whether the items were friendly to nature or not. It appears that the Singapore Ministry of Education has introduced some concepts on sustainability at the primary school level.

It is important for the sustainability of KN-KS to be introduced as a mandatory items at *all* levels of education, namely Primary, Secondary and Tertiary. For example, consider current tertiary education curriculum, world-wide, in Business, Commerce and Economics. It is possible for a student graduate with a degree in in one or a mixture of the disciplines without ever having encountered content on sustainability. Subjects pertaining to the relevance of

9 https://www.straitstimes.com/asia/australianz/australia-in-landmark-19-billion-project-to-turn-farm-waste-to-energy

sustainability are invariably always in the periphery outside the core curriculum. Hence, when graduates from these disciplines enter the work force, and say, perform advisory roles to governments, then their recommendations would fail to uphold the principles of sustainability. The drama of arrests that have unfolded (February 2020) with protests over the logging of Takayna/Tarkine Que River forests in Tasmania most clearly illustrates this. The fact that old growth forests are irreplaceable is lost on the State Government of Tasmania and its advisors. Recall the narrative above illustrating that forests, especially old growth forests, stabilize climate changes through the hydrologic cycle. Barring the fact that members of parliament - State and Federal – will all need an urgent refresher course on the subject of sustainability, it is important that the principles of sustainability, become part of the core curriculum in all disciplines ranging from the sciences to the social sciences. This would then pave the way forward towards the moulding of a sustainable society.

There appears to be a fixation with the notion that the quick fixes for employment creation requires GDP growth through mining and forest logging. But several employment opportunities do exist in the areas identified above for enhancing the resilience of KN. These can include, for example, the creation of mangroves on the coastline and riverbanks. As indicated above, mangroves possess the special attribute of stabilising ambient temperature, besides facilitating fish and other aquatic resources to spawn and spread. Establishment of mangroves are in fact a special class of investments – KN investments that would raise GDP. In fact, closed loop production systems and several of the examples identified above, provide several opportunities for employment creation.

As indicated above, there is strong relationship between KN and KS. The deterioration KS would inevitably impact the health of KN and vice versa. In contemporary society, many KS related issues stem from spread of drug-use, which among many other outcomes leads to high exposure to debt and in many cases homelessness. Many Australian cities have witnessed the sad phenomenon of people sleeping on the streets. At the same time rehabilitation and the return of drug affected persons into the workforce is important. Many of these schemes do operate now – but they would fall outside the orbit of a general economic policy. Planners and policy makers do not quite see the expansion of KN-KS as a vehicle for economic recovery. A detailed narrative on preventing and dealing with homelessness is beyond the scope of this paper. Nevertheless, erecting less KN invasive housing structures such as those offered by architects like Shigeru Ban could enable at least transient shelter for those living on the streets, whilst measures enabling their resilience are effected. However, above all - A dedicated education program to protect children from exposure to drugs is of paramount importance.

Concluding Comments

Date line 21 January 2020: The headlines of the Financial Times read as follows: **Downbeat IMF outlook diverts Davos focus from Climate Goals**. Gita Gopinath IMF's chief economist called multilateral cooperation to achieve global recovery because the world GDP forecasts for 2020 are now down from 3.4 to 3.2 per cent. That is a drop of 0.2 of a per cent in GDP is a calamity that outstrips raging fires and floods. It is pertinent to reiterate the prisoner analogy from Thampapillai and Ruth (2019), where the prisoner's torso is one massive flesh wound owing to repeated lashings. Halving the number of daily lashes would certainly not heal the wound. Increasing GDP without careful navigation is tantamount to inflaming the wound. The IMF is clearly out of touch with reality. For a recovery - the essential first thing to do is to seek multilateral cooperation towards revitalising the KN-KS sinks that are so choked - from the polluted lakes and rivers and societies riddled with conflict and corruption.

For us in Australia, the frequency and intensity of extreme climate events have all increased - the mistaken belief that the fallacious indicator called GDP must grow has played an important role in this.

REFERENCES

Andrews, P., *Back from the Brink: How Australia's Landscape can be Saved*, ABC Books, Sydney, 2006.

Andrews, P., *Beyond the Brink: A Radical Vision for Australia's Landscape*, ABC Books, Sydney, 2008.

Australian Bureau of Agricultural and Resource Economics and Sciences, *State of the Forest Report – 2018*, Australian Government, Canberra, 2019.

Australian Bureau of Agricultural and Resource Economics and Sciences, *State of the Forest Report – 2018*, Australian Government, Canberra.

Australian Bureau of Agricultural and Resource Economics and Sciences, *State of the Forest Report – 2008*, Australian Government, Canberra.

Batisha, A. F. Feasibility and sustainability of fog harvesting. *Sustainability of Water Quality and Ecology*, 6, 1–10, 2015

Benyus, J., *Biomimicry*, Harper Collins, New York, 1997.

Bystriakova, N., Kapos, V., Stapleton, C. and Lysenko, I., *Bamboo biodiversity: Information for planning conservation and management in the Asia-Pacific region*, UNEP-WCMP, UK 2003

Celermajer, D., "Omnicide: Who is responsible for the gravest of all crimes?" Online Opinion, *Australian Broadcasting Corporation*, 03 January 2020.

Chindarkar, N. and Thampapillai, D. J., "Rethinking Teaching of Basic Principles of Economics from a Sustainability Perspective", *Sustainability*, May 2018

Crowther, D., *Social and Environmental Accounting,* (London: Financial Times Prentice Hall, 2000), p. 20.

Ellen MacArthur Foundation, *Towards the Circular Economy: Economic and Business Rationale for an Accelerated Transition*, Cowes, United Kingdom, 2017

Grann, H., "Industrial Symbiosis at Kalundborg", in National Academy of Engineering, *Industrial Green Game: Implications for Industrial Design and Environmental Management*, The National Academies Press, Washington D.C., 1997

Hamilton-McKenzie, J., Utopos?: A Consideration of the Life of Irrigationist, George Chaffey, *Australasian Journal of American Studies*, 32(2): 63-80, 2013.

Hartwick, John M., 1978. "**Investing returns from depleting renewable resource stocks and intergenerational equity**," ***Economics Letters***, 1(1):85-88, 1978.

Khatri, K. 'Integrated biosystems -Montfort Boys Town, Suva, Fiji Islands', in Nair, J., Furedy, C., Hoysala, C. and Doelle, H. (Eds), *Technologies and Management for Sustainable Biosystems*, Nova Science Publishers Inc., 2009.

Mankiw, N.G., *Principles of Macroeconomics*, Thomson South-Western, Mason Ohio, (3rd edition) 2004.

Martin P., "2020 survey: no lift in wage growth, no lift in economic growth and no progress on unemployment in year of low expectations", *The Conversation*, 28 January 2020.

Qiu, H., Xu, J., He, Z., Long, L., and Yue, X. "Bamboo as an emerging source of raw material for household and building products," *BioRes.* 14(2), 2465-2467, (2019).

Quiggin, J., "Fact Check: does it take three years to get approval for a mine?" *The Conversation* , 7 July 2013

Ruggles, N. D., "social accounting," The New Palgrave: A Dictionary of Economics, v. 4, pp. 377–82, 1987.

Sivapalan, M., Savenije, H. H. G., and Blöschl, G., "Socio-hydrology: A new science of people and water", *Hydrological Processes*, Invited Commentary, 2011.

Stout, L. A., *Cultivating Social Conscience: How Good Laws Make Good People*, Princeton University Press, NJ, 2011

Thampapillai, D. J., "Lessons from Science: Need for a Rethink of Concepts in Economics", *Economic and Political Weekly*, September, 2014.

Thampapillai, D. J and Ruth, M., *Environmental Economics: Concepts, Methods and Policies,* Routledge, London UK, 2019.

Thampapillai, V., 'Limits to government water buy-backs for environmental flows in the Murray-Darling Basin (part 1)', *Environmental Policy and Law*, 39(4–5): 247–65, 2009.

Thampapillai, V., Market Failure in the Murray Darling Basin and Theoretical Foundations for Intervention by Government Water Institutions, 2011. Available at SSRN: **https://ssrn.com/abstract=1790064** or **http://dx.doi.org/10.2139/ssrn.1790064**

Valentine, S., "Kalundborg Symbiosis: fostering progressive innovation in environmental networks", *Journal of Cleaner Production*. 118: 65-77, 2016.

Vanderbilt, T. "How Biomimicry is Inspiring Human Innovation", *Smithsonian Magazine*, September 2012; (Accessed at: **https://www.smithsonianmag.com/science-nature/how-biomimicry-is-inspiring-human-innovation-17924040/**)

Van Eijs, R.M.H.E., Mulders, F.M.M., Nepveu, M., Kenter, C.J. and Scheffers, B.C., 'Correlation between hydrocarbon reservoir properties and induced seismicity in the Netherlands', *Engineering Geology*, 84(3–4): 99–111, 2006.

Victor, P., *Managing without Growth: Slower by Design, not Disaster*, (Second Edition), Edward Elgar, London UK, 2019

Wheeling, K. (2019), How forest structure influences the water cycle, *Eos, 100,* **https://doi.org/10.1029/2019EO134709**. Published on 15 October 2019.

Yerkes, R.F. and Castle, R.O., 'Seismicity and faulting attributable to fluid extraction', *Engineering Geology*, 10(2–4): 151–67, 1976.

FIGURES AND TABLES

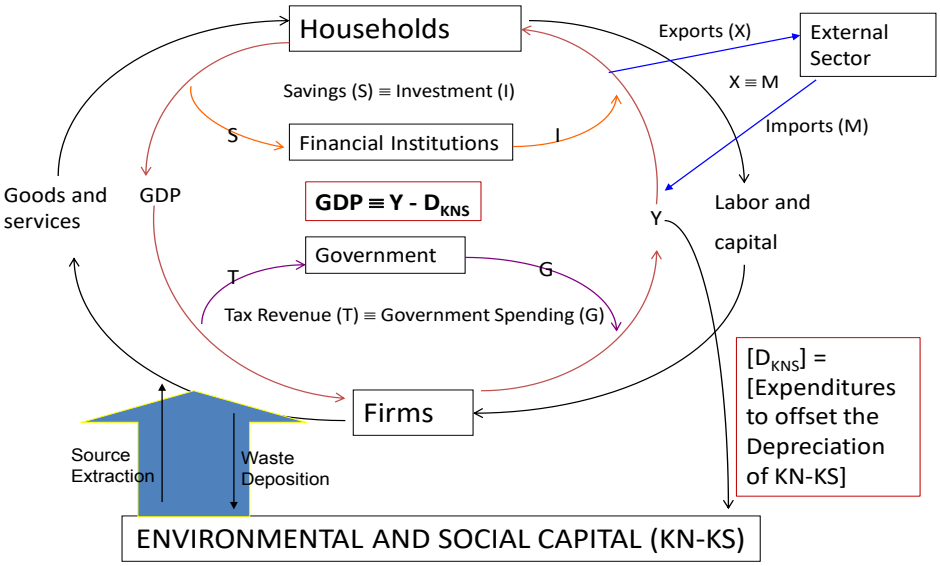

Figure-1: The Economy and its KN-KS Foundation

Table-1: Summary of Policy Measures for Intervention

	POLICY MEASURE	IMPLEMENTATION
I	REVITALIZE RIVER SYSTEMS • Mandatory Returns of Unlicensed Withdrawals of Water • Mandated Abstractions and Returns of from Licensed Withdrawals in Compliance with Socio-Hydrology and Conservation Biology • Reduce Reliance on River Systems ➢ Natural Sequence Farming ➢ Air-Drop Irrigation ➢ Drip Irrigation	Legislation Institutional Capacity Fiscal and Monetary Incentives Investment Assistance
II	STREAMLINE MINING ON NEEDS BASIS • Prioritize on the basis of domestic needs and resource requirements – especially water • Scale down exports • Promote Renewable- Energy	Reintroduce Resource Rent Tax Evaluation to Include Hartwick-Rule and Environmental Damage in Trade Balance
III	REVITALIZE FOREST SYSTEMS • Mandatory conservation of all old-growth forests • Active re-forestation with native species • Forest Product Industries to use only plantation forests in compliance with socio-hydrology and conservation biology	Legislation Institutional Capacity Fiscal and Monetary Incentives
IV	RESTRUCTURE ECONOMY IN TERMS OF CLOSED LOOP PRODUCTION SYSTEMS • Industrial Symbiosis • Sewerage Treatment Systems and Recycling Waste Water • Bio-Mimicry and Other Innovations	Fiscal and monetary incentives
V	REVITALIZE KN-KS • Sustainability Education at all levels • Curriculum Development	Legislation