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BUS RAPID TRANSIT (BRTS): AN EFFICIENT AND COMPETITIVE MODE OF MASS TRANSPORT

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Abstract

Transport is very important part of nation's economy. Public transport is the primary mode of transport for most of the population, and India's public transport systems are world's most heavily used systems. The main problems are common all around the world including India. They have to face problems associated with passenger mobility and connecting the city verge with central part. There are few innovative solutions are present to overcome these problems. Urban Planners and Administrator have found Bus Rapid Transit System (BRTS) as efficient, cost effective and simple as compare to other Light Rail Transit (LRT) and Metro Rail solution to provide mass public transport to city. This is a bus based mass transit system. It is known as a "surface subway", BRTS aims to join the capacity and simplicity of a bus system. BRTS is best suited to mid-size cities like Indore with deficient bus services and middle class basically forms the social structure. There is high demand irrespective of availability of Right Of Way; it can operate in a mixed traffic situation also. Basic concept of BRTS is to relieve road space by reducing private vehicles with low occupancy, to a comfortable, fast, mass transit mode. The objective was to study the BRT system based on qualitative parameters. This will help when designing future systems. The paper discusses about the vehicular growth and modal split in India and advantages of BRTS over other Transit systems. The Design and operational features of BRT are discussed in detail, problems presently faced by the system are discussed and solutions to these are suggested. Further improvements are suggested which can help to increase the ridership of the system.

Keywords: Public transport system; passenger mobility; BRTS; LRT; Metro rail; vehicular growth; modal split.

1. Introduction

Improvement of Transportation system is very important for development of urban areas. By providing access and mobility we enable functioning of urban areas efficiently. Passenger has an influence on the functioning of the city and with growth the mobility also needs to be increased. There is two ways to increase mobility, by encouraging private transport services like auto-rickshaw, private buses, and taxis or by public transport systems. Instead of private transport system we can choose public transport system to decrease traffic congestion, air pollution, and greenhouse gas emissions. By attracting development around transit stations it helps in reduction of sprawl. Hence community planning officials examined improved public transportation for addressing their urban mobility issues. There are many transit technologies like Metro Rail Transit, Light Rail Transit (LRT), Mono Rail etc. but these are uneconomical, non-flexible and have high capital and operating costs so we needed creative ways of improving service quality cost-effectively. BRTS has operational flexibility, and can be built quickly, incrementally, and economically.

1.1. Vehicular growth and modal split in India.

In recent decades India has seen a high rate of increase of motorised vehicles. In 'National Urban Transport Policy' it is mentioned that during 1981-2001 the population of India's six major metropolises increased by about 1.9 times, Where the number of motor vehicles went up by over 7.75 times. The Census 2011 shows that 35% of urban households had a motorised two-wheeler and 9.7% had a motorised four-wheeler and whole, registered motor vehicles increased by 2.4 times during 2002-11. In such a rapid vehicular growth, the number of vehicles per 1,000 populations is still low at 117. However, continued high economic growth and bad governance of motor vehicles will increase vehicle density in India in coming years. Urban traffic in India includes high levels of Non-Motorized Transport (NMT). This means Walking and cycling which constitute 42% of the total trips and public transport 16%. Walking and cycling are "no choice" modes used by the urban poor. For sustainable transport there is need of shifting motorized vehicle users, mainly car (16%) and two-wheeler (21%) users, to public transport. Public transport systems in Indian cities have not improved with the increasing demand so it compelling people to turn to either personalized modes or Intermediate Public Transport which creates congestion and air pollution and force poor people to grow slum near the work station to reduce daily trips from work place. To reduce congestion road widening and flyover construction may be solutions but improving the public transport system it has been seen as solutions for the all mentioned concerns.

Present condition of municipal or state-run urban bus services is very bad they are volatile, depend on infirmly maintained bus fleets and lack financial. Vast improvements are needed in India's public transport systems. In Indian cities condition of buses are very bad they are old and poorly designed, badly maintained, overcrowded and slow. Transportation demands are increasing rapidly in urban areas as a result population growth and changes in travel patterns. In this time two major factors are taken in consideration while designing anything that are environment concerns and limited space available in cities, transport planners have to provide a system, which can ensure safe and clean mobility. This planning requires a system, which is affordable, reliable and efficient from the user as well as operator's perspectives. After realizing the importance of public transport and equity concerns, A road based Bus Rapid Transit system (BRTS) is needed which offers an opportunity for creating a system capable of meeting multiple needs of users and operators.

1.2. What is Bus Rapid Transit?

Bus rapid transit (BRT) is a high-quality, efficient mass transport mode, providing capacity and speed comparable with urban rail (light and heavy rail). Its insertion in urban transport systems is relatively recent and as a result there remains a need to introduce the concept to several audiences, particularly urban transport decision makers, and to better understand its cost, performance and impacts.

BRT flexibly combines stations, buses, exclusive and segregated bus ways, and intelligent transportation system elements into an integrated transit system with a strong brand that evokes a unique identity. BRT provides higher quality of service than traditional urban bus operations because of reduced travel and waiting times, increased service reliability and improved user experience. BRT has contributed to an urban transport transformation in the last decade. Today, more than 160 cities around the world have implemented 4,200 kilometers of bus rapid transit or high-quality bus corridors which carry nearly 30 million daily passenger trips. The global growth of BRT has been tremendous in recent years. In the ten years from 1992-2001, only 23 cities had implemented new BRTs or bus ways while 115 cities have implemented BRT since 2002.

Any Bus Rapid Transit systems have the following characteristics:

• Exclusive right of way
• Rapid boarding and
• Clean, secure, and comfortable stations and terminals
• Fast and efficient fare collection, collection at stations or on board vehicles.
• Effective regulations for bus operators
• Use of Intelligent Transportation Systems
• Transit priority at signalized intersections
• Integration with other modes of transportation

A good BRT system works well when it is integrated with other transport systems and an efficient “Park and Ride” facility which can compensate the feeder service, enabling people to use their private vehicles till the corridor. A successful system requires some special measures like restricting certain movements of traffic at junctions, development of an intelligent signaling system to provide priority to buses, etc.

1.3. Feasibility of technology and operational necessities :

Generally speaking, BRT is a very suitable technology for urban transport systems, both for both developed and developing countries. It should mainly be seen in competition with types of mass rapid transit (MRT) systems, mainly rail-based systems such as metro or light rail. The main advantage of a BRT compared to other MRT options is the substantially lower investment cost, while its main drawback is its demand for space in a city. In many cases, when BRTs are being constructed, road space for private vehicles is reduced, as there may be no opportunity to expand the total road space.

International experience has shown various successful and unsuccessful examples of BRTs, from which important lessons about how to introduce and maintain a BTR can be drawn. The following points should be taken into account:

- Public acceptance of the BRT and awareness of the diverse benefits (social, environmental, etc)
- Appropriate consideration of non-technical aspects.
- Careful planning, for example in order to avoid bus overcrowding during peak periods.
- Possible resistance by existing bus operators, with negative consequences on the initial implementation.

- Transparency and good practices in all steps of the project in order to avoid any risk of money misuse and political tensions
- Appropriate fare collection systems
- Good pavement maintenance

1.4. BRT COSTS AND PERFORMANCE

BRT system performance can vary significantly depending on design characteristics and level of integration with other transport modes. For instance, corridors with exclusive, segregated bus lanes will be able to move more passengers in an hour than a corridor where buses operate in bus-priority lanes, which also permit access to mixed traffic. Bypassing lanes at stations enable express routes to skip certain stations and reduce travel times for some passengers. Not all corridors have the same travel demand and so there is not a one-size-fits-all BRT. A city should aim to implement the highest-quality BRT that meets the travel demand and mobility needs on a particular corridor.

Globally, the range of systems varies from very high-capacity to relatively low-volume corridors as with BRT performance, project costs vary significantly across systems depending on the extent of the roadwork's required (e.g., bridge or tunnel construction), corridor capacity (e.g., inclusion of bypass lanes at stations), obligatory simultaneous repair or upgrading of urban utilities (e.g., water, sanitation and electric services along the BRT corridor) and the quantity and type of equipment used (e.g., articulated or bi-articulated buses, automatic fare collection, passenger information systems, advanced traffic control), among other factors. Local conditions, such as cost of labor and capital, will also have an impact on total system costs. Where BRTs are used as a vehicle for broader urban transport reform, such as formalizing an informal transport industry, there are added costs associated with that transformation.

While capital costs per kilometer and operating costs can vary significantly among BRTs, data from existing systems help to define an indicative range of BRT costs. Total BRT capital costs include busway infrastructure, stations, buses and technology systems such as passenger information and fare collection systems.

1.5. COST-BENEFIT ANALYSIS METHODOLOGY

Bus rapid transit projects have the potential to provide travel time, public health, environmental, land use, and other benefits to society. However, like all transport options, BRT systems can also impose social costs from construction, operation, and maintenance. In order for policymakers to make an informed decision regarding the development or expansion of a BRT project, the project should be evaluated in terms of total benefits compared to total costs. Ideally, an analysis of alternatives should be done comparing alternative solutions in a preconstruction phase. Cost-benefit analysis (CBA) is used to capture both public and private costs and benefits for society as a whole. In addition to the financial or market costs, it also considers externalities and indirect or intangible costs to capture social effects. Cost-benefit analysis therefore provides policymakers with a valuable tool for comparing net benefits (benefits minus costs).

The costs and benefits of transportation projects will continue over many years, the future costs and benefits are often discounted over the life of a project, in the form of an estimated net present value (NPV). A positive NPV implies that a project offers net benefits.

BRT Costs	BRT Benefits
• Planning and design • Capital costs • Infrastructure (e.g. busways, stations, depots) • Equipment (e.g. fleet acquisition, fare collection, passenger information, control center) • Bus operations and maintenance • Infrastructure operations and maintenance • Negotiations with existing transit operators	• Changes in travel time (BRT users and others) • Changes in vehicle operating costs (private vehicles and public transit) • Changes in CO2 emissions • Changes to exposure to local air pollutants • Road safety benefits (fatalities, injuries, property damage) • Changes in physical activity

- **Benefit-cost ratio.** A ratio of the net present benefits and costs greater than one indicates that the total benefits to society exceed the costs.
- **Internal rate of return (IRR).** The IRR is the discount rate at which the net present value of costs equals the net present value of the benefits and indicates the attractiveness of the investment. The IRR of a public investment should exceed the cost of capital.

Transport, environmental, public health and safety benefits described earlier. While CBA is a powerful tool to guide decisions, the methodology does not typically include a distributional analysis. The methodology goes beyond traditional CBA, evaluating the distribution of benefits and costs across society to identify which income groups are winners and losers. We consider the benefit-cost ratio by income strata as well as how net benefits (benefits minus costs) are distributed across socio-economic groups.

2. CASE STUDIES

This report features five case studies that use available data to estimate the net benefit to society from a bus rapid transit project:

- TransMilenio, Bogota, Colombia;
- Metrobús, Mexico City, Mexico;
- Rea Vaya, Johannesburg, South Africa;
- Metrobüs, Istanbul, Turkey.
- Janmarg, Ahmedabad's BRTS
- MYBUS, BRTS in Bhopal

These case study BRT systems were selected on the basis of success and failure of system to learn both the points. As a set, the cases provide a glimpse into the costs and benefits of BRT projects and shed light on the variance found among the over 160 cities around the world that have implemented BRT or high-quality bus corridors.

2.1. National cases

2.1.1. Ahmedabad's Bus Rapid Transport System 'Janmarg'

It is a wonderful case study of revolutionizing urban transport. Ahmedabad's BRTS has the following special features that have truly made it a cut above the rest:

- Over 60 buses with GPS enabled facility with 2 way voice days and Passenger Information System as well as e-ticketing system.
- Extensive application of Intelligent Transport System (ITS).
- Low floor buses with large central doors of both sides. Accessible to persons with special needs.
- Bus Stations with the latest technology.
- Option of a Janmarg Travel Card that saves the commuter the need to stand in long lines and buy tickets.

2.2. International cases

The four BRTs presented in the case studies represent a variety of projects with a range of infrastructure and service designs, implemented and operated in different urban and political contexts. All of the projects have positive net present benefits and benefits exceeding costs. The internal rates of return indicate each of the investments was at least as socially profitable as the opportunity cost of public funds.

Key findings from each case study include:

2.2.1. **Bogota's TransMilenio**

• The two largest benefits are travel time savings for transit users, and savings on the operation of traditional buses removed from service following the implementation of the TransMilenio system. • The largest proportion of users of the BRT system is in the lower- and middle-income groups.

• TransMilenio benefits are biased towards the lower income strata, and with costs biased towards the highest socioeconomic stratum, reflecting the profile of users and the structure of the Colombian tax structure.

2.2.2. **Mexico City's Metrobús**

• The largest benefits were travel time savings for public transport users, due to the segregated bus lane allowing buses to achieve high operation speeds.

• Savings in operation costs of public transport vehicles are the second largest benefits. This is the result of larger, newer buses that operate at higher speeds. This also helps the system to achieve lower emissions.

• The largest proportion of users of the BRT system is in the lower- and middle-income groups.

• The largest proportion of benefits accrue to those of modest income (monthly income = MXN $4500-7500)—representing the second quintile of the income distribution.

• The largest losses accrue to those at the top of the income distribution.

2.2.3. **Johannesburg's Rea Vaya**

• Together the bus operation and maintenance contract and the capital costs constitute 96 percent of the total project costs.

• The high cost of the bus operating contract reflects, in part, the cost of formalizing and empowering the minibus taxi industry.

• The largest portion (37 percent) of benefits comes from travel time reductions followed by improved road safety (28 percent).

• Phase 1A has been a progressive project; the upper income quintile bears the majority of the costs, while the project benefits accrue to lower quintiles, predominately the 4th highest income quintile.

3. SOCIAL, ENVIRONMENTAL AND ECONOMIC IMPACTS OF BRT SYSTEMS

The city's poorest residents are underrepresented in BRT users and therefore are not significant beneficiaries of the project. They do share in 4% of the project benefits, while only contributing to 2% of the costs.

3.1. Istanbul's Metrobüs

• The largest proportion (64 percent) of benefits comes from travel time reductions, followed by vehicle operating cost reductions (23 percent) and traffic safety (9 percent).

• Metrobüs costs are driven primarily by operating and maintenance costs.

• The largest proportion of users of the BRT system are in the lower- and middle-income groups, though benefits exceeded costs in all income groups.

The five cases suggest several general conclusions about BRT costs and benefits:

• Travel time savings dominate the BRT benefits as a result of segregated bus lanes and other design features that minimize waiting and in vehicle times.

• Shifting from informal/unregulated service with smaller vehicles operating in mixed traffic, to newer, larger buses operating at higher speeds results in significant reductions in vehicle operating costs with BRT (Bogota, Mexico City and Istanbul).

• Capital costs and bus operating costs were the most significant portion of project costs in the cities.

For the most part, the largest proportion of users from the case study BRT systems is in the lower- and middle-income groups. The lowest and the highest income groups are not well represented among the BRT passengers, a fact which influences how the project benefits are distributed across society. The majority of the BRT costs in the cases are paid with public revenue derived from taxes.

4. MERITS

BRTS provide good quality mass public transport system which is economical, environment friendly, easily accessible and rapid. Beyond singular performance indicators, high-quality bus rapid transit systems can impact the quality of life, productivity, health, and safety of people living in cities. These impacts have been explored in varying depth in the existing research as travel time benefits, environmental impacts, and public health and safety benefits.

- Impacts of BRTS are as follow:
- reduces travel time because of segregated lanes
- prepaid boarding at stations
- high-capacity buses
- minimize passenger waiting time
- positive environmental impacts

Impact	How does BRT achieve the benefit?
Travel time savings	• Segregated busways separate BRT buses from mixed traffic; • Pre-paid level boarding and high-capacity buses speed passenger boarding; • Traffic signal management and high-frequency bus service minimize waiting times

GHG and local air pollutant emissions reductions	• Reduce VKT by shifting passengers to highcapacity BRT buses • Replace/scrap older, more polluting traditional vehicles • Introduce newer technology BRT buses • Better driver training leads to improved driving cycles which have lower fuel consumption and emissions
Road safety improvements – reductions in fatalities and crashes	• Improve pedestrian crossings • Reduce VKT by shifting passengers to high capacity BRT buses • Reduces interaction with other vehicles by segregating buses from mixed traffic • BRT can change drivers' behaviors by reducing on-the-road competition and improving training
Reduced exposure to air pollutant	• Cleaner vehicle technologies and fuels lower concentration of ambient air pollution citywide or inside the BRT vehicles; • Reduce time passengers are exposed to air pollution at stations or inside the bus by reducing travel times.
Increased physical activity	• Spacing of BRT stations tend to require longer walking distances than all other motorized modes with the exception of Metro • Higher operation speeds increases passengers' willingness to walk to stations

5. DEMERITS

.BRTS public transport system has some demerits. It is not feasible for every city and each area of the city. It works only on major corridors of the city. Some demerits are as following.

- It is slower than other mass transit system(Metro, Light Rail Transit (LRT) and Mono Rail)
- Decreases the size of private vehicle lanes.
- Works in major urban cities with high population.
- It need separate infrastructure which needs initial investment. All municipalities don't have that much financial stability to install such kind of systems.
- Old urban areas are not able to take benefits of these systems.
- There is a lack of people using public Transport systems.

6. CONCLUSIONS AND FUTURE REFERENCES:

The paper reviewed the vehicular growth and Modal split in India. The number of vehicles per 1,000 populations is still low at 117. However, continued high economic growth will increase vehicle density in India in coming years. There is a lack of people using public Transport systems. So there a need to develop new sophisticated systems to change the trend from people using private vehicles to people using public Transport systems. Among different Transit Systems it came out that Bus Rapid Transit System is better option than other systems. The system was reviewed on different qualitative parameters. This study also discussed about the design and operational features of the system. After the study it came out that the system suffered from problems related to Design issues, Bus operations, and Infrastructural Requirements. No proper footpaths are provided along the corridors and no Public convenience is provided at the bus stops in some case studies this is what makes the system unsatisfactory for commuters as they are not very comfortable while travelling. The system was studied based on

qualitative parameters and learning about the problems presently can act as guidelines for future systems to be built. We are moving towards building smart cities in India. Smart mobility is one of the major parts of smart city. So the first step in this direction should be that existing systems that are being developed should be built so that they can compete with already existing world class systems and also they should be equipped with latest technology. A lot of work can be done to study the BRT systems by taking those studies of different Cities we learn important aspests of this system. Studies based on quantitative parameters can be done like change in ridership, satisfaction of people with system etc. This study will actually reflect of how the ridership pattern has shifted and also give results about the customer satisfaction. This will be helpful in developing further strategies to enhance the working, quality and comfort of system. The implications of BRTS system can be studied by conducting surveys. This will help in learning how the system has changed the life of people in the city. More cities can be expected to implement BRT systems in the future. There will be a growing number of fully integrated systems, and even more applications of selected elements. These efforts will lead to substantial improvements in transit access and mobility.

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Calculation Of Economy-Wide Material Flow Indicators Based On Monetary And Physical Supply And Use Tables

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ABSTRACT

The overall environmental pressure and impact caused by human societies is to a large extent induced by the consumption of energy and resources [1]. In order to measure resource and energy flows and to mitigate the related problems, material flow analysis has been developed. The economy-wide material flow analysis and indicators treats the economy as a black-box monitoring overall input and output flows only [2]. In order to increase analytical potential of this tool, it is advisable to construct a physical supply and use tables (PSUT) which shows input of raw materials and products by industries, inter-industry deliveries of products and a breakdown of output products and waste residues by industries.

The study presented on this poster shows first ever physical supply and use tables (PSUT) based on the recently published methodological standard for System of Environmental-Economic Accounting (SEEA) [3]. The tables were compiled for the Czech Republic for 2014. The major shortcoming of the PSUT is that not all needed data were readily available in physical units and required estimations based on proxies. Some parts of the tables can therefore be burdened by quite large uncertainties.

In order to address price inhomogeneity of sectoral prices for commodity outputs, imports and exports which is typical for monetary supply and use tables (MSUT), the PSUT and also MSUT were further used for calculation of selected economy-wide material flow indicators: raw material equivalents of imports, raw material equivalents of exports, raw material input (RMI) and raw material consumption (RMC). Comparison of results showed that the total indicators based on MSUT and PSUT do not differ that much: the largest difference of 5% was recorded for raw material equivalents of exports while RMC, for instance, remained nearly the same. We still argue that the use of PSUT for calculation of raw material equivalents makes sense, as changes in total volume of the indicators were accompanied with changes in their material structure. This can have significant consequences for assessment of environmental impacts related to material consumption, as environmental impacts are very material specific.

KEYWORDS: System of environmental-economic accounting (SEEA), physical supply and use tables (PSUT), raw material equivalents (RME), Czech Republic

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Comparative Sustainability Window analysis of eight ASEAN countries: Integrated analyses of different dimensions of weak and strong sustainability trends

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Abstract:

The Sustainability Window -analysis is a method to evaluate the drivers and driven variables of sustainability. Sustainability Window is an analysis tool for assessing the sustainability of development simultaneously in all of its three pillars: environmental, economic, and social. The SW analysis method provides information of the maximum and minimum economic development that is required to maintain the direction of social and environmental development towards more sustainable targets.

With the Sustainability Window method, it is possible to easily analyse the sustainability using different indicators and different time periods making comparative analyses easy. The new method makes it also possible to analyse the dynamics of the sustainability and the changes over time in the width of the window. This study provides a comparative Sustainability Window analysis of the eight ASEAN countries. Thus, the study covers eight ASEAN countries in the time frame of 2010-2016 except Singapore and Brunei. The data of the study is the database of the Sustainable Society Index (SSI) database, which provides comprehensive data set for key dimensions of sustainability.

This study reveals key challenges and successful developments of sustainable development in eight ASEAN -countries. The study reports all key results in the terms of strong and weak sustainability. The results can be used in the formulation of strategic sustainability policies in the ASEAN country group. Probably the ASEAN countries can learn more from their experiences in the formulation of sustainability policies. This study can be seen as a part of such mutual learning process among the ASEAN countries.

Key words: the ASEAN region, Sustainable development, Sustainability Window, Economic growth, population, environment policy, social policy, sustainability transitions, green transition path, trend analysis

1. Introduction

In the field of sustainability science, sustainable development can be defined in several different ways, but normally the term refers to the definition given by the Brundtland Commission in the publication Our Common Future (1987): “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

The measurement of sustainable development is however a complex problem and several different methods have been developed for it. This article uses a novel tool for sustainability analysis developed by the research team of Finland Futures Research Centre. This new Sustainability Window (SuWi) tool combines all the three dimensions of sustainable development (social, environmental and economic) in a single coherent analysis framework.

In this article we present the SuWi tool and provide results of a comparative analysis of ASEAN countries.

2. Data and methodology

The Sustainability Window approach can be used as a tool for transdisciplinary sustainability analysis because it provides simultaneous assessment of different dimensions of sustainability in one method. SuWi analysis makes *key transition paths visible for decision-makers and stakeholders* providing a multifaceted perspective for planning (see Komiyama & Takeuchi 2006, Kajikawa 2008, Brandt et al 2013). The analyses can be utilised for governance purposes for transition management (see. Loorbach 2002, 2007, Kemp & Parto 2005). With the Sustainability Window method both transition scenarios and realistic backcasting scenarios can be constructed, because the transition paths and associated backcasting targets can be identified (see Sondeijker 2006). Reflective evaluations of sustainable development can be developed by Sustainability Window approach (see Voss et al 2006, Quental, Lourenço & da Silva 2011).

3. Theoretical approach

Sustainability Window analysis is based on the one hand on the idea that certain economic development is need in order to guarantee the sustainability of the social development. This can mean for instance that the level of education does not deteriorate, the access to health care does not weaken, the nutrition level of the population does not get worse, etc. In the SuWi analysis the social development sets the lower limit of sustainable economic development – certain economic development is needed in order not to deteriorate the social wellbeing.

On the other hand it is assumed that the economic development may cause environmental deterioration such as increased use of energy and increased emissions of CO_2, increased use of natural resources, etc. These environmental considerations set the upper limit for economic growth – the state of environment should not get worse. The lower limit, set by the social development and social wellbeing, and the upper limit, set by the environmental considerations, define the boundaries for sustainable economic development – the Sustainability Window.

The impact of economic development on social wellbeing and environmental wellbeing does not, however, stay constant over time but depends on several factors such as technology, policy programmes, priorities in spending and investments etc. The SuWi approach takes these changes into account and defines the lower and higher limit of economic development

accordingly. The SuWi analysis provides a dynamic view of sustainable development taking into account the time-variant nature of all development.

A simple illustration of the SuWi analysis is provided in Figure 1. The indicators used for the analysis are Healthy life years as the social indicator, Greenhouse Gas emission intensity (GHG/GDP) as the environmental indicator and GDP as the economic indicator. The indexed data in the base year of analysis, 2006, have values 1 (point A in the Fig) and the development of the social and environmental indicators (on y-axis) are plotted against GDP (on the x-axis) and shown in Fig. 1.

Healthy life years increase from the point A to point B until 2014. In 2006 the line r1 (going via A) describes the 'Healthy life year productivity of GDP', while in 2014 the line r2 (going via B) describe the reduced productivity. With this productivity (determined by r2) the GDP should reach the level indicated by point D in order not to reduce the Healthy life years. This indicates the minimum economic growth level (GDP_{min}) to reach sustainable social development with the productivity determined by r2, when we use the chosen indicators. GDP_{min} determines the lower boundary of the Sustainability Window.

The Greenhouse gas emission intensity (GHG/GDP) decreases from the base year level (point A) to the level determined by point C in the year 2014. This determines the GHG intensity productivity of GDP indicated by line r3 in the figure. This productivity line r3 determines the maximum economic growth, point E, in order not to increase the environmental impact. Thus, point E determines the GDP_{max} or the upper boundary for Sustainability Window in the environmental dimension. The SuWi for this example is determined by GDP_{min} and GDP_{max} as shown in the Figure 1. In this example the real GDP growth (GDP_{real}) is within the SuWi.

This SuWi example indicates the Weak Sustainability Window because the indicator for the environmental dimension refers to the intensity value, not the absolute value of the environmental dimension. More discussion of the weak and strong sustainability window can be seen in Neumayer 1999, Kaivo-oja et al. 2001, Vehmas et al. 2007, Kaivo-oja et al. 2014 and Luukkanen et al. 2015, 2018.

If the GDP_{min} is larger than GDP_{max} the SuWi does not exist. In this type of case the environmental sustainability restricts the economic development so much that the social sustainability cannot be reached or, put in another way, the social sustainability requires so large economic growth that the environmental sustainability cannot be reached. The existence of both the Strong and the Weak SuWi analyses have been carried out for the ASEAN countries in this article. In addition, we have analysed whether the real GDP growth is within the SuWi.

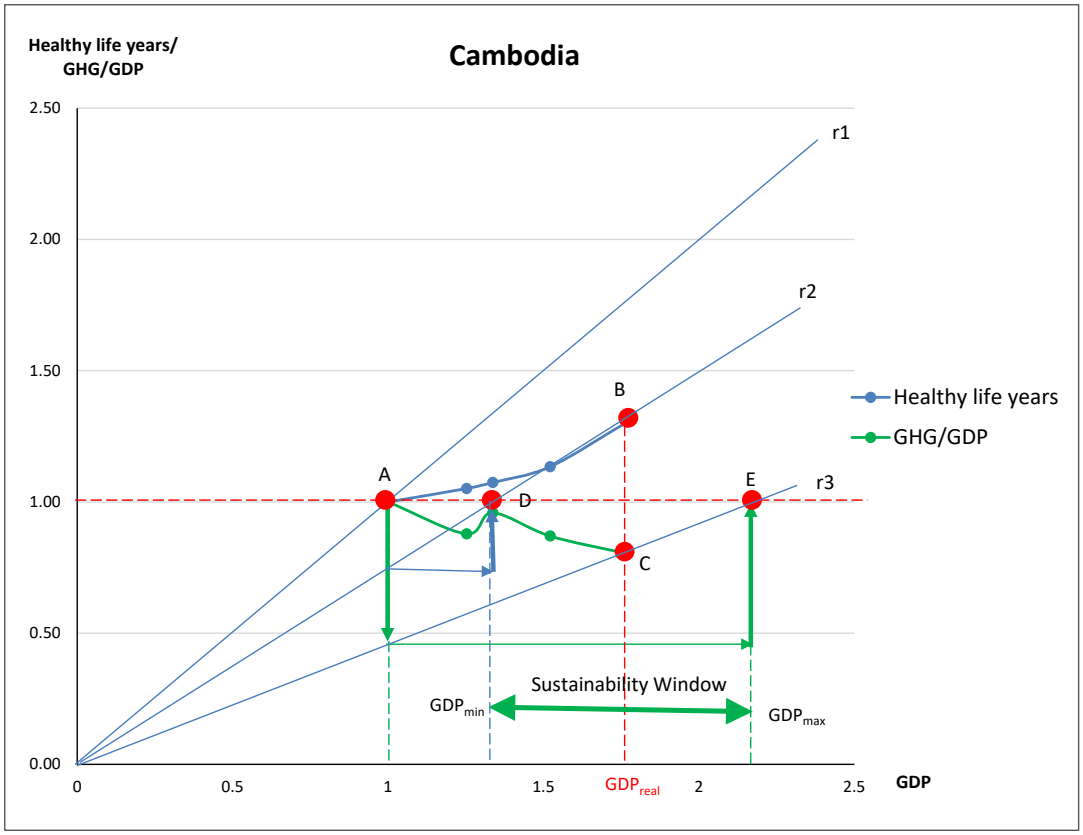


Figure 1. Sustainability Window analysis for Cambodia using Healthy life years as a social indicator, Greenhouse gas emissions intensity (GHG/GDP) as environmental indicator and GDP as economic indicator. The base year of analysis is 2006 and the data is shown for two year intervals up to 2014.

Figure 2 shows and example of SuWi analysis for Cambodia using both Strong and Weak Sustainability. In this case the real GDP is within the Weak SuWi but not in the Strong SuWi.

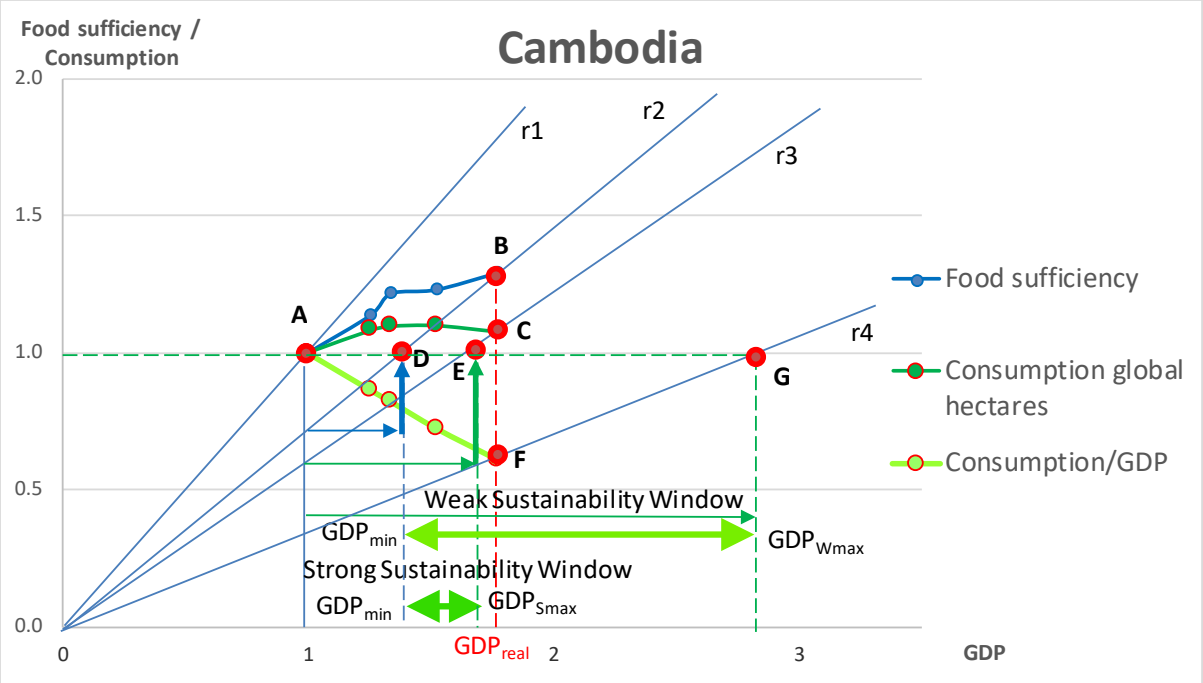


Figure 2. Weak and Strong Sustainability Window for Cambodia using 'Food sufficiency' as social indicator and 'Consumption of global hectares' as environmental indicator for Strong SuWi and 'Consumption of global hectares'/GDP as environmental indicator for Weak SuWi, and GDP as economic indicator. The base year is 2006 and final year 2014.

The dynamic changes in the Sustainability Window for different years can be analysed using the developed methodology. Figure 3 shows an example of the analysis for Laos using Healthy life years as social indicator and GHG intensity as the environmental indicator (weak sustainability). In this case the real GDP growth has been within the SuWi during the period of analysis 2006-2014. During the first years the real GDP growth has been just high enough to fulfil the social sustainability criterion, but 2012 and 2014 the social sustainability has been secured with larger margin.

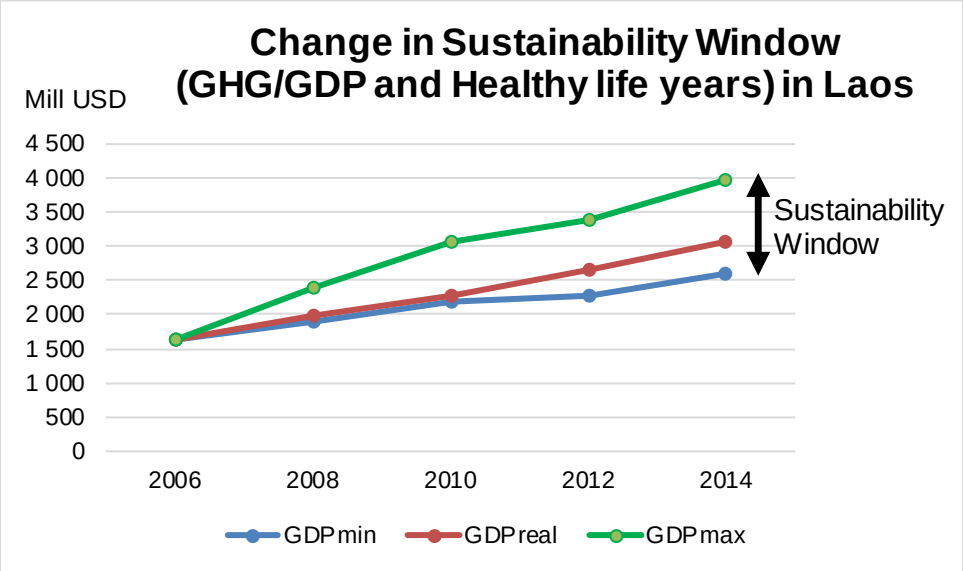


Figure 3. The dynamic changes in Sustainability Window for Laos for the years 2006-2014 using 'healthy life years' as social indicator and 'GHG intensity' (GHG/GDP) as the environmental indicator.

4. Data sources and use

The main data source for this analysis is the Sustainable Society Index (SSI) of van de Kerk & Manuel (2014). The SSI integrates indicators of Human Wellbeing, Environmental Wellbeing and the Economic Wellbeing based on the definition of sustainable development elaborated by the Brundtland report. The period of analysis is from 2006 to 2016, the period for which the SSI data is available.

In addition, we have also used the World Bank database for the indicator of 'Social inclusion', the CPIA database (Country Policy and Institutional Analysis) in order to explicitly include this green growth dimension in the analysis (World Bank 2016a). World Bank data is also used for the 'Forest rent' indicator (World Bank 2016b). The social inclusion indicator is, however not available for all ASEAN countries. It was used in the analysis only for Cambodia, Laos and the Philippines.

The SSI database does not have data for Brunei and Singapore and that is why they are omitted in this analysis. Other eight ASEAN countries are included with full datasets.

For the SuWi analyses we have indexed the indicators from SSI database and the World Bank database to have the value 1 for the base year 2006 of the analysis.

5. Dimensions of sustainability and used indicators

The economic dimension was measured in the analysis using GDP as the indicator. For environmental dimension several indicators were used in order to have a wider perspective of the sustainability of the development. For the environmental dimension both strong and weak sustainability was analysed. The use of weak sustainability analysis is based on the idea that the strong criterion e.g. related to GHG emissions may be too demanding for LDC countries with very low level of emissions per capita. A requirement that the CO_2 emissions e.g. in Laos could not increase in the future could be seen too restricting from the point of view of global equality.

For the social sustainability we have used eight indicators to have a wide perspective in this dimension and to be able to include the variety of development paths.

Table 1 shows the indicators used the analysis.

Table 1. Indicators used in the SuWi analysis for ASEAN countries.

Economic	Environmental	Social
GDP	CO_2 emissions	Sufficient food
	Consumption (Global hectares)	Healthy life years
	Energy use	Social inclusion
	Sanitation	Sufficient drink

		Gender equity
		Income distribution
		Good governance
		Education

6. Comparative analyses

For the comparative analysis of the eight ASEAN countries we have used all the possible combinations of the indicators of Table 1 for all the years where the data is available (2006 as base year, and 2008, 2010, 2012, 2014 and 2016 for the analysis). There are 32 different combinations of the used indicators and when they are carried for eight ASEAN countries we get 256 results for five different years. Since the 'Social inclusion' data was available only for three countries the number of results is reduced.

We have collected the results of the comparative analysis in different tables. We have analysed whether there exists a Strong SuWi and a Weak Suwi and whether the real GDP is within the Strong Suwi or within the Weak Suwi. The results of this comparison are illustrated in Appendix using colour codes for different ASEAN countries.

We have also compared the dynamics and the trends of the Sustainability Window for different countries. Some illustrative figures of the sustainability trends are presented in the next section.

In addition, we have calculated an aggregative indicator for the sustainability for the different countries and the different combinations of the indicators. The aggregative indicator is the sum of the existence (0 or 1) of strong and weak SuWi in different years and the whether the real GDP is (0 or 1) in the strong of weak SuWi in different years. The maximum of the aggregative indicator is 20 (5 years x 4 variables). These results are presented in a graphical form in the next section, too.

7. Results

Following figures illustrate the trends of Sustainability Window for different ASEAN countries as an example of 'Sufficient food' and 'CO_2' analysis. In the figures the minimum level of GDP (social dimension, Min), maximum level of GDP (environmental dimension, Max), maximum level of GDP in weak sustainability sense (Maxw), and real GDP (GDPreal) levels are presented for the years 2006-2016.

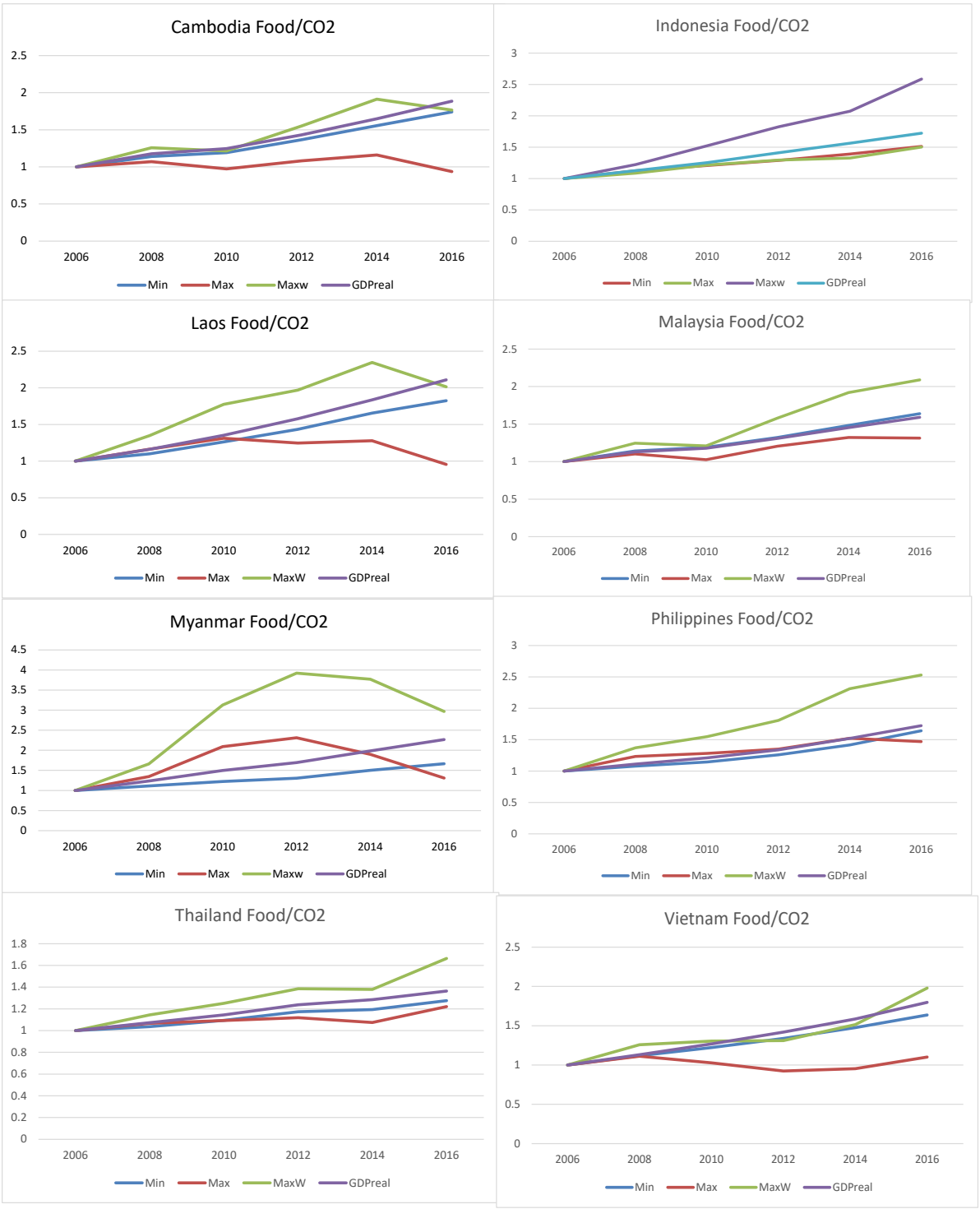


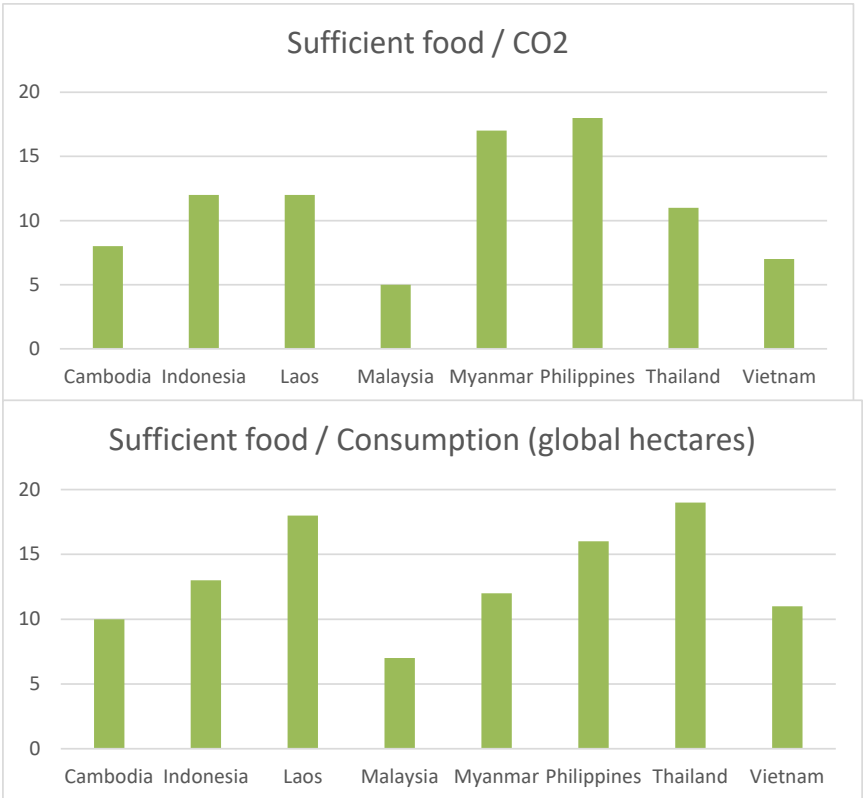
Figure 4. Trends of the Sustainability Window for the different ASEAN countries using 'Sufficien food' as the social indicator 'CO_2 emissions' as the environmental indicator (strong sustainability), 'CO_2 emission intensity' (weak sustainability) environmental indicator and GDP as the economic indicator.

It can be seen in the trend figures (4) that the strong sustainability in regard to the CO_2 emissions is problematic for the ASEAN countries. Only Myanmar and Philippines have existing strong SuWi up to 2014 and the real GDP is within this SuWi.

For all countries exept Indonesia the weak SuWi exists for the whole analysis period. The real GDP growth is however outside the weak SuWi in Cambodia, Laos and Philippines in 2016 and in Vietnam for 2010-2014.

Next comparison of the aggregated sustainability indicator for different combinations of used indicators are presented.

Food sufficiency and sustainability comparison of ASEAN countries is reported in Fig. 5.



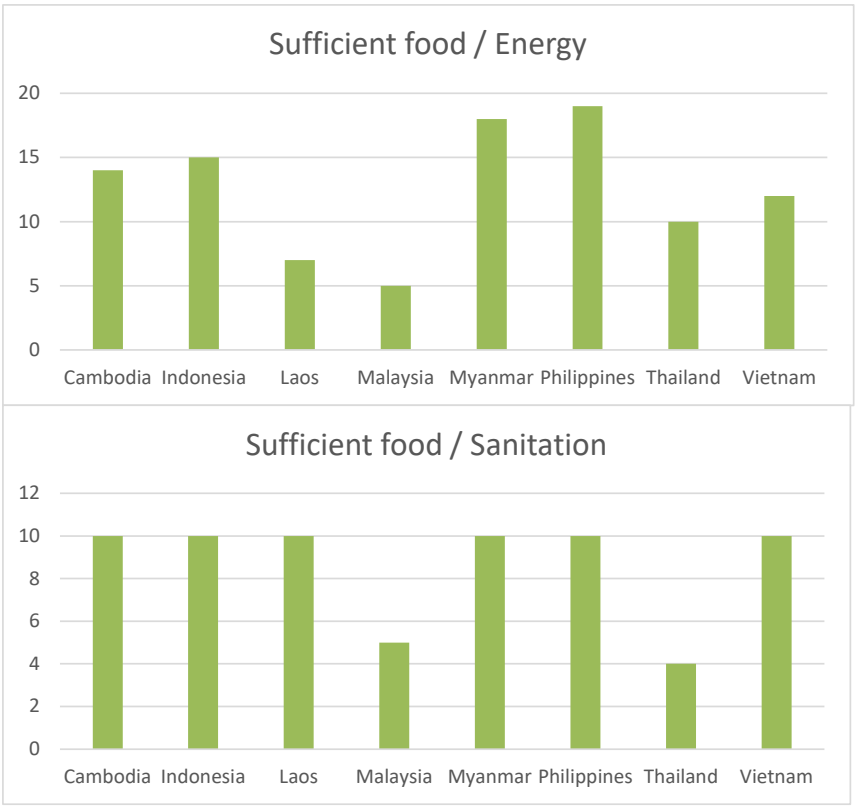


Figure 5. Comparison of aggregated sustainability SuWi indicators using 'Food sufficiency' as social indicator for the ASEAN countries.

The aggregated sustainability SuWi indicators using 'Food sufficiency' as social indicator shows that Malaysia and Vietnam have the poorest performance when this indicators is used against the different environmental indicators. Myanmar, Philippines and Laos show the best performance in this indicator.

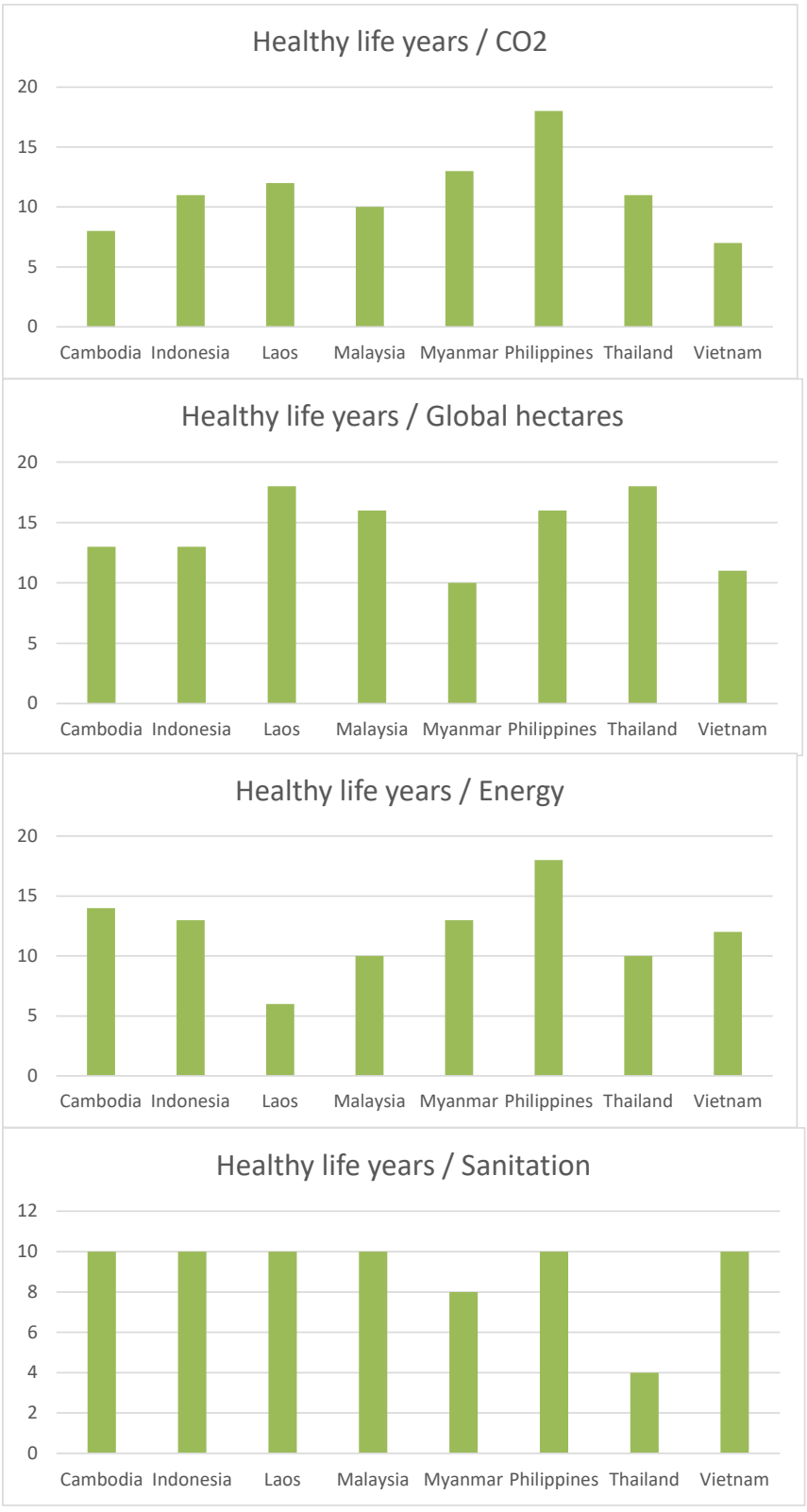


Figure 6. Aggregated SuWi indicator using 'Healthy life years' as the social indicator for sustainability comparison of ASEAN countries.

The Philippines seem to show the best performance when 'Healthy life years' is used as the social indicator and Vietnam has the lowest score in this dimension.

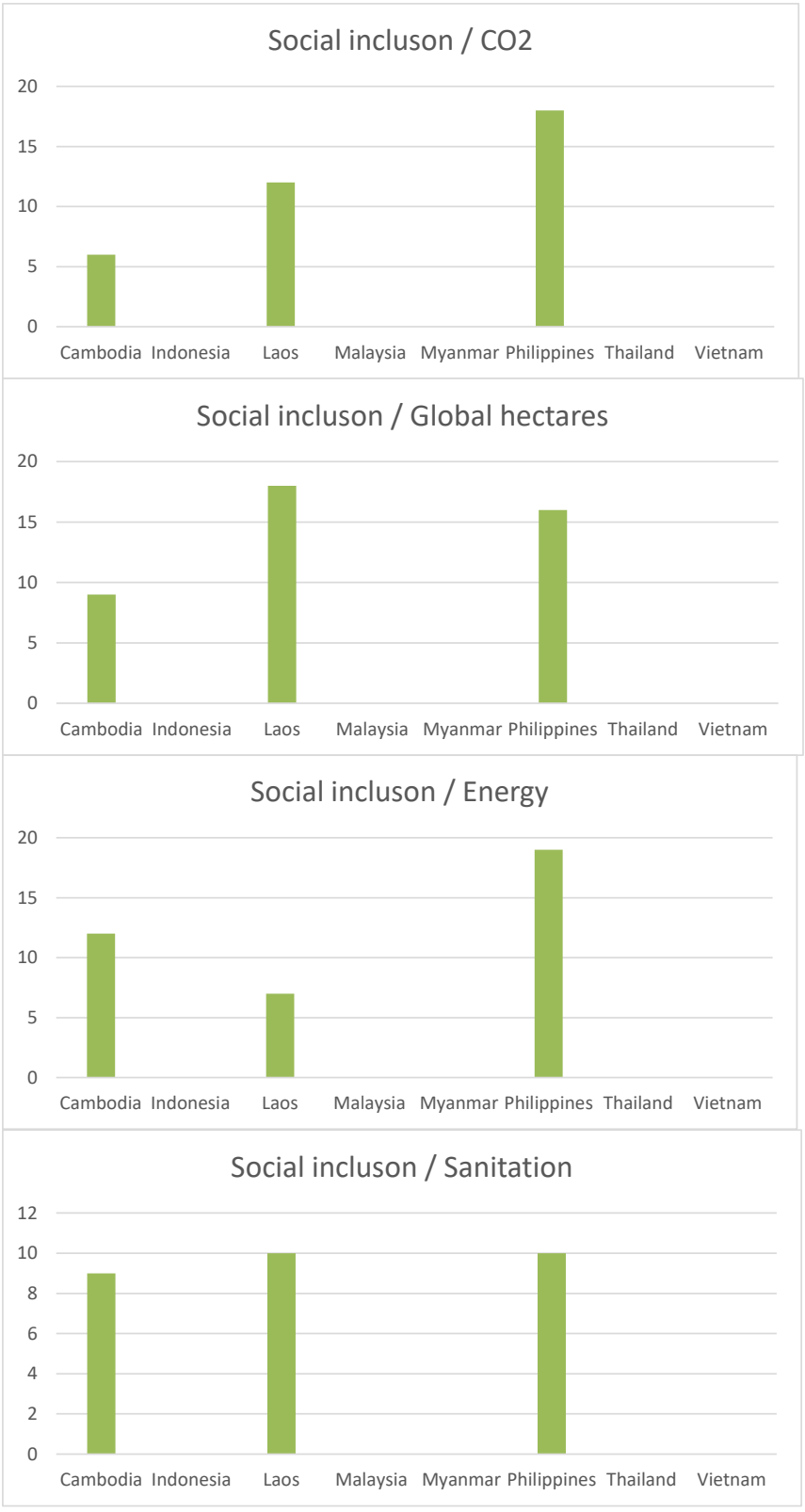


Figure 7. Social inclusion and sustainability comparison of ASEAN countries (data available only for Cambodia, Laos and the Philippines).

For the social inclusion data was only available for Cambodia, Laos and the Philippines.

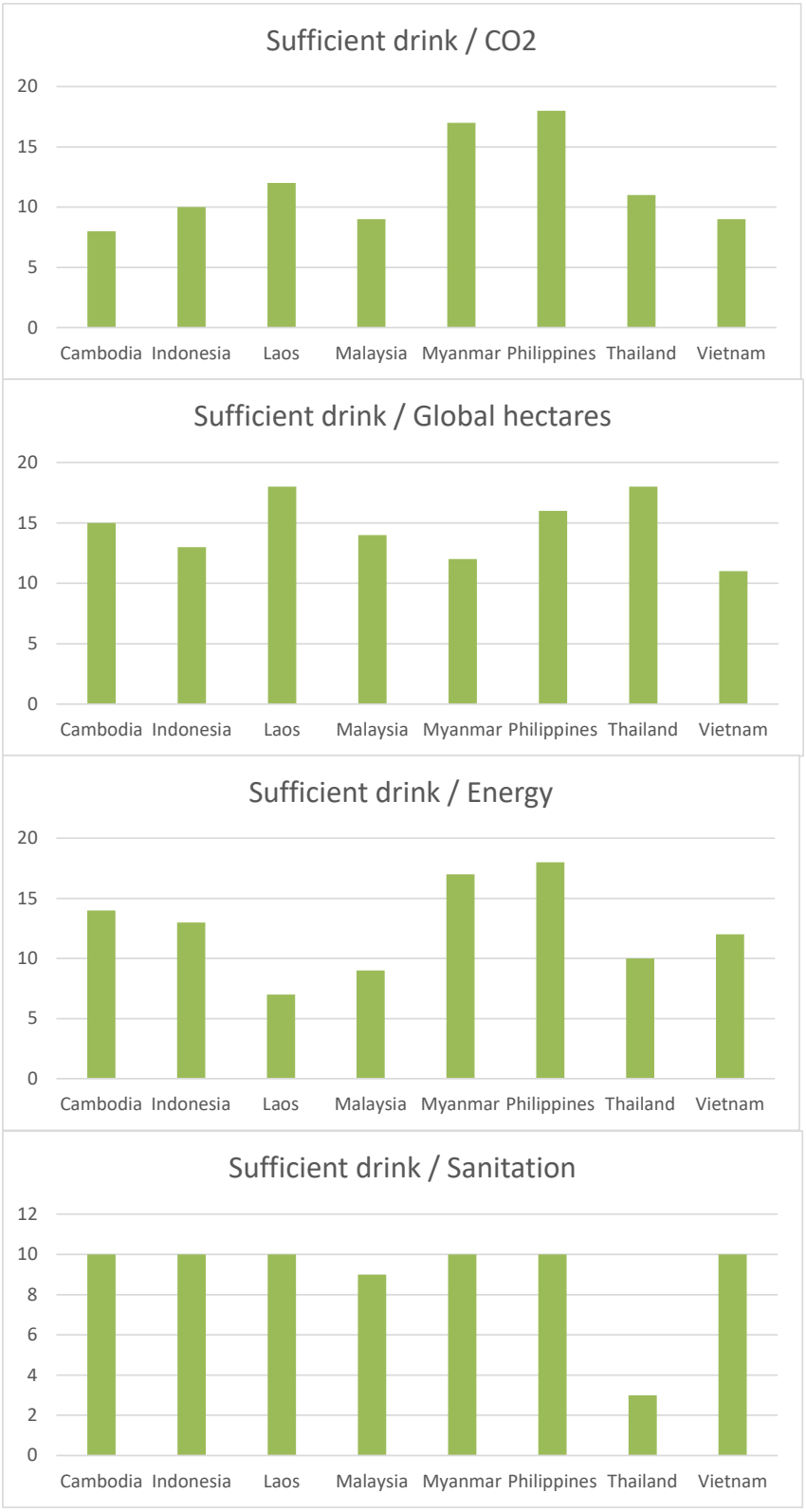


Figure 8. Sufficient drinking water and sustainability comparison of ASEAN countries.

For the sufficient drinking water the Philippines and Myanmar show the best performance while Laos, Malaysia and Vietnam have the lowest scores.

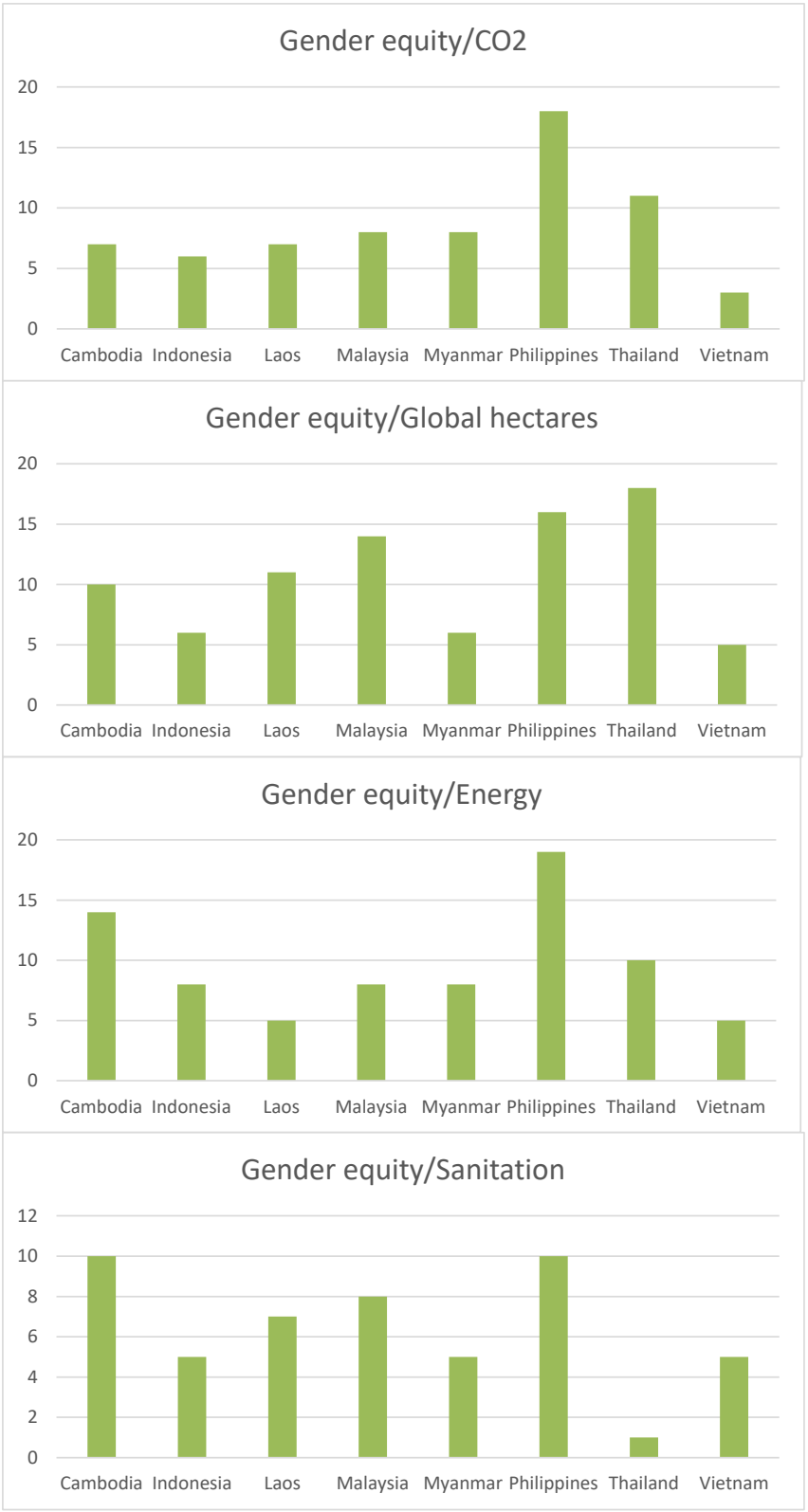
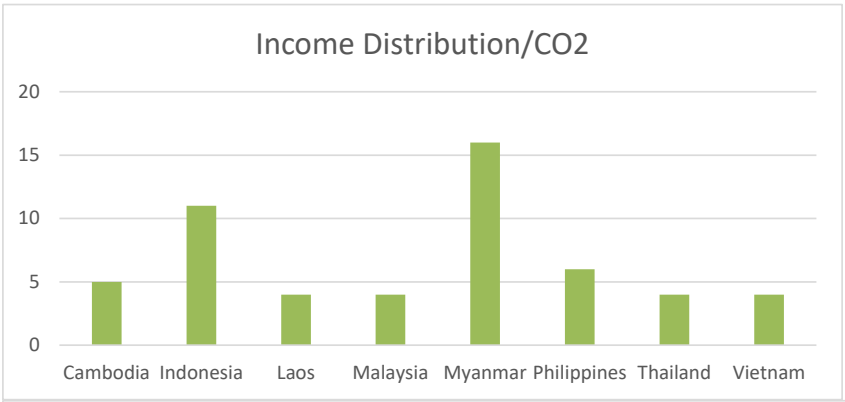
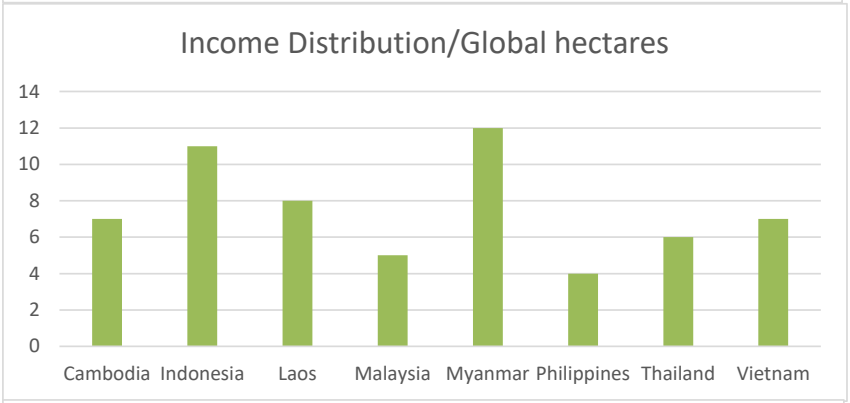
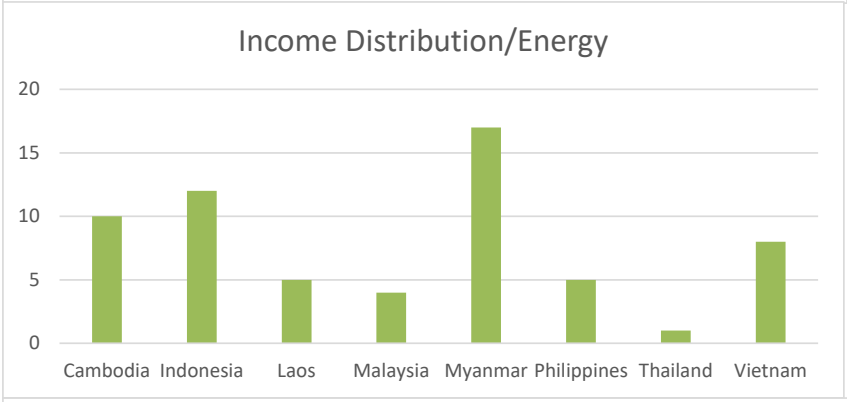


Figure 9. Gender equity and sustainability comparison of ASEAN countries.

When we compare the gender equality in the different ASEAN countries the Philippines show the best performance. In this respect Vietnam, Indonesia and Myanmar seem to indicate poorest performance.







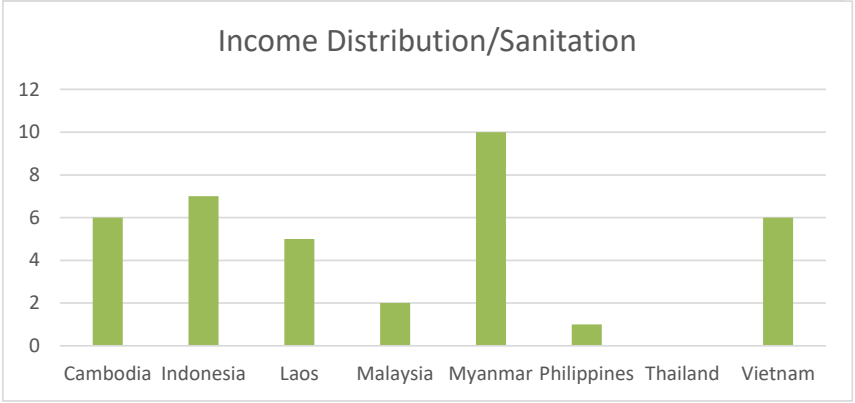


Figure 10. Income distribution and sustainability comparison of ASEAN countries.

In regard the income distribution Myanmar and Indonesia show the best performance among ASEAN countries. Thailand and Malaysia show the lowest scores in this dimension.

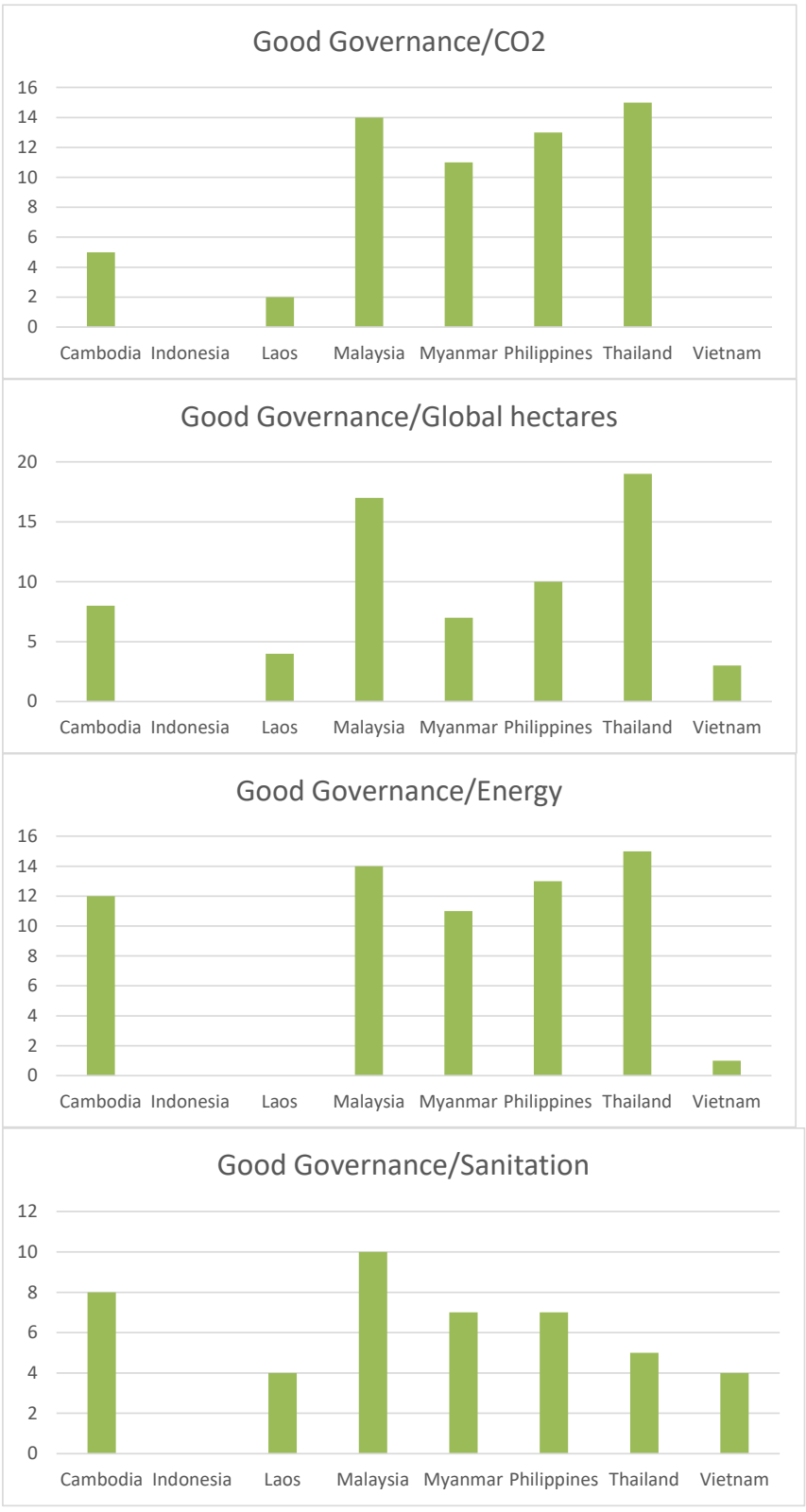
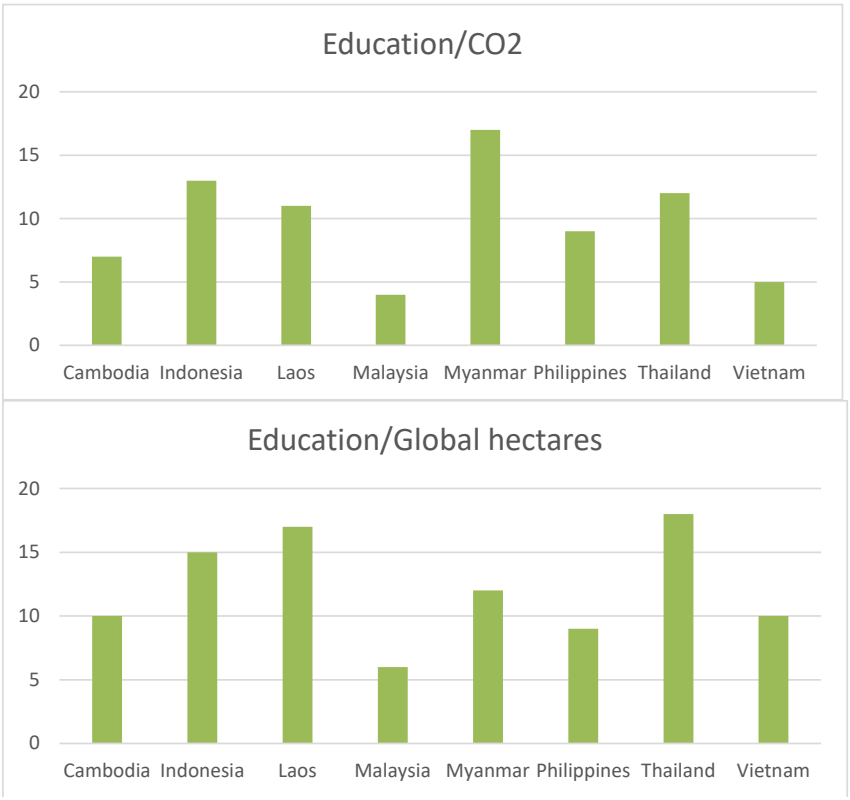


Figure 11. Good governance and sustainability comparison of ASEAN countries.

When we look at the Good governance dimension Malaysia and Thailand show the best results. Indonesia seems to have the poorest performance in this respect and Vietnam and Laos also score quite low figures.



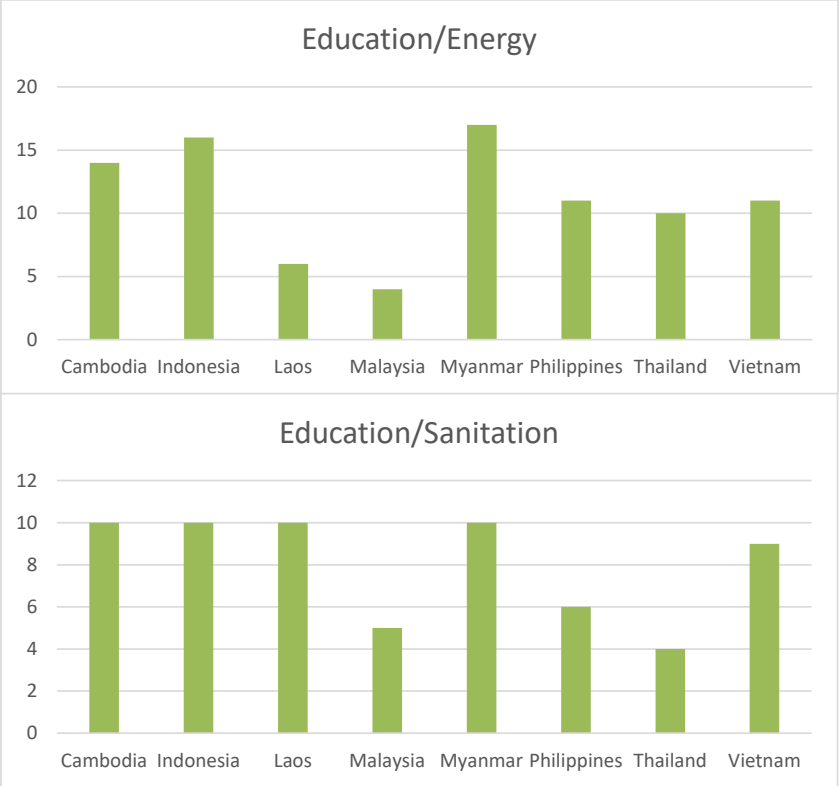


Figure 12. Education and sustainability comparison of ASEAN countries.

When we compare the performance of ASEAN countries in relation to Education and the SuWi aggregated indicators we find that Myanmar and Indonesia show the best performance while Malaysia shows the lowest scores.

Total Sustainability Score, in relation to the used indicators, has been calculated as a sum of the individual indicator pairs and is illustrated in the following Figure 13 (not including 'Social inclusion' for which data was not available for all countries).

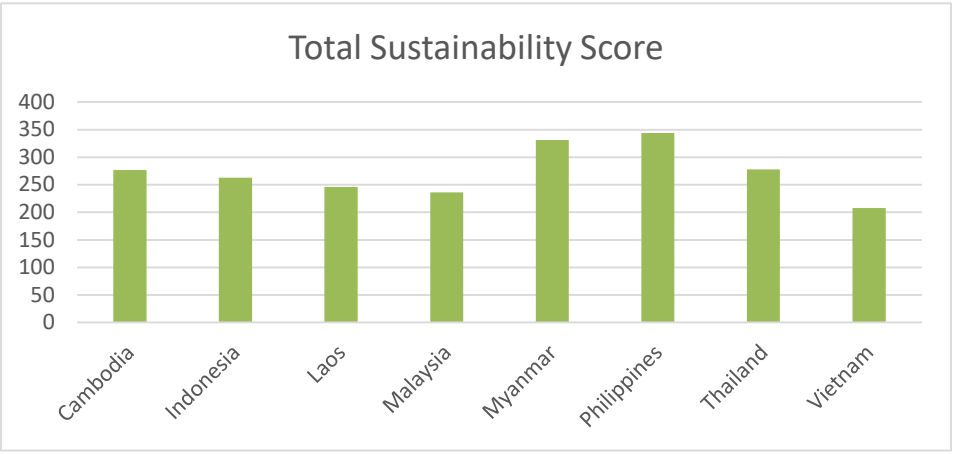


Figure 13. The Total Sustainability Score for the ASEAN countries showing the aggregated indicator for the measured indicator pairs.

It seems that the Philippines and Myanmar have the highest Total Sustainability Score when we use the chosen indicators for Sustainability Window analysis. The performance of the countries in the different areas, however, vary considerably and each country has several areas where further development emphasis is needed.

8. Conclusions

Sustainability Window analysis provides an easy to use tool for comparative analysis of different countries integrating the different dimensions of sustainability in the same analysis framework. The results of the SuWi analysis are easy to interpret and it is easy to make comparisons based on the analyses.

The SuWi method provides an interesting tool for dynamic analysis of the development. It illustrates the trends and their changes and can be used for sustainability policy planning

The tool does not provide direct recommendations for policy making, but shows the areas of development, where problems and sustainability challenges exist. This makes it a useful tool for pre-planning analysis of sustainability transitions.

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Appendix 1. Explorative sustainability analyses for eight ASEAN countries.

Table A1. Assessment of the a) Existence of Sustainability Window in Strong and Weak definition and b) whether the real GDP growth is located within the Strong or Weak Sustainability Window for different ASEAN countries. The economic dimension of development is measured with GDP and social dimension of development is measured with 'Food sufficiency', 'Healthy life years', 'Social inclusion', 'Sufficient drink', 'Gender equity', 'Income distribution', 'Good governance' and 'Education' and the environmental dimension is measured with with (i) CO_2 emissions, (ii) Consumption, measured in global hectares, (iii) availability of improved sanitation and (iv) energy use. Base year of assessment is 2006.

Colour code: 0 = red = does not exist; 1 = green = does exist

Sufficient food

		Sufficient food / CO2				Sufficient food / Consumption (global hectares)				Sufficient food / Sanitation		Sufficient food / Energy			
		Existence of SuWi		Real GDP in SuWi		Existence of SuWi		Real GDP in SuWi		Existence	Real in SuWi	Existence of SuWi		Real GDP in SuWi	
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Cambodia	2008	0	1	0	1	0	1	0	1	1	1	1	1	1	1
Cambodia	2010	0	1	0	0	0	1	0	1	1	1	1	1	1	1
Cambodia	2012	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Cambodia	2014	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Cambodia	2016	0	1	0	0	0	1	0	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Indonesia	2008	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Indonesia	2010	1	1	0	1	0	1	0	1	1	1	1	1	1	1
Indonesia	2012	1	1	0	1	1	1	0	1	1	1	1	1	0	1
Indonesia	2014	0	1	0	1	1	1	0	1	1	1	1	1	0	1
Indonesia	2016	0	1	0	1	1	1	0	1	1	1	1	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Laos	2008	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Laos	2010	1	1	0	1	1	1	1	1	1	1	0	1	0	0
Laos	2012	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Laos	2014	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Laos	2016	0	1	0	0	1	1	1	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Malaysia	2008	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Malaysia	2010	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Malaysia	2012	0	1	0	0	1	1	0	0	1	0	0	1	0	0
Malaysia	2014	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Malaysia	2016	0	1	0	0	1	1	0	0	1	0	0	1	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Myanmar	2008	1	1	1	1	0	1	0	1	1	1	1	1	0	1
Myanmar	2010	1	1	1	1	0	1	0	1	1	1	1	1	1	1
Myanmar	2012	1	1	1	1	0	1	0	1	1	1	1	1	1	1
Myanmar	2014	1	1	0	1	0	1	0	1	1	1	1	1	1	1
Myanmar	2016	0	1	0	1	1	1	1	1	1	1	1	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Philippines	2008	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Philippines	2010	1	1	1	1	0	1	0	1	1	1	1	1	1	1
Philippines	2012	1	1	1	1	0	1	0	1	1	1	1	1	1	1
Philippines	2014	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Philippines	2016	0	1	0	1	1	1	1	1	1	1	1	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Thailand	2008	1	1	0	1	1	1	0	1	1	0	0	1	0	1
Thailand	2010	0	1	0	1	1	1	1	1	1	0	0	1	0	1
Thailand	2012	0	1	0	1	1	1	1	1	1	0	0	1	0	1
Thailand	2014	0	1	0	1	1	1	1	1	1	0	0	1	0	1
Thailand	2016	0	1	0	1	1	1	1	1	0	0	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Vietnam	2008	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Vietnam	2010	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Vietnam	2012	0	0	0	0	0	1	0	1	1	1	0	1	0	1
Vietnam	2014	0	1	0	0	0	1	0	1	1	1	0	1	0	1
Vietnam	2016	0	1	0	1	1	1	0	1	1	1	1	1	1	1
		Sufficient food / CO2				Sufficient food / Consumption (global hectares)				Sufficient food / Sanitation		Sufficient food / Energy			

Healthy life years

		Healthy life years / CO2				Healthy life years / Global hectares				Healthy life years / Sanitation		Healthy life years / Energy			
		Existence of SuWi		Real GDP in SuWi		Existence of SuWi		Real GDP in SuWi		Existence	Real in SuWi	Existence of SuWi		Real GDP in SuWi	
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Cambodia	2008	0	1	0	1	0	1	0	1	1	1	1	1	1	1
Cambodia	2010	0	1	0	0	0	1	0	1	1	1	1	1	1	1
Cambodia	2012	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Cambodia	2014	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Cambodia	2016	0	1	0	0	1	1	0	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Indonesia	2008	0	1	0	1	1	1	0	1	1	1	1	1	0	1
Indonesia	2010	1	1	0	1	0	1	0	1	1	1	1	1	1	1
Indonesia	2012	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Indonesia	2014	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Indonesia	2016	0	1	0	1	0	1	0	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Laos	2008	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Laos	2010	1	1	0	1	1	1	1	1	1	1	0	0	0	0
Laos	2012	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Laos	2014	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Laos	2016	0	1	0	0	1	1	1	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Malaysia	2008	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Malaysia	2010	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Malaysia	2012	0	1	0	1	1	1	1	1	1	1	0	1	0	1
Malaysia	2014	0	1	0	1	1	1	1	1	1	1	0	1	0	1
Malaysia	2016	0	1	0	1	1	1	1	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Myanmar	2008	1	1	1	1	0	1	0	1	1	1	1	1	0	1
Myanmar	2010	1	1	1	1	0	1	0	1	1	1	1	1	1	1
Myanmar	2012	1	1	0	0	0	1	0	0	1	0	1	1	0	0
Myanmar	2014	0	1	0	0	0	1	0	0	1	0	1	1	0	0
Myanmar	2016	0	1	0	1	1	1	1	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Philippines	2008	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Philippines	2010	1	1	1	1	0	1	0	1	1	1	1	1	1	1
Philippines	2012	1	1	1	1	0	1	0	1	1	1	1	1	1	1
Philippines	2014	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Philippines	2016	0	1	0	1	1	1	1	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Thailand	2008	1	1	0	1	0	1	0	1	1	0	0	1	0	1
Thailand	2010	0	1	0	1	1	1	1	1	0	0	0	1	0	1
Thailand	2012	0	1	0	1	1	1	1	1	1	0	0	1	0	1
Thailand	2014	0	1	0	1	1	1	1	1	1	0	0	1	0	1
Thailand	2016	0	1	0	1	1	1	1	1	1	0	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Vietnam	2008	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Vietnam	2010	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Vietnam	2012	0	0	0	0	0	1	0	1	1	1	0	1	0	1
Vietnam	2014	0	1	0	0	0	1	0	1	1	1	0	1	0	1
Vietnam	2016	0	1	0	1	1	1	0	1	1	1	1	1	1	1
		Healthy life years / CO2				Healthy life years / Global hectares				Healthy life years / Sanitation		Healthy life years / Energy			

Social inclusion

		Social incluson / CO2				Social incluson / Global hectares				Social incluson / Sanitation		Social incluson / Energy			
		istence of SuV		Real GDP in SuWi		istence of SuV		Real GDP in SuWi		Existen	Real in SuWi	istence of SuV		Real GDP in SuWi	
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Cambodia	2008	0	1	0	0	0	1	0	0	1	0	1	1	0	0
Cambodia	2010	0	1	0	0	0	1	0	1	1	1	1	1	1	1
Cambodia	2012	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Cambodia	2014	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Cambodia	2016	0	0	0	0	0	1	0	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Laos	2008	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Laos	2010	1	1	0	1	1	1	1	1	1	1	0	1	0	0
Laos	2012	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Laos	2014	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Laos	2016	0	1	0	0	1	1	1	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Philippines	2008	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Philippines	2010	1	1	1	1	0	1	0	1	1	1	1	1	1	1
Philippines	2012	1	1	1	1	0	1	0	1	1	1	1	1	1	1
Philippines	2014	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Philippines	2016	0	1	0	1	1	1	1	1	1	1	1	1	0	1

Sufficient drink

		Sufficient drink / CO2				Sufficient drink / Global hectares				Sufficient drink / Sanitation		Sufficient drink / Energy			
		Existence of SuWi		Real GDP in SuWi		Existence of SuWi		Real GDP in SuWi		Existence	Real in SuWi	Existence of SuWi		Real GDP in SuWi	
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Cambodia	2008	0	1	0	1	1	1	0	1	1	1	1	1	1	1
Cambodia	2010	0	1	0	0	1	1	0	1	1	1	1	1	1	1
Cambodia	2012	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Cambodia	2014	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Cambodia	2016	0	1	0	0	1	1	0	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Indonesia	2008	0	1	0	1	1	1	0	1	1	1	1	1	0	1
Indonesia	2010	0	1	0	1	0	1	0	1	1	1	1	1	1	1
Indonesia	2012	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Indonesia	2014	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Indonesia	2016	0	1	0	1	0	1	0	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Laos	2008	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Laos	2010	1	1	0	1	1	1	1	1	1	1	0	1	0	0
Laos	2012	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Laos	2014	0	1	0	1	1	1	0	1	1	1	0	1	0	1
Laos	2016	0	1	0	0	1	1	1	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Malaysia	2008	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Malaysia	2010	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Malaysia	2012	0	1	0	1	1	1	1	1	1	1	0	1	0	1
Malaysia	2014	0	1	0	1	1	1	1	1	1	1	0	1	0	1
Malaysia	2016	0	1	0	0	1	1	0	0	1	0	0	1	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Myanmar	2008	1	1	1	1	0	1	0	1	1	1	1	1	0	1
Myanmar	2010	1	1	1	1	0	1	0	1	1	1	1	1	1	1
Myanmar	2012	1	1	1	1	0	1	0	1	1	1	1	1	1	1
Myanmar	2014	1	1	0	1	0	1	0	1	1	1	1	1	1	1
Myanmar	2016	0	1	0	1	1	1	1	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Philippines	2008	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Philippines	2010	1	1	1	1	0	1	0	1	1	1	1	1	1	1
Philippines	2012	1	1	1	1	0	1	0	1	1	1	1	1	1	1
Philippines	2014	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Philippines	2016	0	1	0	1	1	1	1	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Thailand	2008	1	1	0	1	0	1	0	1	1	0	0	1	0	1
Thailand	2010	0	1	0	1	1	1	1	1	1	0	0	1	0	1
Thailand	2012	0	1	0	1	1	1	1	1	1	0	0	1	0	1
Thailand	2014	0	1	0	1	1	1	1	1	0	0	0	1	0	1
Thailand	2016	0	1	0	1	1	1	1	1	0	0	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Vietnam	2008	1	1	0	1	0	1	0	1	1	1	0	1	0	1
Vietnam	2010	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Vietnam	2012	0	1	0	0	0	1	0	1	1	1	0	1	0	1
Vietnam	2014	0	1	0	0	0	1	0	1	1	1	0	1	0	1
Vietnam	2016	0	1	0	1	1	1	0	1	1	1	1	1	1	1
		Sufficient drink / CO2				Sufficient drink / Global hectares				Sufficient drink / Sanitation		Sufficient drink / Energy			

Gender equity

		Gender equity/Global hectares				Gender equity/CO2				Gender equity/Sanitation		Gender equity/Energy			
		Existence of SuWi		Real GDP in SuWi		Existence of SuWi		Real GDP in SuWi		Existence	Real in SuWi	Existence of SuWi		Real GDP in SuWi	
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Cambodia	2008	0	1	0	1	0	1	0	1	1	1	1	1	1	1
Cambodia	2010	0	1	0	1	0	1	0	0	1	1	1	1	1	1
Cambodia	2012	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Cambodia	2014	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Cambodia	2016	0	1	0	1	0	0	0	0	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Indonesia	2008	0	1	0	0	0	1	0	0	0	0	0	1	0	0
Indonesia	2010	0	1	0	1	0	1	0	1	1	1	1	1	1	1
Indonesia	2012	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Indonesia	2014	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Indonesia	2016	0	1	0	0	0	1	0	0	1	0	0	1	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Laos	2008	1	1	0	0	1	1	0	0	1	0	0	0	0	0
Laos	2010	1	1	0	0	0	1	0	0	1	0	0	0	0	0
Laos	2012	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Laos	2014	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Laos	2016	1	1	1	1	0	1	0	0	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Malaysia	2008	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Malaysia	2010	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Malaysia	2012	1	1	1	1	0	1	0	1	1	1	0	1	0	1
Malaysia	2014	1	1	1	1	0	1	0	1	1	1	0	1	0	1
Malaysia	2016	1	1	1	1	0	1	0	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Myanmar	2008	0	1	0	0	1	1	0	0	1	0	0	1	0	0
Myanmar	2010	0	1	0	0	1	1	0	0	1	0	1	1	0	0
Myanmar	2012	0	1	0	0	1	1	0	0	1	0	1	1	0	0
Myanmar	2014	0	1	0	0	0	1	0	0	1	0	1	1	0	0
Myanmar	2016	1	1	0	0	0	1	0	0	1	0	0	1	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Philippines	2008	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Philippines	2010	0	1	0	1	1	1	1	1	1	1	1	1	1	1
Philippines	2012	0	1	0	1	1	1	1	1	1	1	1	1	1	1
Philippines	2014	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Philippines	2016	1	1	1	1	0	1	0	1	1	1	1	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Thailand	2008	0	1	0	1	1	1	0	1	1	0	0	1	0	1
Thailand	2010	1	1	1	1	0	1	0	1	0	0	0	1	0	1
Thailand	2012	1	1	1	1	0	1	0	1	0	0	0	1	0	1
Thailand	2014	1	1	1	1	0	1	0	1	0	0	0	1	0	1
Thailand	2016	1	1	1	1	0	1	0	1	0	0	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Vietnam	2008	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Vietnam	2010	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Vietnam	2012	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Vietnam	2014	0	1	0	0	0	0	0	0	1	0	0	1	0	0
Vietnam	2016	0	1	0	0	0	1	0	0	1	0	1	1	0	0
		Gender equity/Global hectares				Gender equity/CO2				Gender equity/Sanitation		Gender equity/Energy			

Income distribution

		Income Distribution/Global hectares				Income Distribution/CO2				Income Distribution/Sanitation		Income Distribution/Energy			
		istence of SuV		Real GDP in SuWi		istence of SuV		Real GDP in SuWi		Existence	Real in SuWi	istence of SuV		Real GDP in SuWi	
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Cambodia	2008	0	1	0	1	0	1	0	1	1	1	1	1	1	1
Cambodia	2010	1	1	0	1	0	1	0	0	1	1	1	1	1	1
Cambodia	2012	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Cambodia	2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cambodia	2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Indonesia	2008	0	1	0	0	0	1	0	0	0	0	0	1	0	0
Indonesia	2010	1	1	0	1	1	1	0	1	1	1	1	1	1	1
Indonesia	2012	1	1	0	1	1	1	0	1	1	1	1	1	0	1
Indonesia	2014	1	1	0	1	1	1	0	1	1	1	1	1	0	1
Indonesia	2016	0	1	0	0	0	1	0	0	1	0	0	1	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Laos	2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laos	2010	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Laos	2012	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Laos	2014	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Laos	2016	1	1	1	1	0	1	0	0	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Malaysia	2008	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Malaysia	2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Malaysia	2012	0	1	0	0	0	1	0	0	0	0	0	1	0	0
Malaysia	2014	0	1	0	0	0	1	0	0	0	0	0	1	0	0
Malaysia	2016	1	1	0	0	0	1	0	0	1	0	0	1	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Myanmar	2008	0	1	0	1	1	1	1	1	1	1	1	1	0	1
Myanmar	2010	0	1	0	1	1	1	1	1	1	1	1	1	1	1
Myanmar	2012	0	1	0	1	1	1	1	1	1	1	1	1	1	1
Myanmar	2014	0	1	0	1	0	1	0	1	1	1	1	1	1	1
Myanmar	2016	1	1	1	1	0	1	0	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Philippines	2008	0	1	0	0	1	1	0	0	0	0	0	1	0	0
Philippines	2010	0	0	0	0	0	1	0	0	0	0	0	1	0	0
Philippines	2012	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Philippines	2014	0	1	0	0	0	1	0	0	0	0	0	1	0	0
Philippines	2016	0	1	0	0	0	1	0	0	0	0	0	1	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Thailand	2008	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Thailand	2010	1	1	0	0	0	1	0	0	0	0	0	1	0	0
Thailand	2012	0	1	0	0	0	1	0	0	0	0	0	0	0	0
Thailand	2014	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Thailand	2016	1	1	0	0	0	1	0	0	0	0	0	0	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Vietnam	2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vietnam	2010	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Vietnam	2012	0	1	0	0	0	0	0	0	1	0	0	1	0	0
Vietnam	2014	0	1	0	0	0	0	0	0	1	0	0	1	0	0
Vietnam	2016	1	1	0	1	0	1	0	1	1	1	1	1	1	1
		Income Distribution/Global hectares				Income Distribution/CO2				Income Distribution/Sanitation		Income Distribution/Energy			

Good governance

		Good Governance/Global hectares				Good Governance/CO2				Good Governance/Sanitation		Good Governance/Energy			
		Existence of SuWi		Real GDP in SuWi		Existence of SuWi		Real GDP in SuWi		Existence	Real in SuWi	Existence of SuWi		Real GDP in SuWi	
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Cambodia	2008	0	1	0	1	0	1	0	1	1	1	1	1	1	1
Cambodia	2010	0	1	0	1	0	0	0	0	1	1	1	1	1	1
Cambodia	2012	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Cambodia	2014	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Cambodia	2016	0	1	0	0	0	0	0	0	1	0	0	1	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Indonesia	2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indonesia	2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indonesia	2012	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indonesia	2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indonesia	2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Laos	2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laos	2010	0	1	0	0	0	1	0	0	1	0	0	0	0	0
Laos	2012	0	1	0	0	0	1	0	0	1	0	0	0	0	0
Laos	2014	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Laos	2016	0	1	0	0	0	0	0	0	1	0	0	0	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Malaysia	2008	1	1	0	1	1	1	0	1	1	1	1	1	0	1
Malaysia	2010	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Malaysia	2012	1	1	1	1	1	1	0	1	1	1	1	1	0	1
Malaysia	2014	1	1	1	1	1	1	0	1	1	1	1	1	0	1
Malaysia	2016	1	1	1	1	1	1	0	1	1	1	1	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Myanmar	2008	0	1	0	0	1	1	0	0	1	0	0	1	0	0
Myanmar	2010	0	1	0	1	1	1	1	1	1	1	1	1	1	1
Myanmar	2012	0	1	0	1	1	1	1	1	1	1	1	1	1	1
Myanmar	2014	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Myanmar	2016	0	1	0	0	0	0	0	0	1	0	0	1	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Philippines	2008	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Philippines	2010	0	1	0	1	1	1	1	1	1	1	1	1	1	1
Philippines	2012	1	1	0	1	1	1	1	1	1	1	1	1	1	1
Philippines	2014	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Philippines	2016	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Thailand	2008	1	1	0	1	1	1	0	1	1	0	1	1	0	1
Thailand	2010	1	1	1	1	1	1	0	1	1	0	1	1	0	1
Thailand	2012	1	1	1	1	1	1	0	1	1	0	1	1	0	1
Thailand	2014	1	1	1	1	1	1	0	1	1	0	1	1	0	1
Thailand	2016	1	1	1	1	1	1	0	1	1	0	1	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Vietnam	2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vietnam	2010	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Vietnam	2012	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Vietnam	2014	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Vietnam	2016	0	1	0	0	0	0	0	0	1	0	0	1	0	0
		Good Governance/Global hectares				Good Governance/CO2				Good Governance/Sanitation		Good Governance/Energy			

Education

		Education/Global hectares				Education/CO2				Education/Sanitation		Education/Energy			
		Existence of SuWi		Real GDP in SuWi		Existence of SuWi		Real GDP in SuWi		Existence	Real in SuWi	Existence of SuWi		Real GDP in SuWi	
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Cambodia	2008	0	1	0	1	0	1	0	1	1	1	1	1	1	1
Cambodia	2010	0	1	0	1	0	1	0	0	1	1	1	1	1	1
Cambodia	2012	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Cambodia	2014	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Cambodia	2016	0	1	0	1	0	0	0	0	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Indonesia	2008	1	1	0	1	0	1	0	1	1	1	1	1	0	1
Indonesia	2010	1	1	0	1	1	1	0	1	1	1	1	1	1	1
Indonesia	2012	1	1	0	1	1	1	0	1	1	1	1	1	0	1
Indonesia	2014	1	1	0	1	0	1	0	1	1	1	1	1	0	1
Indonesia	2016	1	1	0	1	1	1	0	1	1	1	1	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Laos	2008	1	1	1	1	1	1	1	1	1	1	0	0	0	0
Laos	2010	1	1	1	1	0	1	0	1	1	1	0	0	0	0
Laos	2012	1	1	0	1	0	1	0	1	1	1	0	1	0	1
Laos	2014	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Laos	2016	1	1	1	1	0	1	0	0	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Malaysia	2008	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Malaysia	2010	0	1	0	0	0	0	0	0	1	0	0	0	0	0
Malaysia	2012	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Malaysia	2014	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Malaysia	2016	1	1	0	0	0	1	0	0	1	0	0	1	0	0
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Myanmar	2008	0	1	0	1	1	1	1	1	1	1	1	1	0	1
Myanmar	2010	0	1	0	1	1	1	1	1	1	1	1	1	1	1
Myanmar	2012	0	1	0	1	1	1	1	1	1	1	1	1	1	1
Myanmar	2014	0	1	0	1	1	1	0	1	1	1	1	1	1	1
Myanmar	2016	1	1	1	1	0	1	0	1	1	1	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Philippines	2008	0	1	0	0	1	1	0	0	1	0	1	1	0	0
Philippines	2010	0	1	0	0	1	1	0	0	1	0	1	1	0	0
Philippines	2012	0	1	0	0	1	1	0	0	1	0	1	1	0	0
Philippines	2014	1	1	0	0	0	1	0	0	1	0	1	1	0	0
Philippines	2016	1	1	1	1	0	1	0	1	1	1	1	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Thailand	2008	0	1	0	1	1	1	0	1	1	0	0	1	0	1
Thailand	2010	1	1	1	1	0	1	0	1	1	0	0	1	0	1
Thailand	2012	1	1	1	1	0	1	0	1	1	0	0	1	0	1
Thailand	2014	1	1	1	1	0	1	0	1	0	0	0	1	0	1
Thailand	2016	1	1	1	1	1	1	0	1	1	0	0	1	0	1
		Strong	Weak	Real Strong	Real weak	Strong	Weak	Real Strong	Real weak	Strong	Real Strong	Strong	Weak	Real Strong	Real weak
Vietnam	2008	0	1	0	0	0	1	0	0	1	0	0	1	0	0
Vietnam	2010	0	1	0	1	0	1	0	1	1	1	0	1	0	1
Vietnam	2012	0	1	0	1	0	0	0	0	1	1	0	1	0	1
Vietnam	2014	0	1	0	1	0	0	0	0	1	1	0	1	0	1
Vietnam	2016	1	1	0	1	0	1	0	1	1	1	1	1	1	1
		Education/Global hectares				Education/CO2				Education/Sanitation		Education/Energy			

Effects of Ga-doping on the Properties of Li_2MnSiO_4 Cathode by Sol−Gel Method

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ABSTRACT

Renewable energy could be considered as a clean energy which is the future power train of the world and Lithium ion battery (LIB) becomes a suitable choice for portable energy source due to its high specific energy and long cycle life. Cathode materials in LIBs have been interested for improving working voltage, rate capability and charge capacity. Recently, orthosilicate compound Li_2MSiO_4 (*M* = Mn, Fe, Ni, etc.) has been interested as new cathode materials due to the strong Si-O covalent bond contributing high chemical stability to electrolyte and high working voltage up to 4.8 V. Among orthosilicate families, Li_2MnSiO_4 has gained much interested owing to its high theoretical capacity (~333 $mA.h.g^{-1}$) leading more than one lithium ion extraction per formula unit. However, Li_2MnSiO_4 has capacity fading problem along cycling because of its structural stability. In order to improve this issue, doping of cation in to Mn-site and Si-site is one of the possible methods to stabilize the structure. In this study, the carbon coated on Li_2MnSiO_4 surface (Li_2MnSiO_4/C) has been synthesized by sol−gel method and sucrose was introduced as carbon source. $Ga_2N_3O_9.xH_2O$ has been used as a dopants for Ga-doping into Mn-site and Si-site of Li_2MnSiO_4/C for comparing the phase purity and electrochemical performance.

The structure of orthorhombic Li_2MnSiO_4 with *Pmnb* space group was obtained. The electrochemical results showed that undoped Li_2MnSiO_4/C obtained first discharge capacity as high as 200 $mA.h.g^{-1}$ at 0.05C but capacity retention was only 37% (~75 $mA.h.g^{-1}$) after 30 cycles. For the Ga-doped synthesized Li_2MnSiO_4/C, 5% Ga-doping into Mn-site led higher discharge capacity than Si-site but Si-site-doped contributed the highest capacity retention. However, both Ga-doped Li_2MnSiO_4/C could not contribute high discharge capacity as much as the undoped Li_2MnSiO_4/C as Ga was incompletely reacted indicating by the appearance of Ga- contained impurity phases.

KEY WORDS: Lithium ion battery, Cathode, Doping, Orthosilicate, Discharge capacity

1. INTRODUCTION

Renewable energy could be considered as a clean energy which is the future power train of the world and Lithium ion battery (LIB) becomes a suitable choice for portable energy source due to its high specific energy and long cycle life. Cathode materials in LIBs have been interested for improving working voltage, rate capability and charge capacity. Recently, orthosilicate compound Li_2MSiO_4 (*M* = Mn, Fe, Ni, etc.) has been interested as new cathode for next generation due to the strong Si-O covalent bond contributing high chemical stability to electrolyte and high working voltage up to 4.8 V. Moreover, Li_2MSiO_4 has a high theoretical capacity (~333 $mA.h.g^{-1}$) which can lead to more than one lithium ion extraction per formula unit [1].

There are many types of cathode in Li_2MSiO_4 family, Li_2MnSiO_4 (LMS) has possible chance to lead two Li-ions moving between two electrodes than other types, under the voltage range which is presently used [2].

Nowadays, many study about the improving of electrochemical performance of LMS have been published such as including particle size improvement and surface modification. Sol−gel synthesis is one of the most popular methods for preparing nano-sized particles and achieving the high phase purity. Furthermore, carbon coating is one of the general techniques to increase electrical conductivity of battery cathode [2].

In addition, many studies show that ion doping was a good way to effectively improve the electrochemical properties of battery's cathode such as structural stability, reversibility,

rate capability and cycling stability. The doping of cations in the crystal of Li_2MnSiO_4 can enhance its electrochemical performances. So, this technique has been used for Li_2MnSiO_4 improvement [3]. Deng *Et al*. have studied about doping of Mn/Si in Li_2MnSiO_4 nanoparticles by V, Cr or Al. They found that the doping has effects to the physical and chemical properties. Comparing with Mn, doping of Si with the same amount can deliver a discharge capacity as high as 108 $mA.h.g^{-1}$. However, doping of Si has faster capacity fading, which can be understood to the decline of the structure when Si is doped. Substitution of Si with Al, V or Cr have a tendency to decrease the insulation effect of $(SiO_4)^{4-}$ polyanion and could improves Li_2MnSiO_4 properties [4]. Kuganathan *Et al.* have done the structural modeling to study about the possibility of trivalent doping for Li_2MnSiO_4 by using and they found that Al^{3+} and Ga^{3+} are possible to be doped into Mn site and Si site for Li_2MnSiO_4 [5] and Ga^{3+} can lead to an initial efficiency and high charge/discharge capacity [6].

Therefore, this research is interested in the Ga-doping on the Li_2MnSiO_4 by focusing on the phase purity and capacities by doping into Mn-site ($Li_{2-x}Mn_{1-x}Ga_xSiO_4/C$; x = 0.05) and Si-site ($Li_{2+y}MnGa_ySi_{1-y}O_4/C$; y = 0.05) which x, y = 0.05 were represented as 5%mol Ga-doping at each site.

2. EXPERIMENTAL

In this study Li_2MnSiO_4, $Li_{2-x}Mn_{1-x}Ga_xSiO_4/C$; x = 0.05 and $Li_{2+y}MnGa_ySi_{1-y}O_4/C$; y = 0.05 with carbon coated (Li_2MnSiO_4/C) have been synthesized by sol−gel method adapted from Liu *Et al.* research [2]. Firstly, water-acetic acid solution was prepared by using 3.6 g DI water and 7.2 g acetic acid (Merck, 100%). Then, 0.02 mol of $CH_3COOLi.2H_2O$ (Sigma-Aldrich, 99%), 0.01 mol $Mn(CH_3COO)_2.4H_2O$ (Sigma-Aldrich, 99%) and 0.95 g sucrose (Sigma-Aldrich, 99.5%) were dissolved in the prepared solution. After that, the solution of 0.01 mol TEOS (Alfa Aesar, 99.9%) with 7 mol% TEOS excess and 8 ml isopropanol (Merck, 99.8%) were added respectively. The solution was continuously stirred (under speed 100rpm) and evaporated at 80 °C for 30 min in order to obtain the wet white gel. Then, the wet gel was dried under 100 °C for 24 h. Finally, the dry gel as a precursor was finely ground and calcined in Wire Wound Single Zone Tube Furnace (CARBOLITE, MTF 12/38/400) at 800 °C for 6 h under a flowing argon atmosphere to obtain the nanoparticle of Li_2MnSiO_4/C. For doped sample, 0.0005 mol of $Ga(NO_3)_3.xH_2O$ (Sigma-Aldrich, 99.9%) has been applied as 5% Ga-doping instead of 5 mol% of total $Mn(CH_3COO)_2.4H_2O$ for Mn-site doping and 5 mol% of total TEOS for Si-site doping.

For physical characterizations, X-ray diffraction (XRD, Rigaku TTRAX III) was carried out to identify the phase and scanning electron microscope (SEM, Hitachi SU8030) was scanned to understand morphology and particle size of the Li_2MnSiO_4 material family obtained.

For Electrochemical characterization, the cathode electrode of the as-prepared Li_2MnSiO_4/C family were prepared by mixing 80 wt% active material, 8 wt% acetylene black, 2 wt% Ketjenblack and 10 wt% polyvinylidene fluoride (PVDF) binder and using N-methyl-pyrrolidone (NMP) as the solvent. After mixing, the slurry was casted on aluminum foil and taken to dry in vacuum oven at 80 °C, overnight. The metallic lithium foil (Alfa Aesar, 99.9% metals basis) was used as the anode. 100 µl of $LiPF_6$ dimethyl carbonate (BASF) and Polyethylene (PE, Tonen) were used as electrolyte and separator, respectively. The half-cell battery sample was assembled by using PFA Swagelok Tube Fitting in an argon glovebox. Cell performance measurements were tested by using a battery tester (MACCOR 4000 serie) at room temperature under testing condition of 1.5-4.8 V at 0.05C. The specific capacity was calculated by Li_2MnSiO_4/C mass loading, excluding the mass of active carbon

and PVDF.

3. RESULTS AND DISCUSSION

Fig. 1 shows the XRD result of Li_2MnSiO_4/C varied by the site of Ga-doping. The result shows that the synthesized Li_2MnSiO_4/C was obtained the orthorhombic structure of Li_2MnSiO_4 with *Pmnb* space group. Small peak of MnO appear at 2θ=40.6 was observed as impurities similar to previous report. This impurity could be reduced by synthesizing under high pressure as Arroyo-deDompablo *Et al.* reported [7].

For Mn-site doped, the synthesized $Li_{1.95}Mn_{0.95}Ga_{0.05}SiO_4$/C was obtained the monoclinic structure of Li_2MnSiO_4 with $P2_1/n$ space group. Gummow *Et al.* reported that monoclinic structure would appeared after applied Mg^{2+}, which has smaller ionic radius than Mn^{2+} similar to Ga^{3+} (The ionic radius of the Mn^{2+}, Mg^{2+} and Ga^{3+} are 0.66, 0.57 and 0.47 Å, respectively), into Mn-site of Li_2MnSiO_4 [8]. Furthermore, Kalantarian *Et al.* reported the unstable structure and poor electrochemical properties of this monoclinic structure [9]. There was a small peak of Ga_2O_3 at 2θ=31.16 which could refer to the incompletely reacted Ga.

For Si-site doped, the synthesized $Li_{2.05}MnGa_{0.05}Si_{0.95}O_4$/C was obtained the orthorhombic structure with *Pmnb* space group with small peaks of MnO appear higher relative intensity than undoped sample. No Ga compound peak could be detected by XRD for this sample, this result is close agreement with Kuganathan *Et al.* that doping trivalent ion into Si-site was easier than Mn-site due to the lower energy [5]. Comparing with the Al-doping of Mn/Si in Li_2MnSiO_4 reported by Deng *Et al.*, the 5% Al-doping led the increasing of MnO in both Mn-site and Si-site [4], our results have the increasing of MnO only in Si-site-doped.

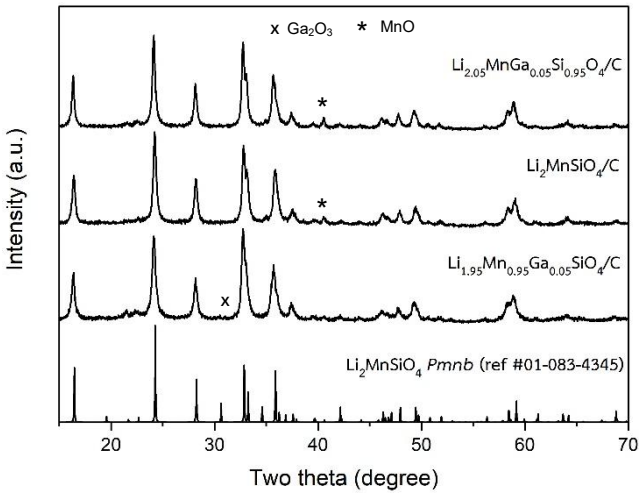

Fig 1. XRD pattern of Li_2MnSiO_4/C with and without Ga-doping. Orthorhombic Li_2MnSiO_4 (ICDD-PDF no. 01-083-4345) denote as a reference.

Fig. 2 show the SEM images of all synthesized samples. The result show that Li_2MnSiO_4/C had particle size of 25-75 nm with uniformly distribution. In addition, the particle size of Ga-doped samples were similar to the undoped sample (the particle size of $Li_{1.95}Mn_{0.95}Ga_{0.05}SiO_4$/C is 20-100 nm and $Li_{2.05}MnGa_{0.05}Si_{0.95}O_4$/C is 20-80 nm). This could be postulated that Ga-doping insignificantly affected to morphologies and particle size. However, impurity phase of MnO and Ga_2O_3 could not been detected by SEM.

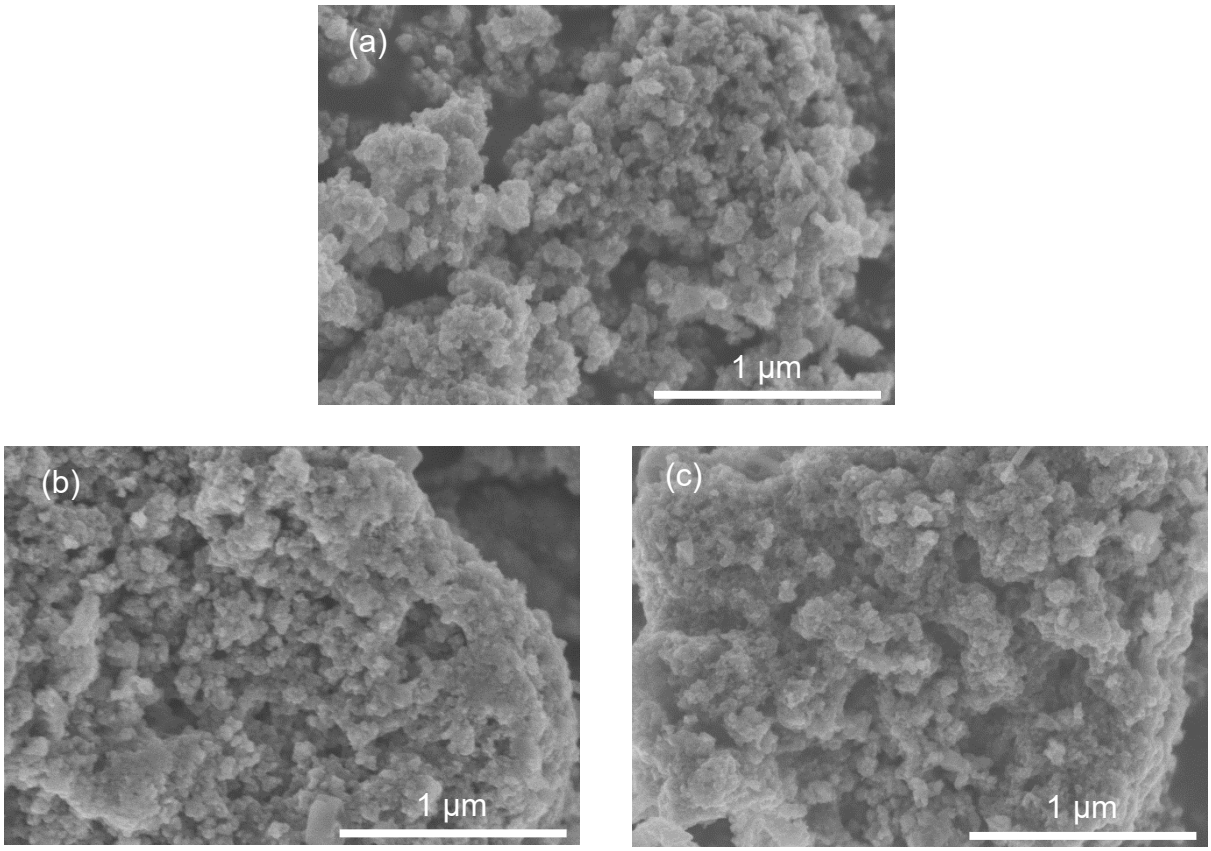

Fig 2. SEM images of (a) the Li_2MnSiO_4/C, (b) the $Li_{1.95}Mn_{0.95}Ga_{0.05}SiO_4/C$ and (c) the $Li_{2.05}MnGa_{0.05}Si_{0.95}O_4/C$

Fig. 3 show the voltage profiles and cycle retention for doped and undoped Li_2MnSiO_4/C. The result showed that the undoped Li_2MnSiO_4/C led the first discharge capacity of 200 $mA.h.g^{-1}$ at 0.05C and remained only 37% (~75 $mA.h.g^{-1}$) after 30 cycles. The Ga-doped into Mn-site sample, $Li_{1.95}Mn_{0.95}Ga_{0.05}SiO_4/C$, led the first discharge capacity of 161 $mA.h.g^{-1}$ and remained 40% (~65 $mA.h.g^{-1}$) after 30 cycles. Furthermore, the Ga-doped into Si-site sample, $Li_{2.05}MnGa_{0.05}Si_{0.95}O_4/C$, led the first discharge capacity of 129 $mA.h.g^{-1}$ and remained 44% (~57 $mA.h.g^{-1}$) after 30 cycles. It could be seen that both Ga-doped sample into Mn-site and Si-site could not contribute high discharge capacity as much as the Li_2MnSiO_4/C due to the distortion to monoclinic structure for the synthesized $Li_{1.95}Mn_{0.95}Ga_{0.05}SiO_4/C$ [9] and the appearance of impurity phase in the synthesized $Li_{2.05}MnGa_{0.05}Si_{0.95}O_4/C$.

Although, there was no Ga-contained impurity phase in $Li_{2.05}MnGa_{0.05}Si_{0.95}O_4/C$ and its XRD pattern was similar to Li_2MnSiO_4/C, which would refer that Ga^{3+} was possibly doped into Si-site and had a good effect to the structural stability. However, its discharge capacity was lower due to the formation of Ga-contained impurity phase, which would not been detected by XRD. Although, Kuganathan *Et al.* reported that trivalent doping into Si-site could increase lithium extracted and enhance higher capacity [5] but our results could not agree due to the appearance of MnO impurity.

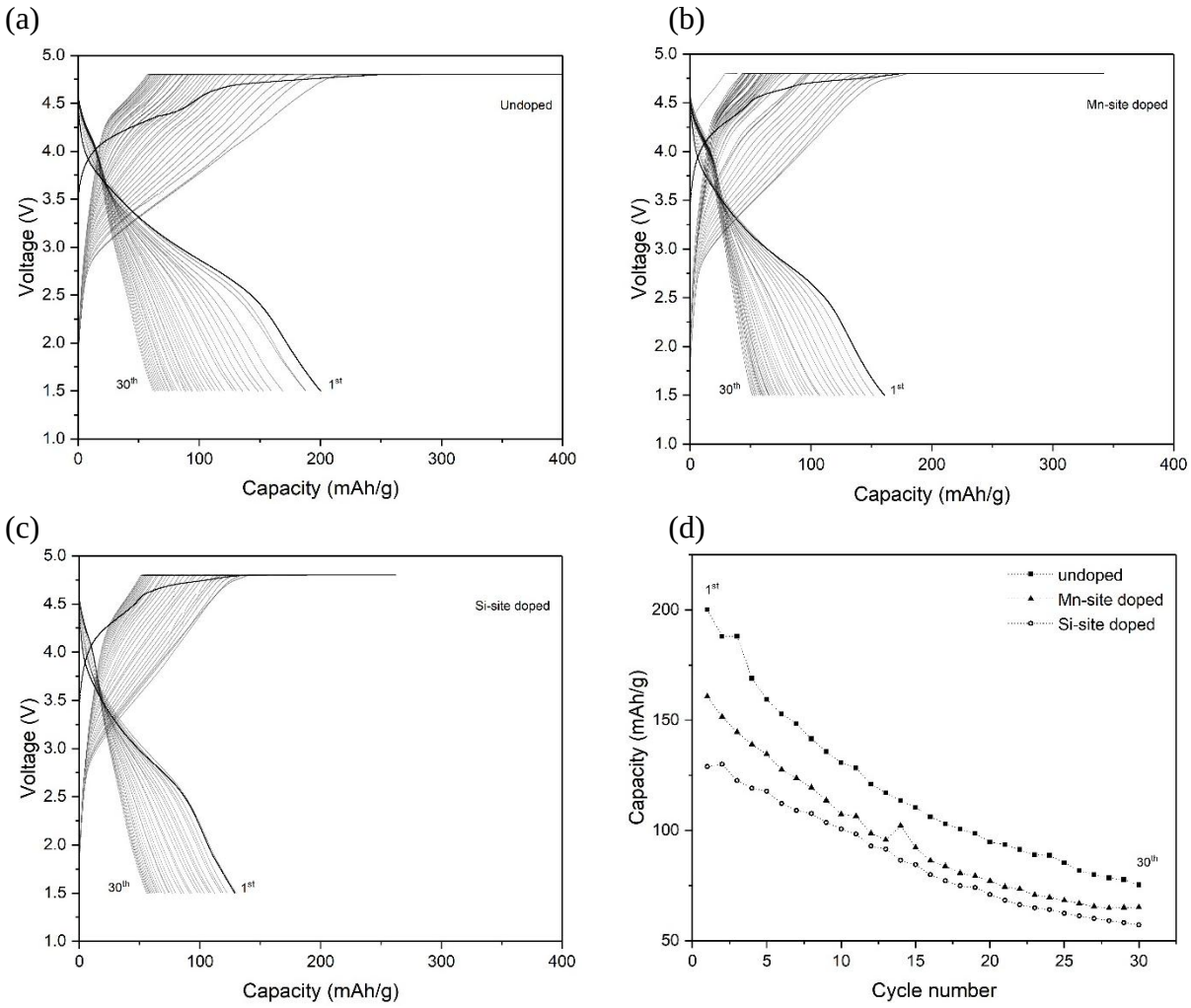

Fig 3. The cell voltage profile of (a) the Li_2MnSiO_4/C, (b) the $Li_{1.95}Mn_{0.95}Ga_{0.05}SiO_4$/C (c) the $Li_{2.05}MnGa_{0.05}Si_{0.95}O_4$/C and (d) cycling capacity retention of undoped and doped sample.

4. CONCLUSION

The structure of orthorhombic Li_2MnSiO_4 with *Pmnb* space group was obtained by synthesizing via sol−gel method. The appearance of small peak of MnO was observed as impurities. For Mn-site doped, the synthesized $Li_{1.95}Mn_{0.95}Ga_{0.05}SiO_4$/C was obtained the monoclinic structure of Li_2MnSiO_4 with $P2_1/n$ space group and for Si-site doped, the synthesized $Li_{2.05}MnGa_{0.05}Si_{0.95}O_4$/C was obtained the orthorhombic structure with *Pmnb* space group with small peaks of MnO appear higher relative intensity than undoped sample. The electrochemical results showed that undoped Li_2MnSiO_4/C has first discharge capacity as high as 200 mA.h.g^{-1} at 0.05C but the capacity retention was only 37% (~75 mA.h.g^{-1}) after 30 cycles. For the Ga-doped Li_2MnSiO_4/C, 5% Ga-doping into Mn-site led higher discharge capacity than Si-site but Si-site-doped enhanced the highest capacity retention. However, both $Li_{1.95}Mn_{0.95}Ga_{0.05}SiO_4$/C and $Li_{2.05}MnGa_{0.05}Si_{0.95}O_4$/C could not contribute high discharge capacity as the undoped Li_2MnSiO_4/C. The reason of capacity reduction after

applied Ga-doping could be the incompletely reacted of Ga which can indicate by the appearance of impurity phase of Ga compound. In addition, the formation of other impurity phase such as MnO could also be another effective factor. Although, our electrochemical results could not agree with other research but these results can introduce the possible alternative method to stabilize Li_2MnSiO_4.

ACKNOWLEDGEMENTS

Thailand Advanced Institute of Science and Technology and Tokyo Institute of Technology (TAIST-Tokyo Tech) is acknowledged for the scholarship. And this work was supported by Electrochemical Materials and System Laboratory (EMS), Materials for Energy Research Unit, MTEC, National Science Technology Development Agency (NSTDA).

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Green Transition in Cambodia, Laos and Myanmar? Long-run Transition Path Analyses

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Abstract: Green transition is a multi-dimensional cooperative process accompanied with increasing uncertainty in economic growth, income distribution, urbanization, complex function system and variant critical resources endowment. Governance structures play an important role in Green Transition. The study is debating the green transition in the three Mekong River countries, Cambodia, Laos and Myanmar. The existing research on Green transition has been generally confined to the cognition of economic and institutional transition, so that the discussion of all societal stakeholders is weakened and marginalized, especially in the aspect of social involvement. The study focuses on describing and evaluating long-term development processes in these three developing countries. This paper includes operationalisation of MLP approach in the summary section. Key aspects of Green Transition are key variable, which have a long time identified in development research, such as demographic trends, economic growth, urbanization, energy economy, education policy, land use development, food security, water security, energy security and key aspects of innovation ecosystem. The study elaborates Green transition paths in these three countries and provides comparative empirical analyses of long-run transition paths. The study defines key challenges of Green Transition in Cambodia, Laos and Myanmar. The Nexus approach is linked to Green Transition analysis in this paper with some key water, food and energy sector analyses. The study emphasizes the significance of the conceptual country-level change and stakeholder involvement relevant to the process of the Green Transition.

Key worlds: Green Transition, Transition path analysis, Cambodia, Laos, Myanmar, sustainable development, demographic change, economic growth, land use, energy use, food security, water security, energy security

1. Introduction to green transition analysis and discussions

Green transition towards sustainable development is one key challenge in developing countries. Cambodia, Lao PDR and Myanmar are Mekong river countries, which are facing the challenges of green transition. The futures of these countries are linked to political, social and economic choices of leaders in these countries. On way to elaborate green transition is to use heuristic Multi-Level Perspective (MLP) model of transition as a tool. In Fig. 1 we have visualised the MLP model. A MLP means for explaining how technological transitions come about. The MLP model helps u to understand the interaction of actors, environments and innovations in a society. The MLP model builds also a bridge between evolutionary economics and technical studies. In this way the MLP model is useful in the analysis of green transition process. The critical levels of green transition are: (1) Socio-technical global landscape (STGL), (2) socio-technical regimes and (3) niche innovation on the grass-root level (see Fig. 1). Global landscape is having many impacts on national socio-technical

regimes. Also local niche level, which is providing local ideas, inventions and innovations changing national socio-technical regimes. Niche level can produce novelties to socio-technical regime. The global landscape has impacts on local entity of novelties. These three levels have complex interactions between each other (see Geels 2002, Berkhout et al. 2004, Geels & Schot 2007, Geels 2012, Smith et al 2005, Kern 2011).

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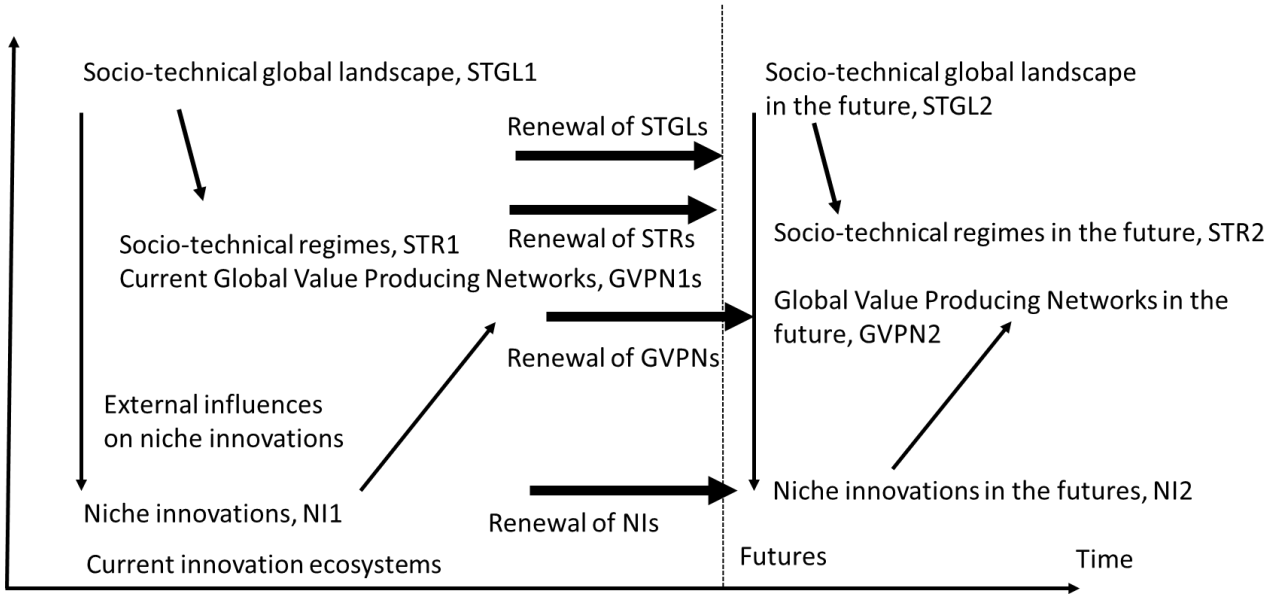

Figure 1. Multi-level systemic changes and key change mechanisms.

Historically, old MLPs provide the basis for future MLPs in the global economy. Political decision-making is an elementary part of sustainability transitions (Foxon 2011, Meadowcroft 2011, Ramos-Mejia et al. 2018). There happens renewal of three systems. How renewal(s) happens, is a key issue in this empirical transition study. We shall provide transition analyses about (1) socio-economic issues (chapter 2), (2) energy and forestry issues (chapter 3) and (3) other environmental issues (chapter 4). In chapter 5 we compare our observations about the transition analyses. In chapter 6 we make a summary about key observed transitions in Cambodia, Lao PDR and Myanmar. The variables for empirical analyses are collected from Sustainable Development Goals database of the World Bank (2018a) and the WGI databank of the World Bank, which includes national governance indicators (World Bank 2018b). The idea of this study is provide a comparative spatial analysis of green transition process and its challenges in Cambodia, Lao PDR and Myanmar.

In societies, evolution as 'variation and selection' – niches provide a vast array of possible innovations, and socio-technical regimes act as the selection environment. If tensions emerge between spatial levels, or between parts of the regime, these can be filled by niche innovations. Niche innovations are very important element in spatial adaptation and smart specialization.

2. Socio-economic contexts of green transition in Cambodia, Lao PDR and Myanmar

In this chapter 2, we report some key findings of ongoing changes in socio-economic variables in Cambodia, Lao PDR and Myanmar.

2.1. Demographic transition in Cambodia, Lao PDR and Myanmar

In Fig. 2, long-run demographic transition in Cambodia, Lao PDR and Myanmar in 1960-2050 is reported (World Bank 2018).

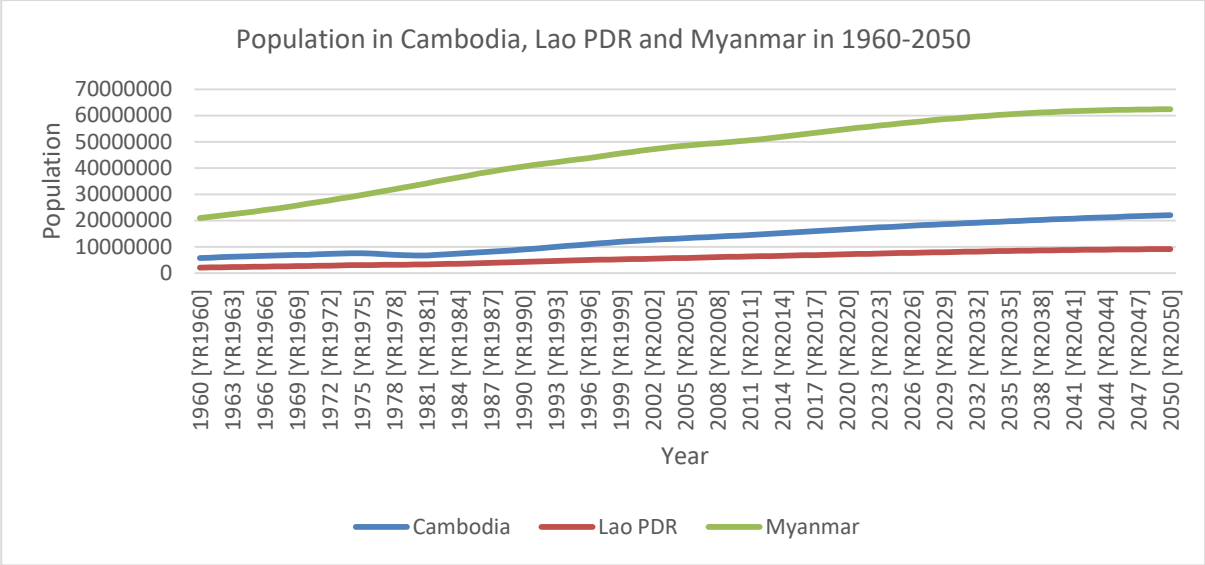

Figure 2. Long-run demographic transition. Population in Cambodia, Lao PDR and Myanmar in 1960-2050 (World Bank 2018).

In Fig. 3, long- urban population growth (annual %) in Cambodia, Lao PDR and Myanmar in 1960-2050 is reported (World Bank 2018).

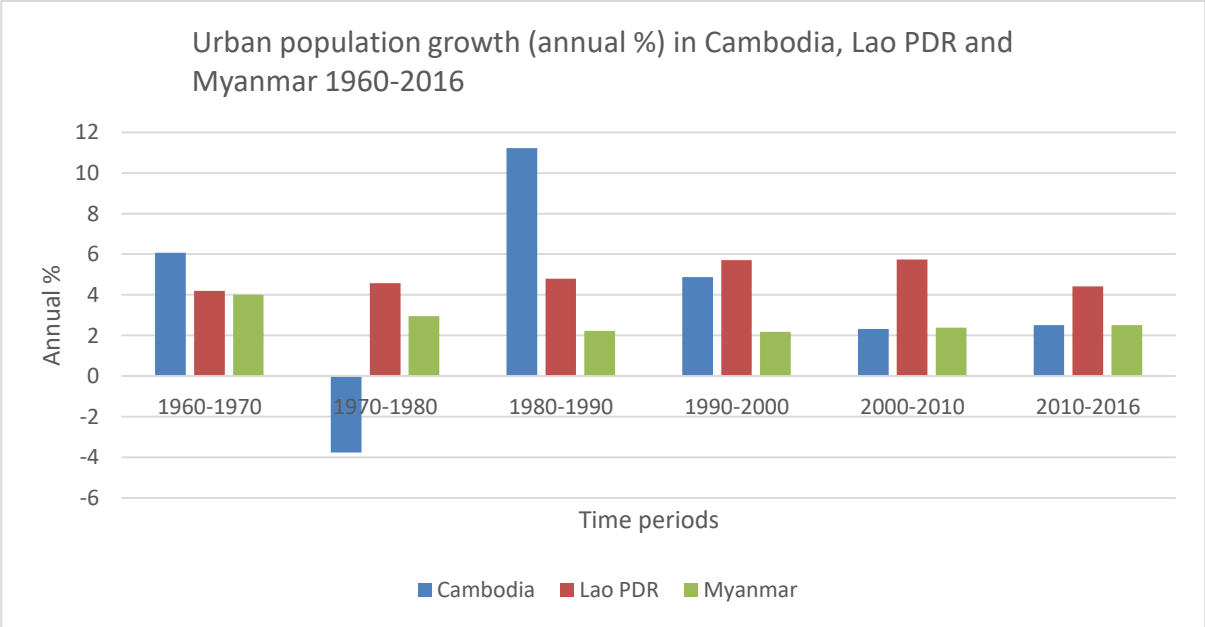

Figure 3. Urban population growth (annual %) in Cambodia, Lao PDR and Myanmar 1960-2016 (World Bank 2018).

In Fig. 4, long-run demographic transition of urbanization, urban population in Cambodia, Lao PDR and Myanmar in 1960-2050 is reported (World Bank 2018).

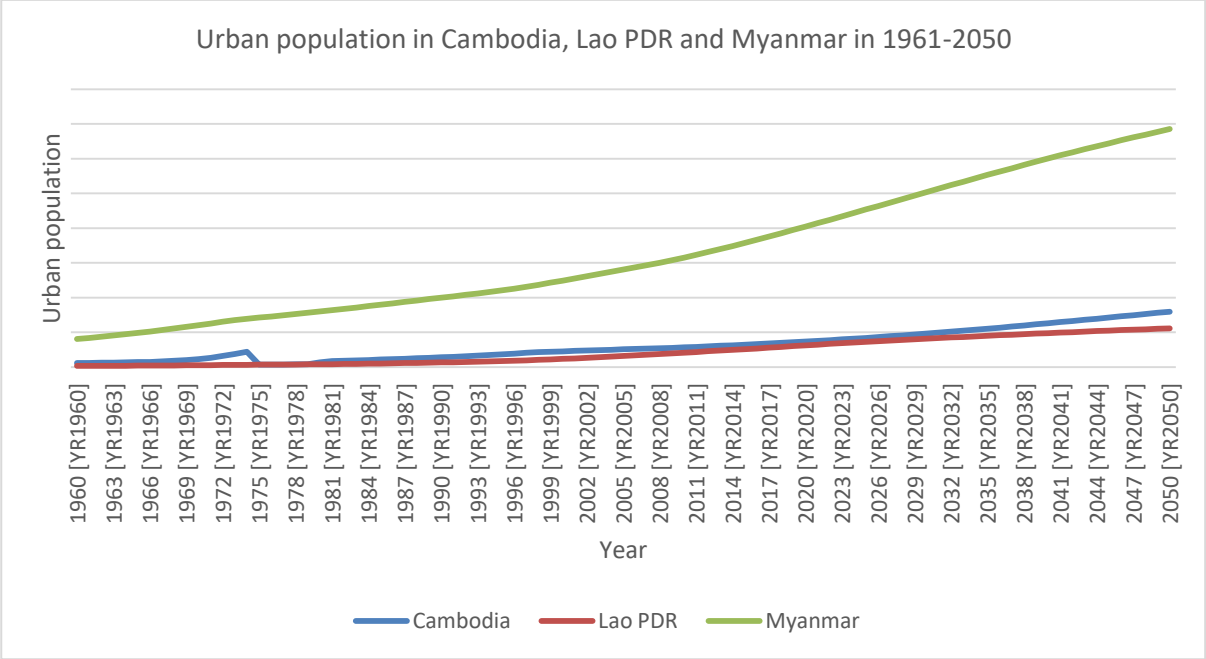

Figure 4. Long-run demographic transition, Urbanisation and urban population in Cambodia, Lao PDR and Myanmar in 1961-2050 (World Bank 2050).

In Fig. 5, long-run population growth (annual %) in Cambodia, Lao PDR and Myanmar in 1960-2016 is reported (World Bank 2018).

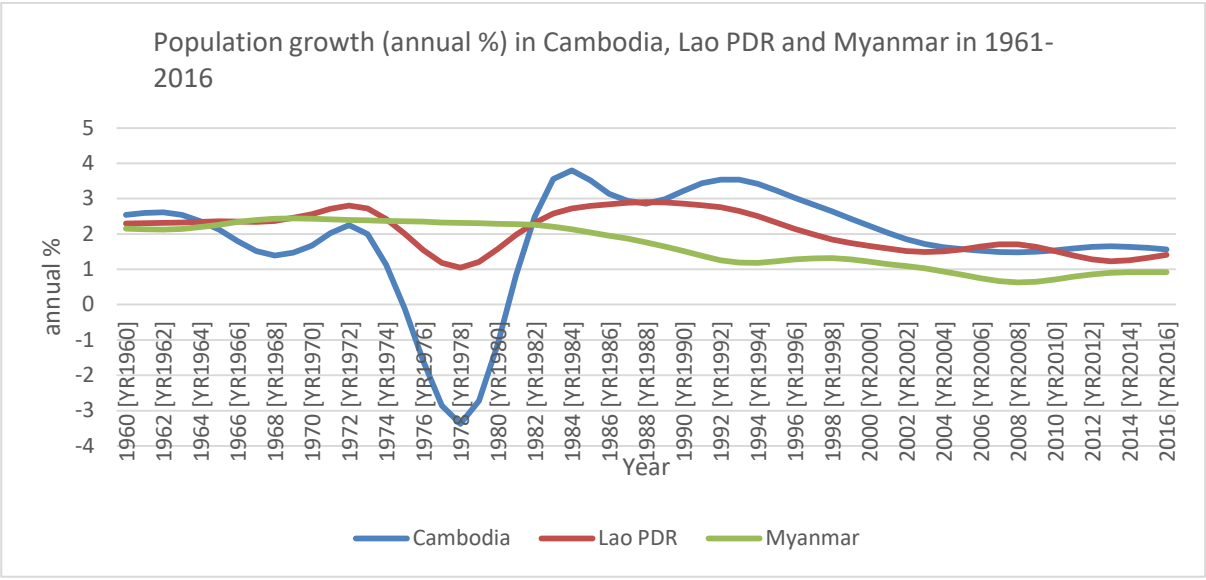

Figure 5. Population growth (annual %) in Cambodia, Lao PDR and Myanmar in 1961-2016 (World Bank 2050).

In Fig. 6, long-run age dependency ratio (% of working-age population) in Cambodia, Lao PDR and Myanmar in 1960-2050 is reported (World Bank 2018).

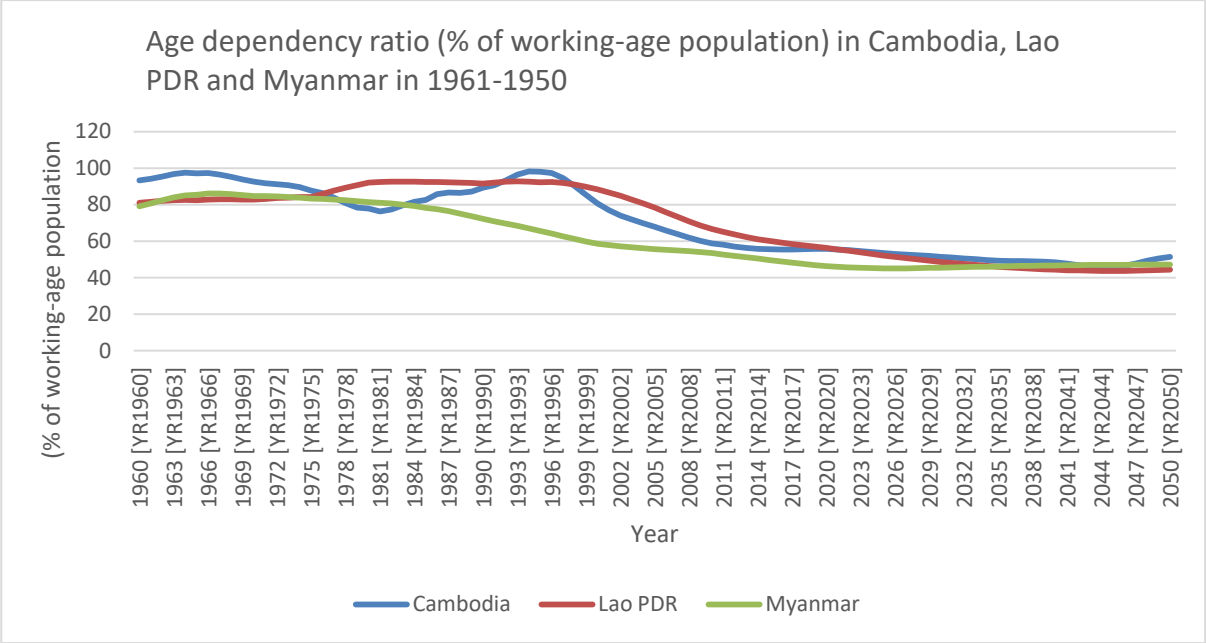

Figure 6. Age dependency ratio (% of working-age population) in Cambodia, Lao PDR and Myanmar in 1961-1950 (World Bank 2050).

2.2. Economic transition in Cambodia, Lao PDR and Myanmar

In Fig. 7, long-run GDP, PPP (current international $) in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

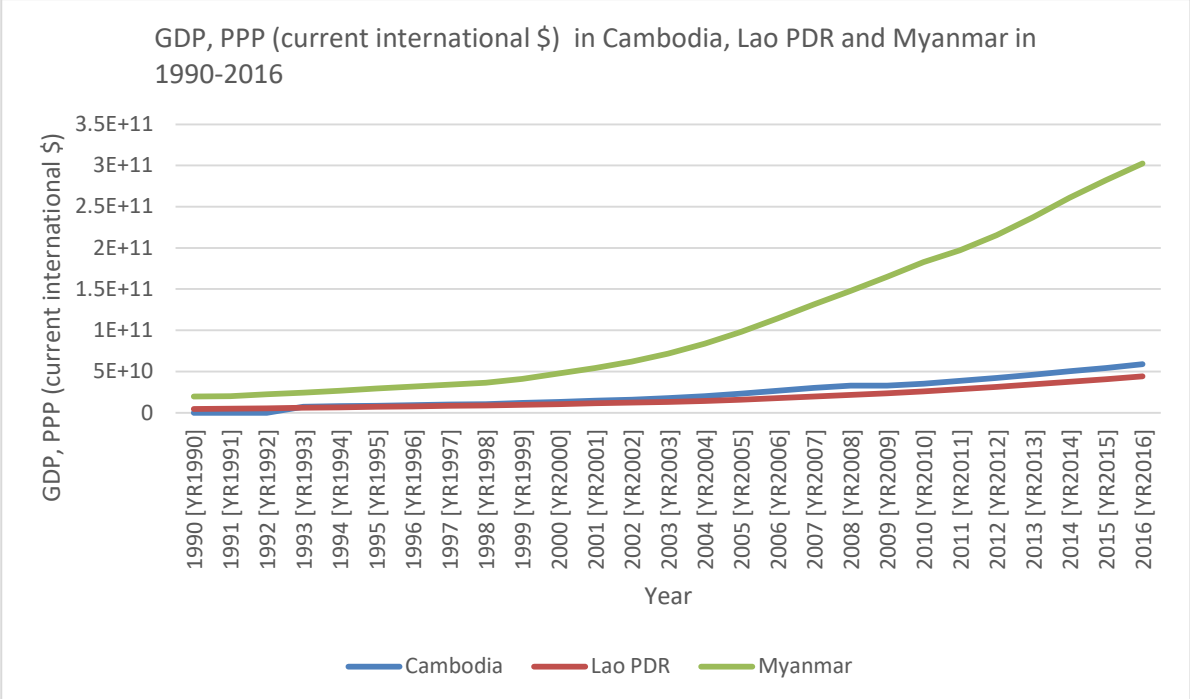

Figure 7. GDP, PPP (current international $) in Cambodia, Lao PDR and Myanmar in 1990-2016 (World Bank 2018).

In Fig. 8, long-run GDP per person employed (constant 2011 PPP $) in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

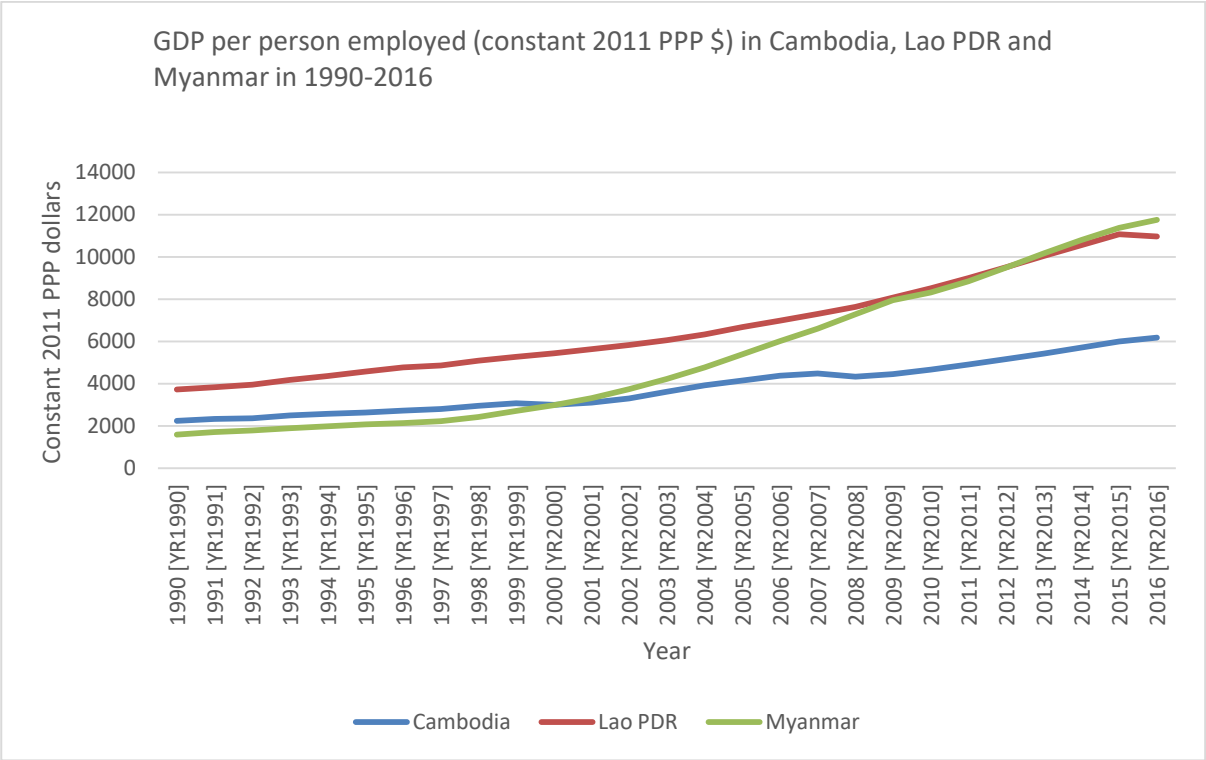

Figure 8. GDP per person employed (constant 2011 PPP $) in Cambodia, Lao PDR and Myanmar in 1990-2016 (World Bank 2018)

In Fig. 9, long-run GDP per capita, PPP (constant 2011 international $) in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

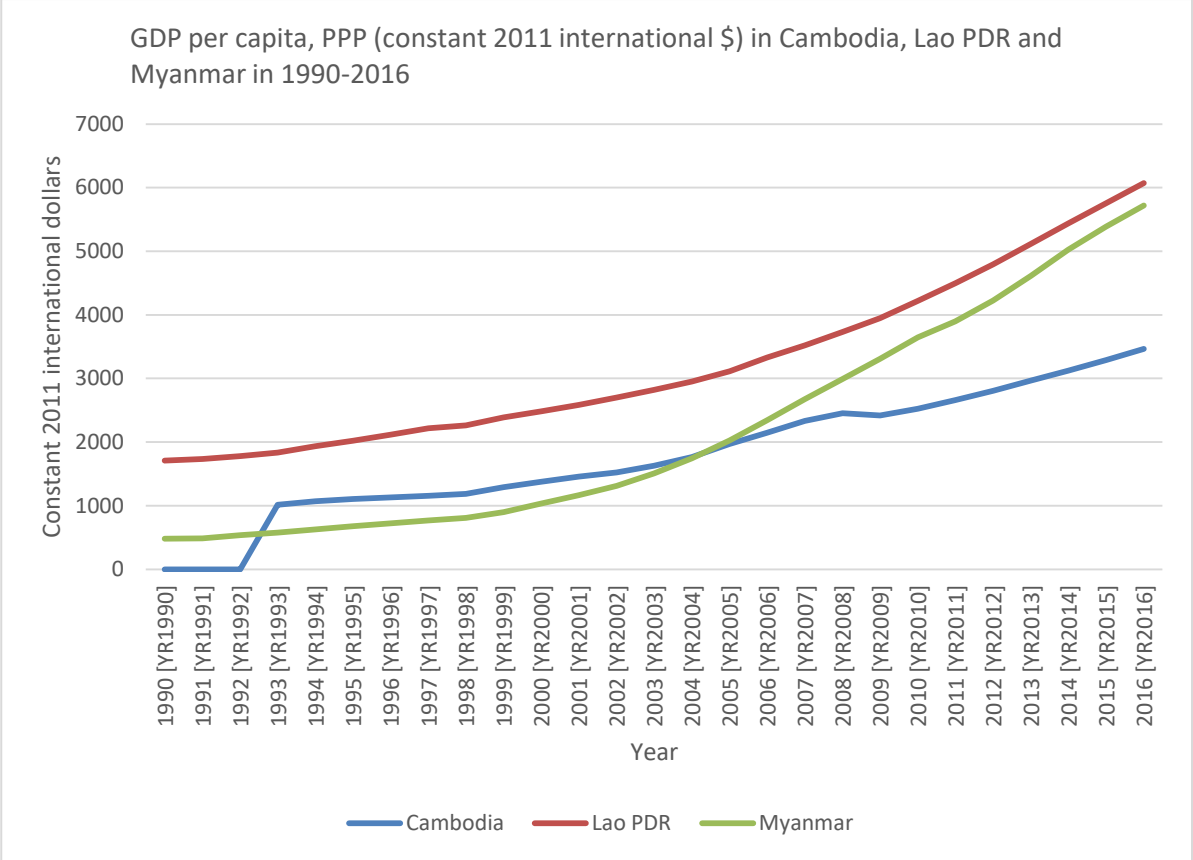

Figure 9. GDP per capita, PPP (constant 2011 international $) in Cambodia, Lao PDR and Myanmar in 1990-2016 (World Bank 2018).

2.3. Employment transition in Cambodia, Lao PDR and Myanmar

In Fig. 10, long-run employment in agriculture, industry and services (% of total employment) (modeled ILO estimate) in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

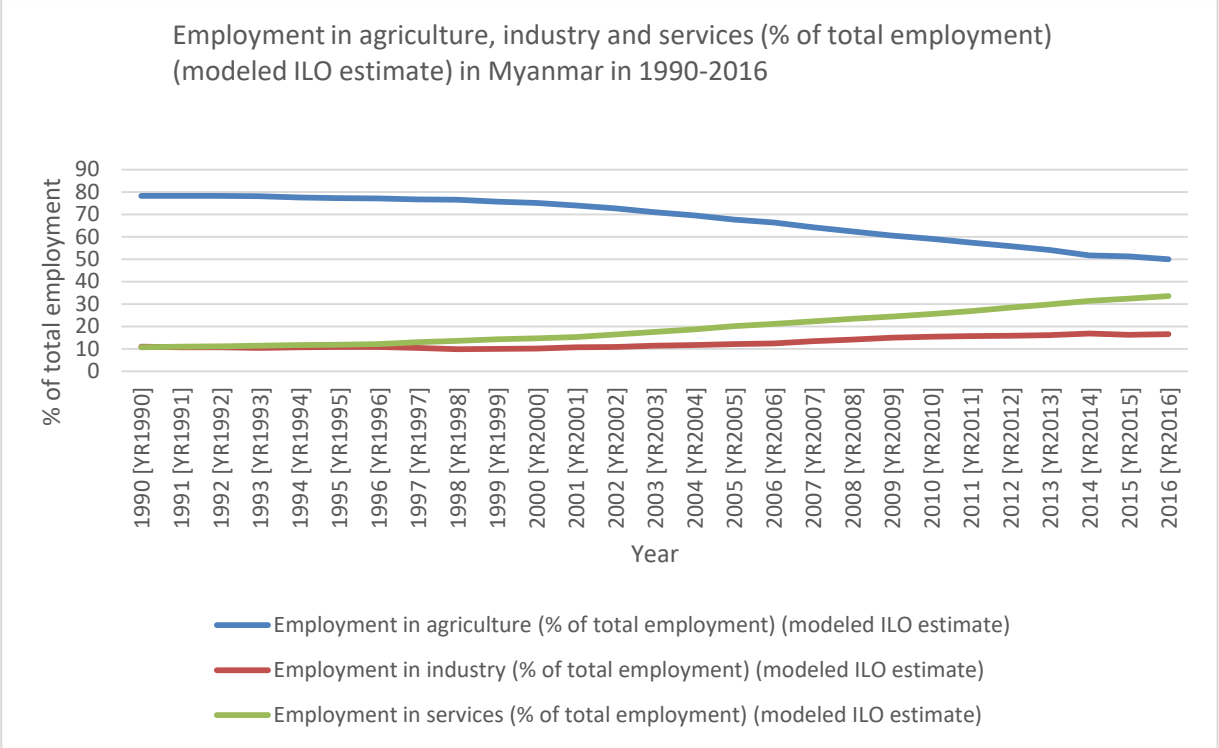

Figure 10. Employment in agriculture, industry and services (% of total employment) (modeled ILO estimate) in Myanmar in 1990-2016 (World Bank 2018).

In Fig. 11, long-run men and female employment (% of male of female employment) in agriculture, industry and services in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

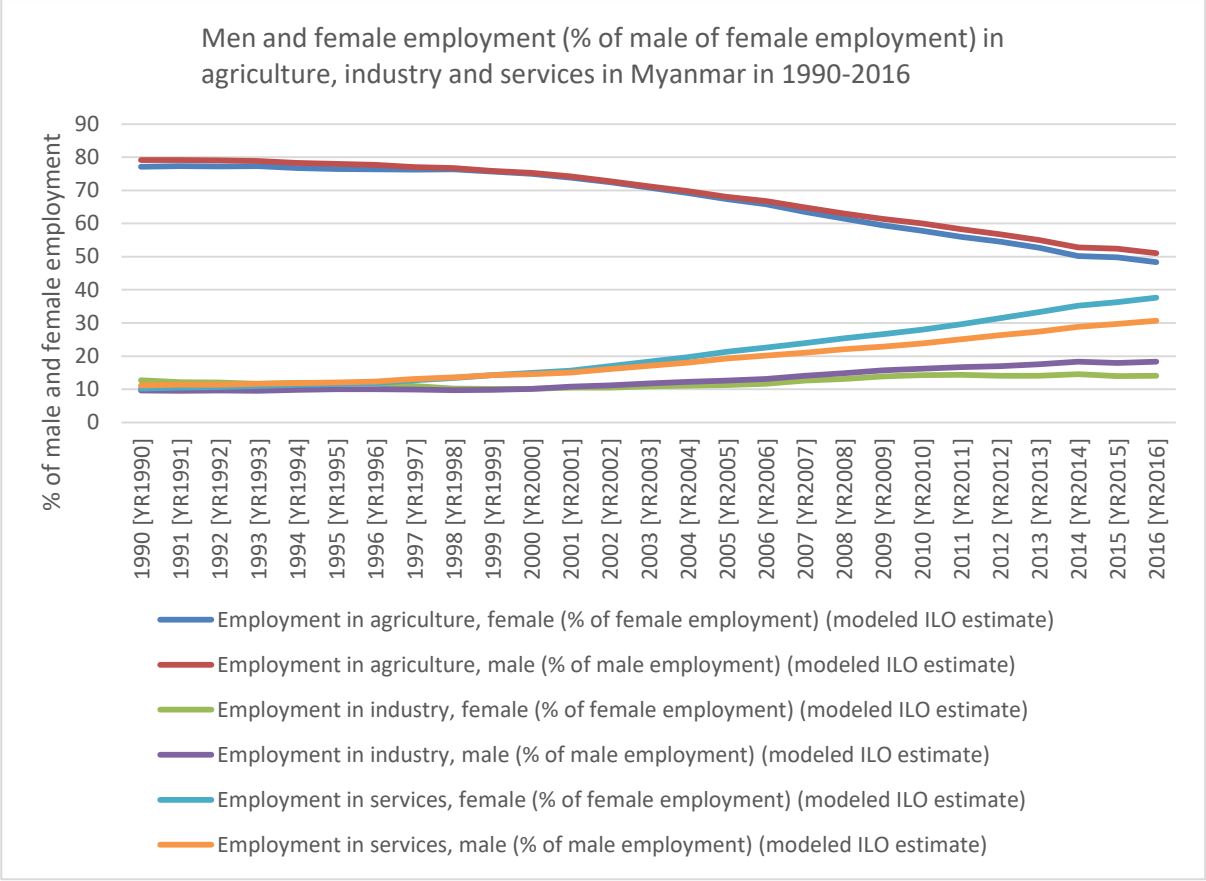

Figure 11. Men and female employment (% of male of female employment) in agriculture, industry and services in Myanmar in 1990-2016 (World Bank 2018).

In Fig. 12, long-run men and female employment (% of male or female employment) in agriculture, industry and services in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

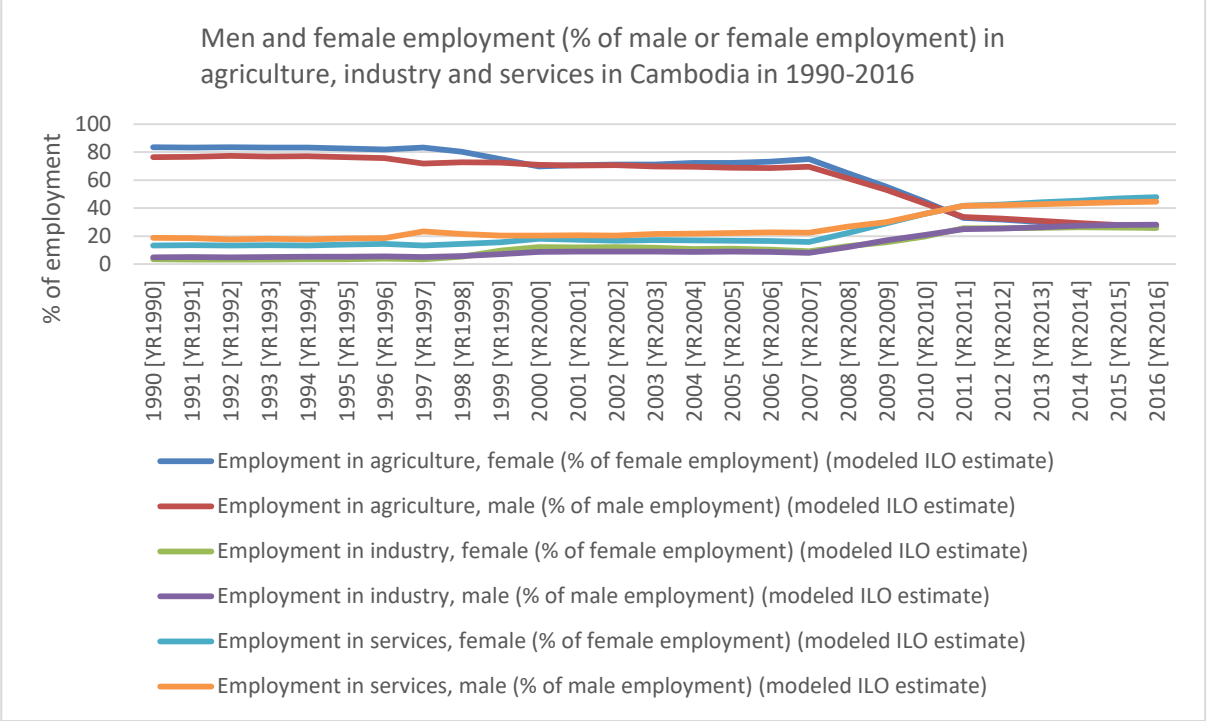

Figure 12. Men and female employment (% of male or female employment) in agriculture, industry and services in Cambodia in 1990-2016 (World Bank 2018).

In Fig. 13, long-run employment in agriculture, industry and services, changes in percentage shares in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

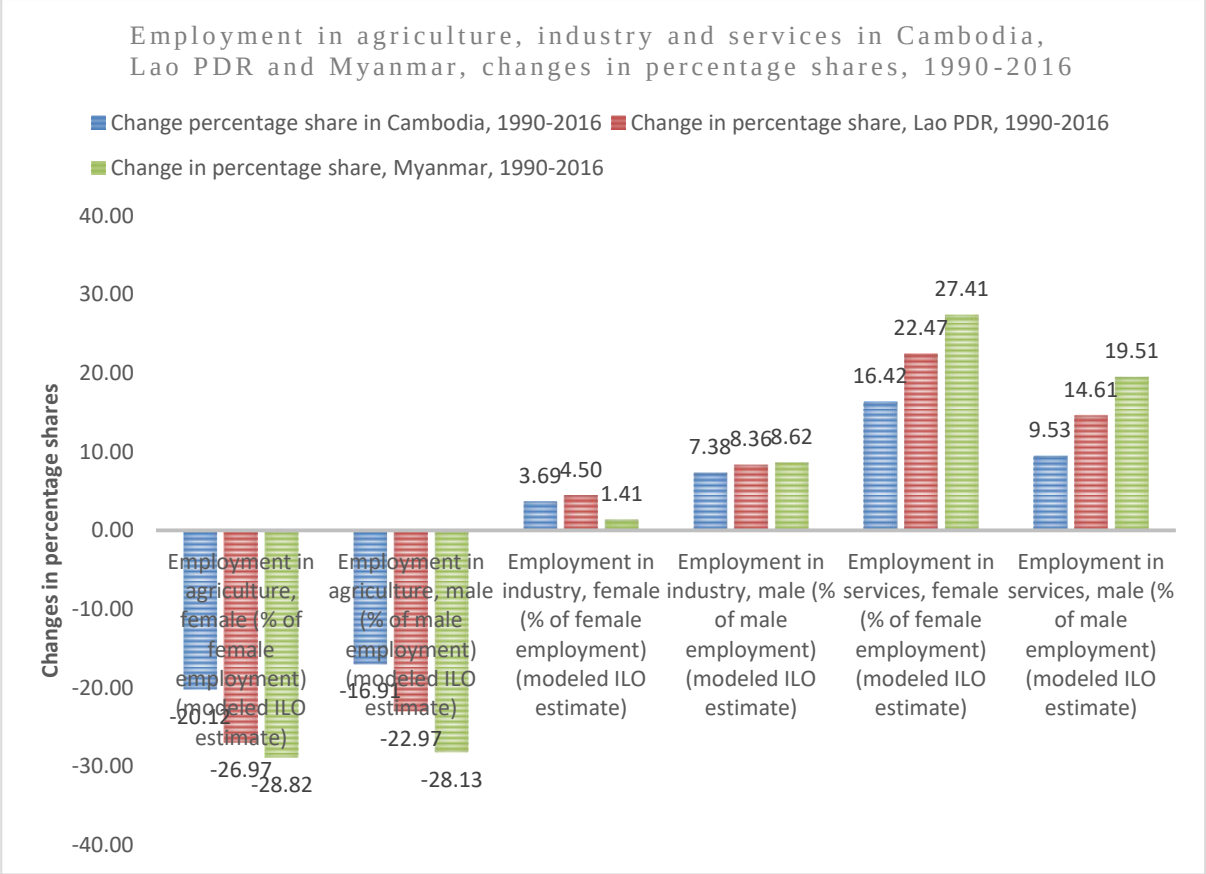

Figure 13. Employment in agriculture, industry and services In Cambodia, Lao PDR and Myanmar, changes in percentage shares, 1990-2016 (World Bank 2018).

2.4. Transitions in foreign direct investments, exports of goods and services

In Fig. 14, foreign direct investments, net inflows (BoP, current US$) in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

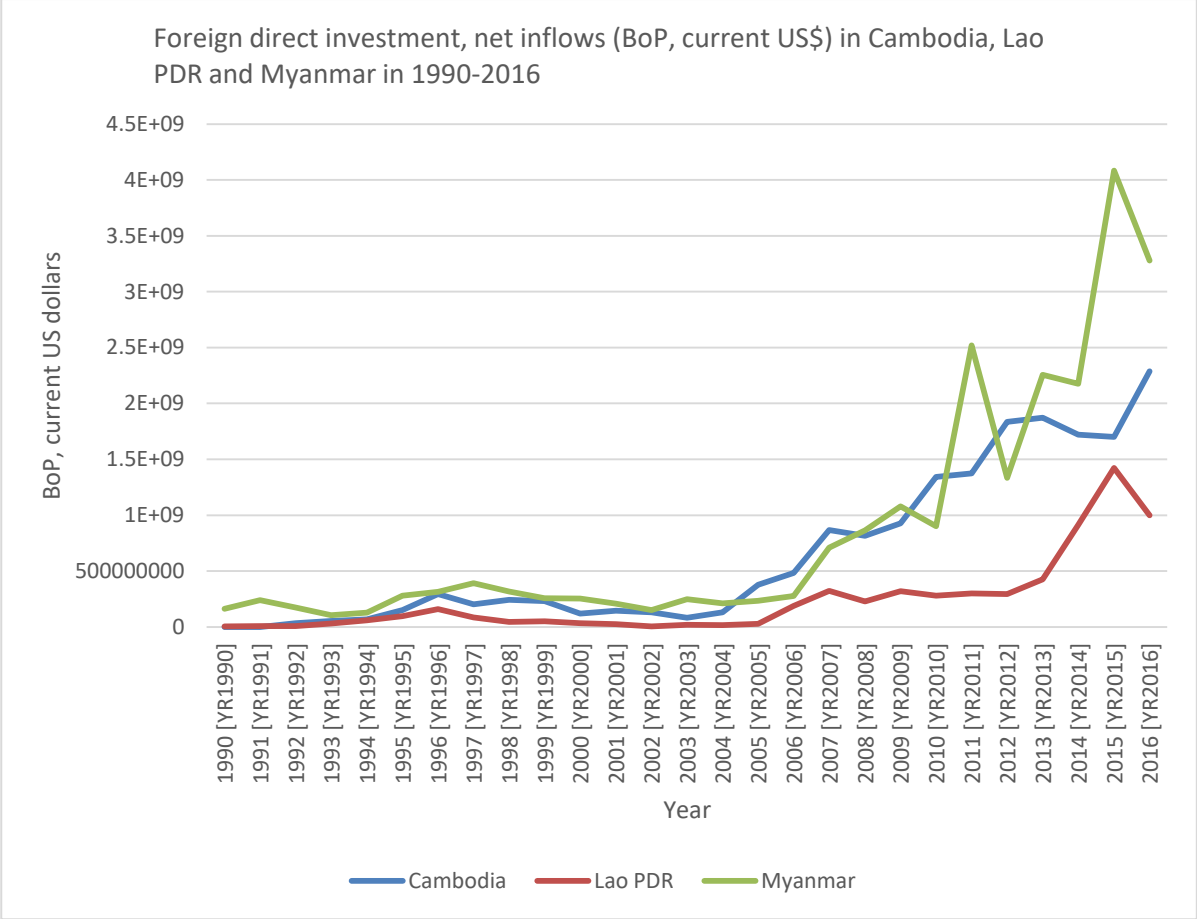

Figure 14. Foreign direct investment, net inflows (BoP, current US$) in Cambodia, Lao PDR and Myanmar in 1990-2016 (World Bank 2018).

In Fig. 15, exports of goods and services (% of GDP) in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

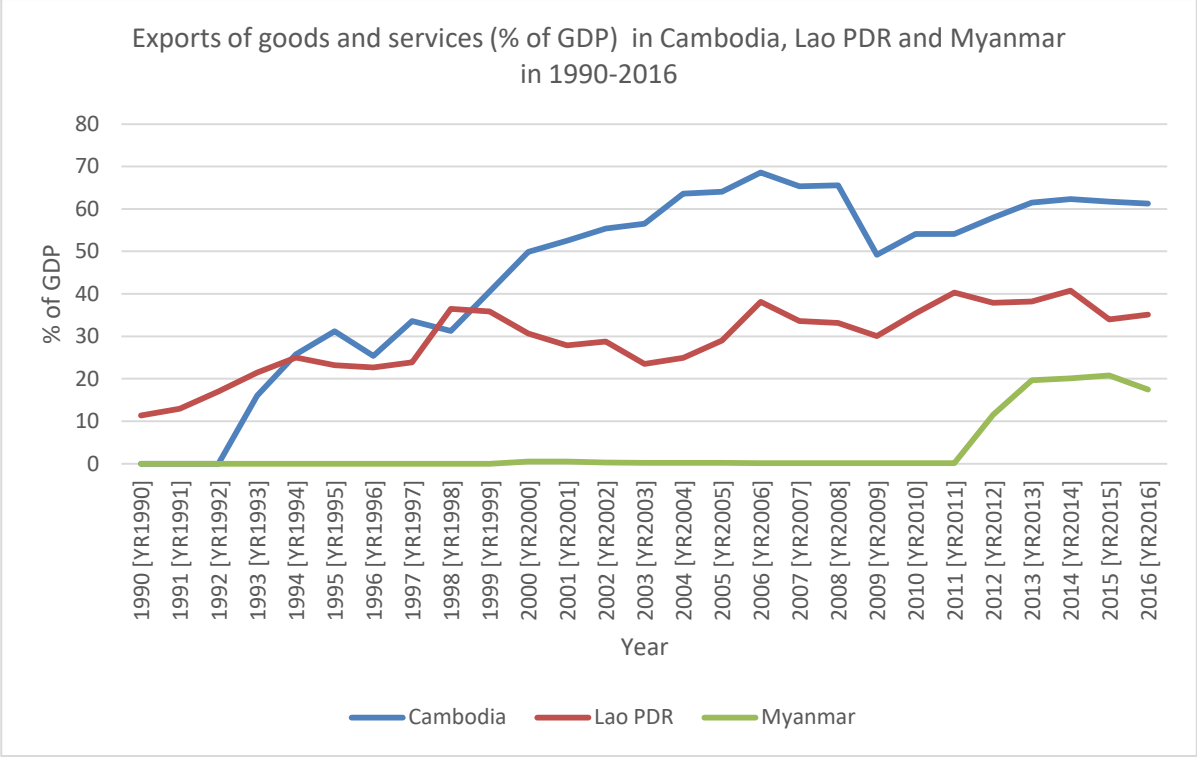

Figure 15. Exports of goods and services (% of GDP) in Cambodia, Lao PDR and Myanmar in 1990-2016 (World Bank 2018).

3. Green transitions in energy and forestry sectors

In Fig. 16, access data sets to electricity, urban (% of urban population) in Cambodia, Lao PDR and Myanmar in 1990-2016 are reported (World Bank 2018).

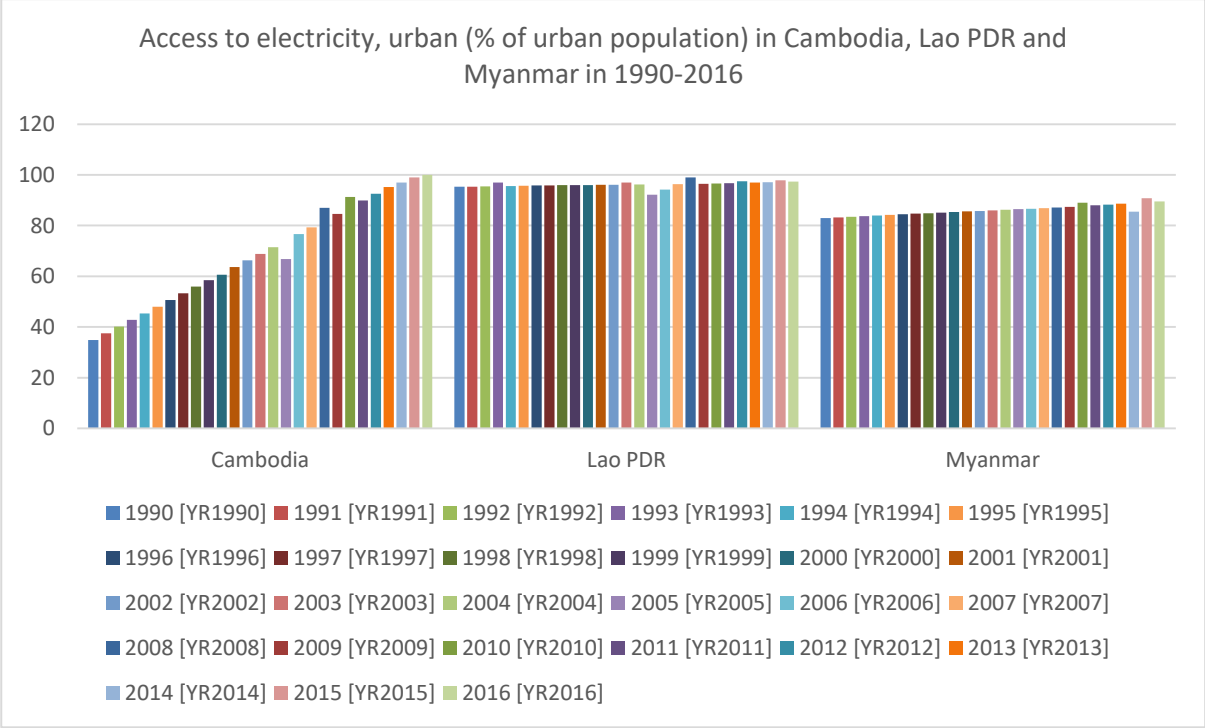

Figure 16. Access to electricity, urban (% of urban population) in Cambodia, Lao PDR and Myanmar in 1990-2016.

In Fig. 17, access data sets to electricity, rural (% of rural population) in Cambodia, Lao PDR and Myanmar in 1990-2016 are reported (World Bank 2018).

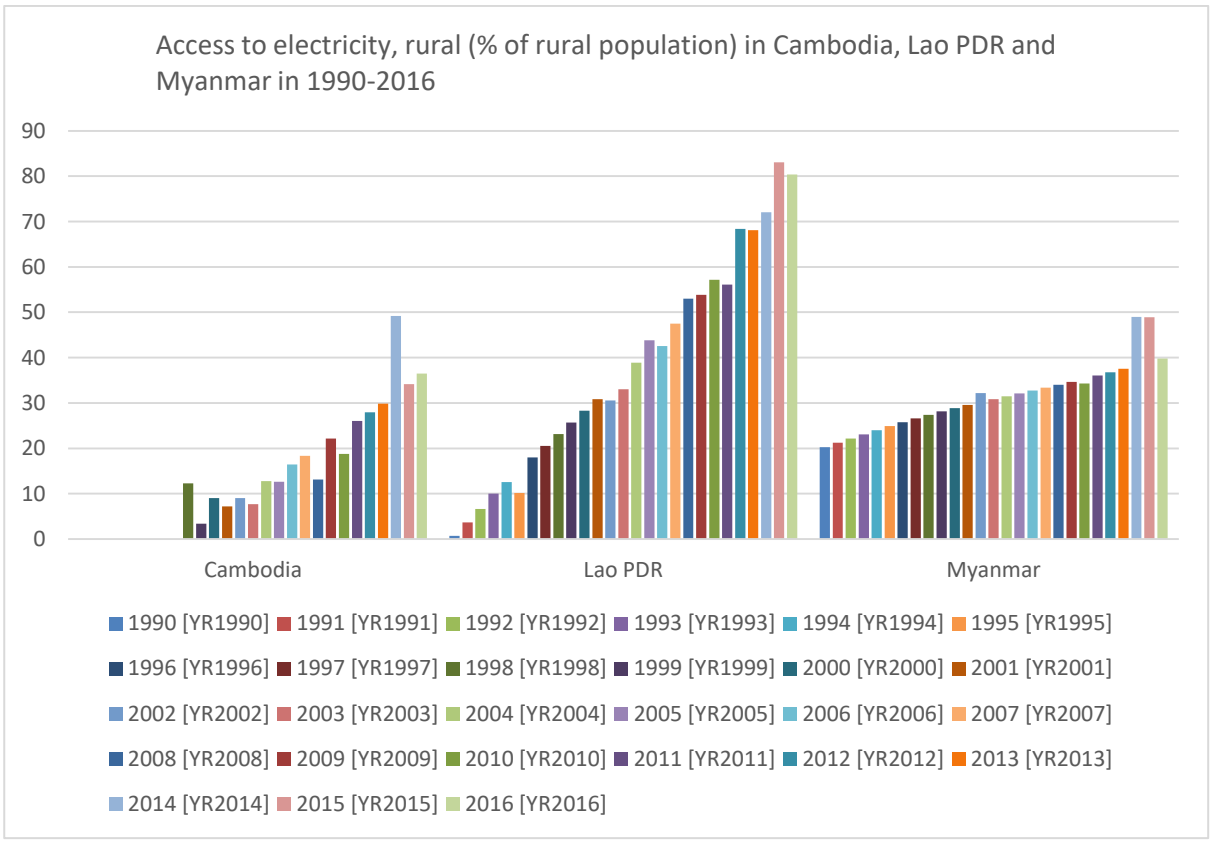

Figure 17. Access to electricity, rural (% of rural population) in Cambodia, Lao PDR and Myanmar in 1990-2016.

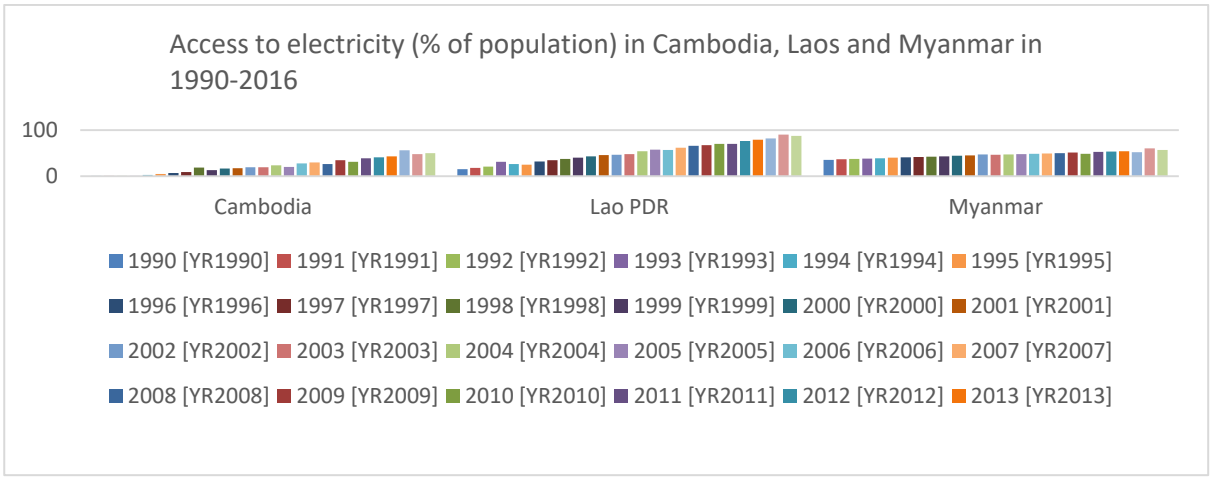

Figure 18. Access to electricity, (% of population) in Cambodia, Lao PDR and Myanmar in 1990-2016 (World Bank 2018).

In Fig. 19, long run trend figures of access to clean fuels and technologies for cooking (% of population) in Cambodia, Lao PDR and Myanmar in 1990-2016 are reported (World Bank 2018).

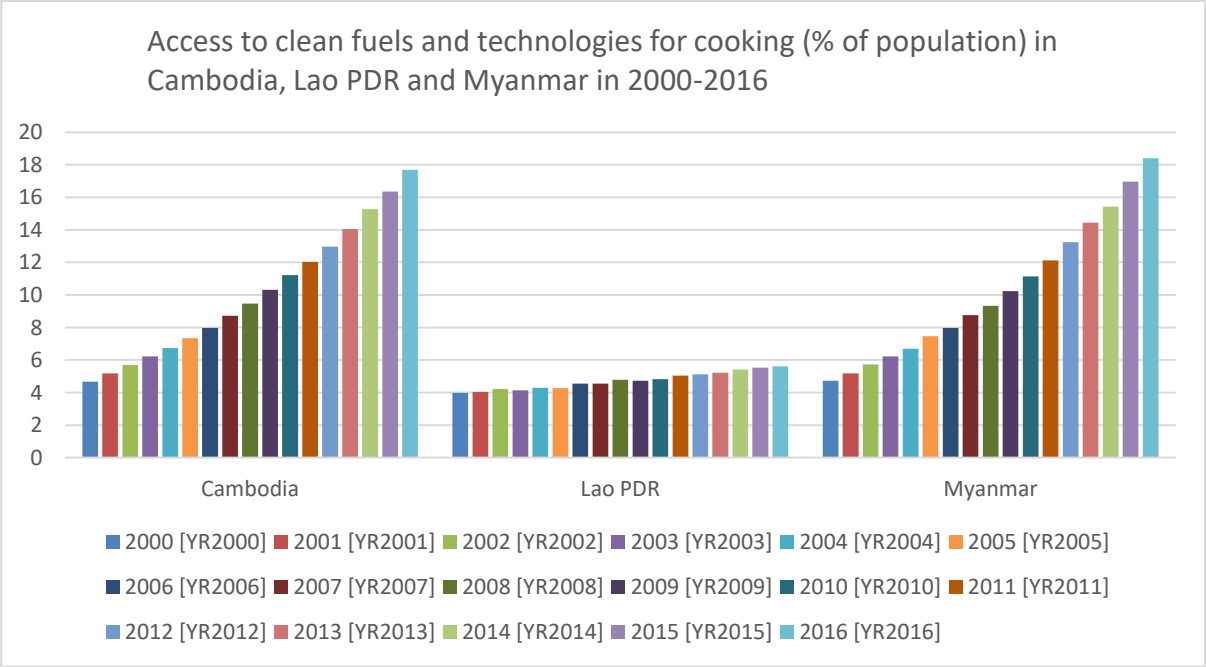

Figure 19. Access to clean fuels and technologies for cooking (% of population) (World Bank 2018).

In Fig. 20, energy intensity level of primary energy (MJ/$2011 PPP GDP) in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

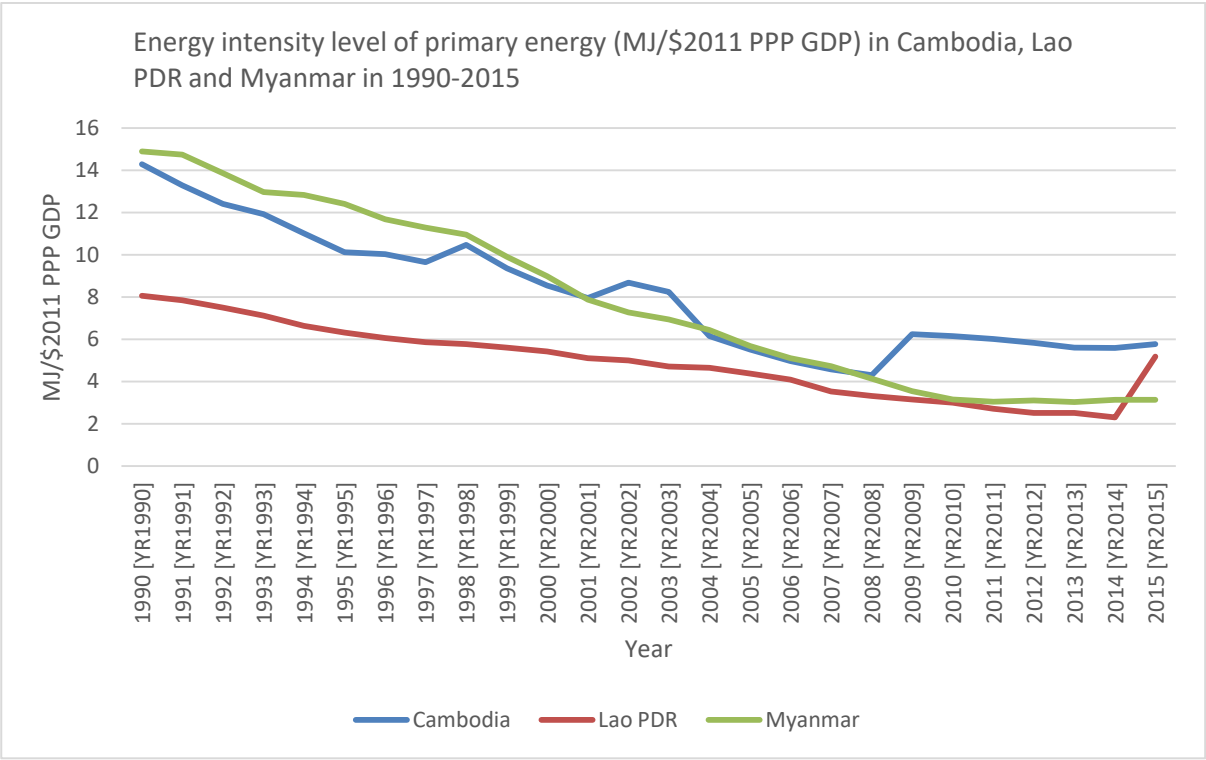

Figure 20. Energy intensity level of primary energy (MJ/$2011 PPP GDP) in Cambodia, Lao PDR and Myanmar in 1990-2015 (World Bank 2018).

In Fig. 21, long-run renewable electricity output (% of total electricity output) in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

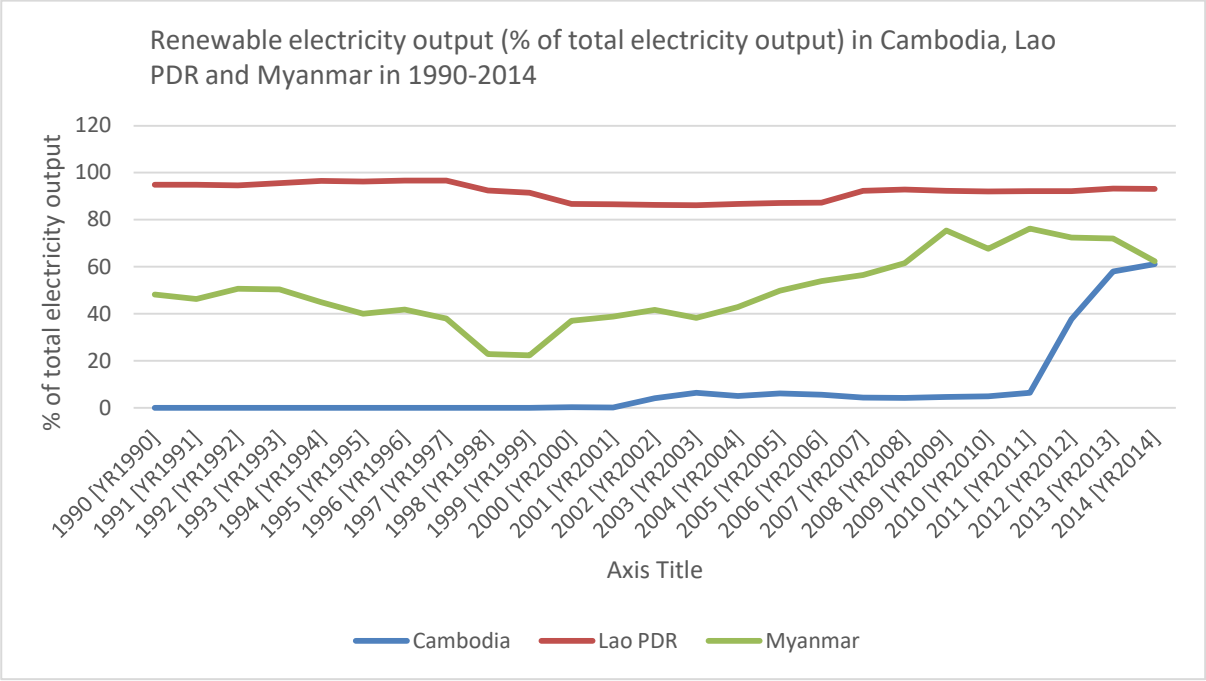

Figure 21. Renewable electricity output (% of total electricity output) in Cambodia, Lao PDR and Myanmar in 1990-2014 (World Bank 2018).

In Fig. 22, long-run renewable energy consumption (% of total final energy consumption) in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

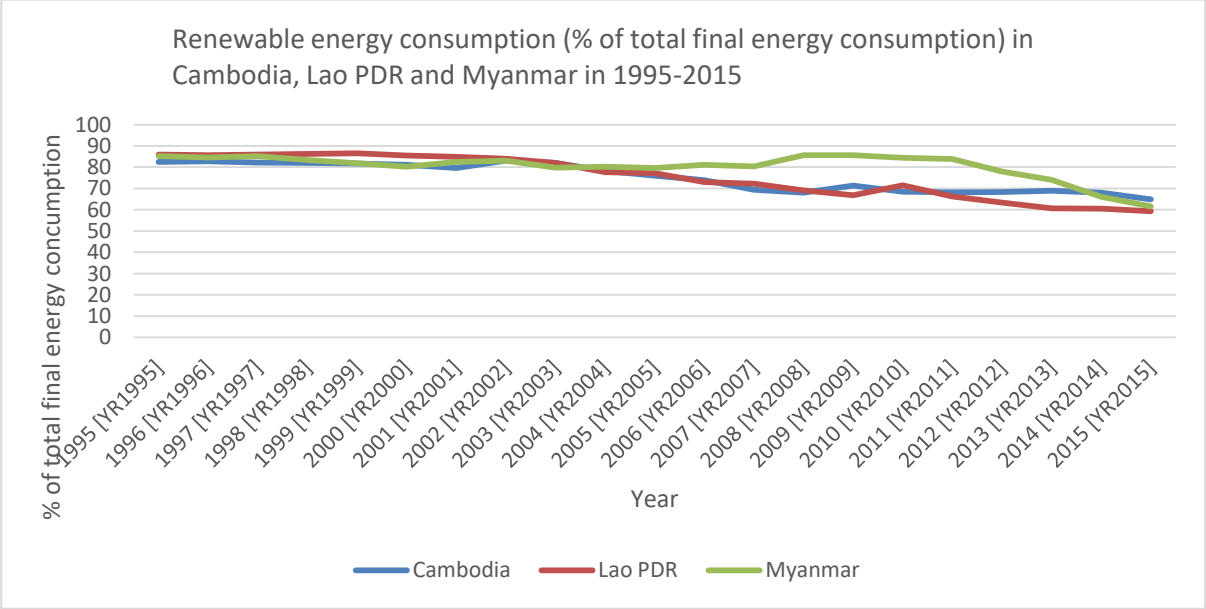

Figure 22. Renewable energy consumption (% of total final energy consumption) in Cambodia, Lao PDR and Myanmar in 1995-2015 (World Bank 2018).

In Fig. 23, long-run CO_2 emissions (metric tons per capita) in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

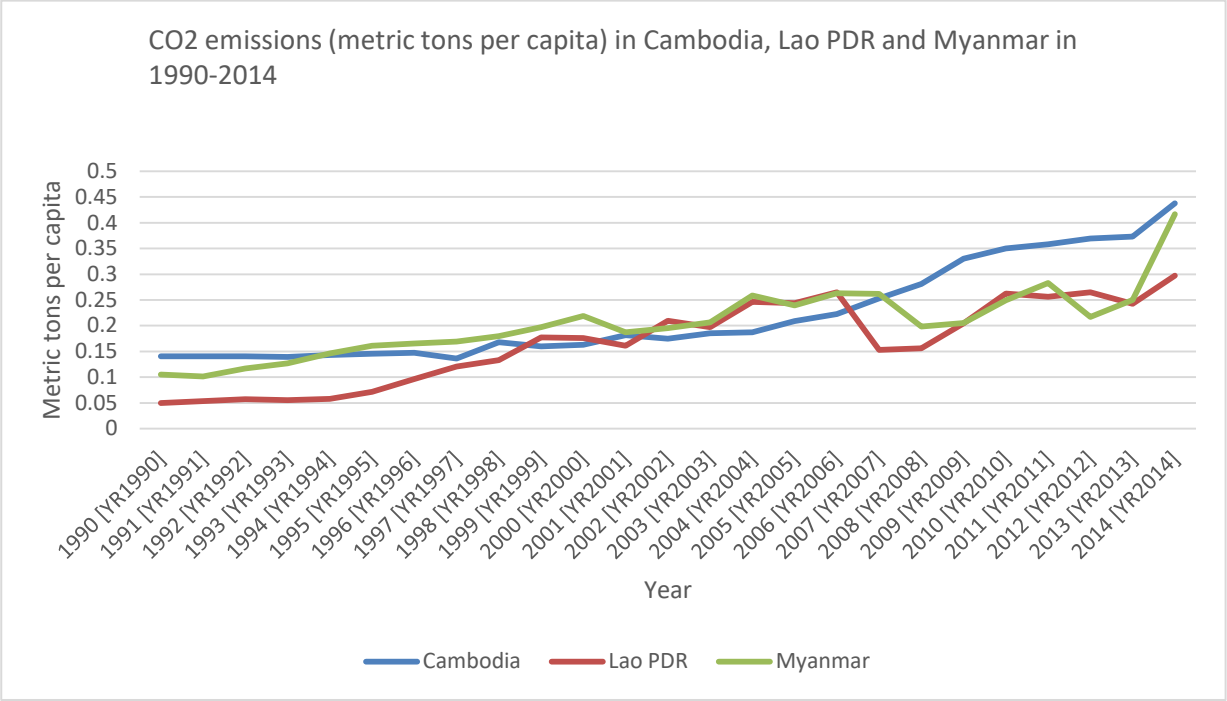

Figure 23. CO2 emissions (metric tons per capita) in Cambodia, Lao PDR and Myanmar in 1990-2014 (World Bank 2018).

In Fig. 24, long-run CO_2 emissions (kg per PPP $ of GDP) in Cambodia, Lao PDR and Myanmar in 1990-2016 is reported (World Bank 2018).

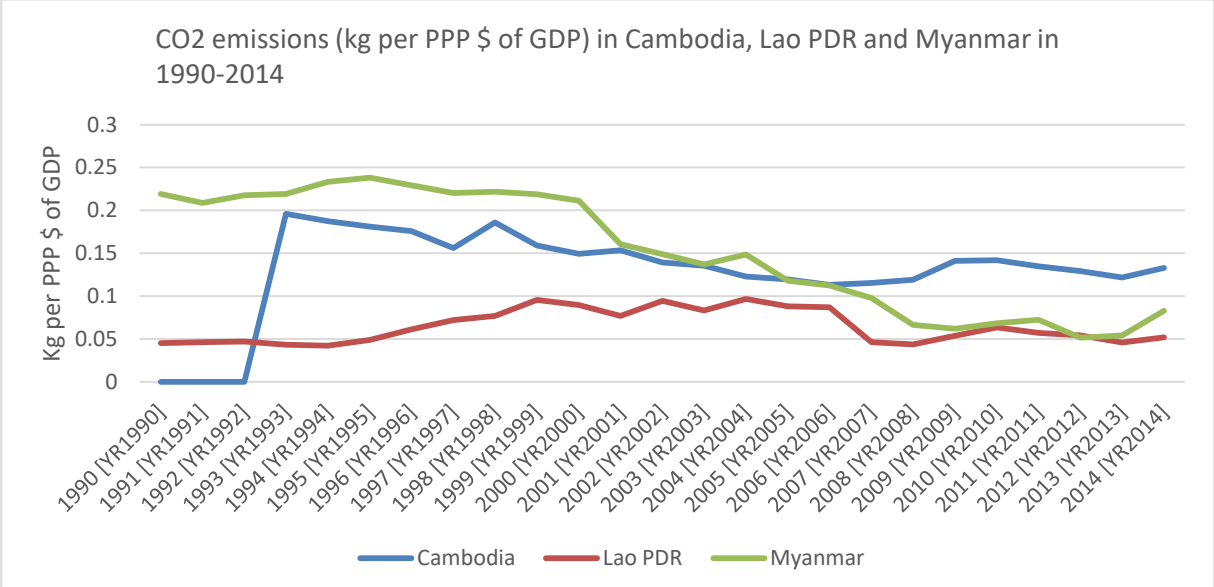

Figure 24. CO_2 emissions (kg per PPP $ of GDP) in Cambodia, Lao PDR and Myanmar in 1990-2014 (World Bank 2018).

In Fig. 25, long-run CO_2 emissions per capita and GDP per capita in Cambodia in 1990-2016 is reported (World Bank 2018).

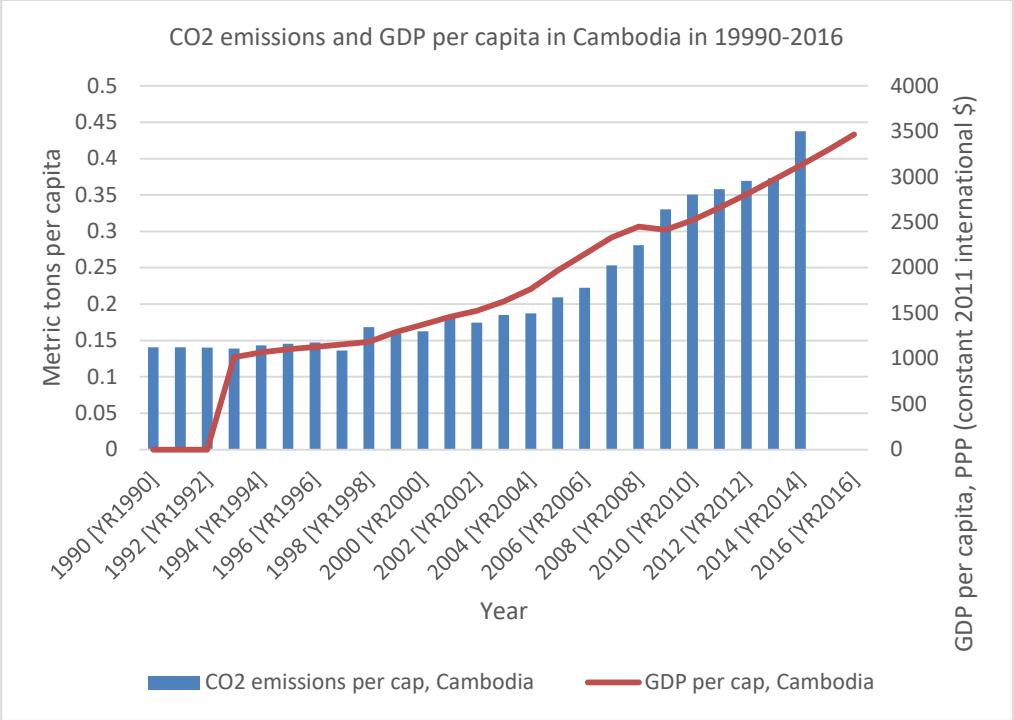

Figure 25. CO_2 emissions per capita and GDP per capita in Cambodia in 19990-2016 (World Bank 2018).

In Fig. 26, long-run CO_2 emissions per capita and GDP per capita in Lao PDR in 1990-2016 is reported (World Bank 2018).

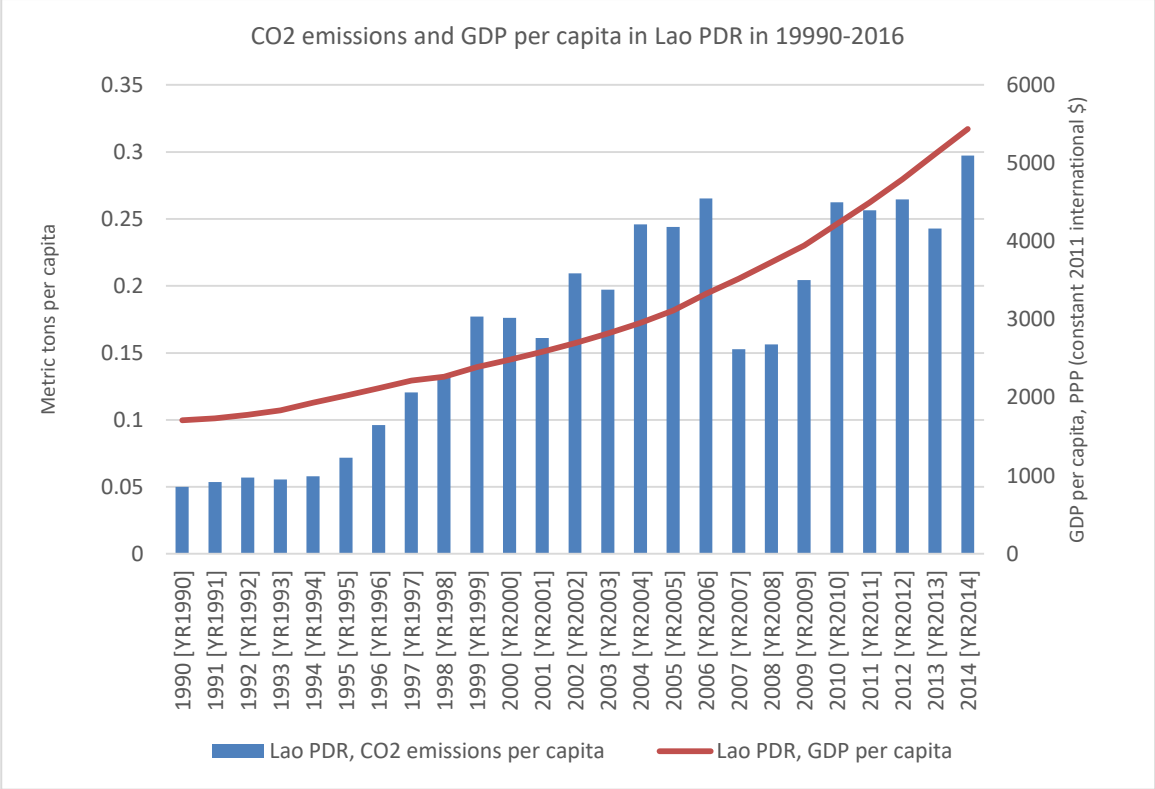

Figure 26. CO_2 emissions and GDP per capita in Lao PDR in 19990-2016 (World Bank 2018).

In Fig. 27, long-run CO_2 emissions per capita and GDP per capita in Myanmar in 1990-2016 is reported (World Bank 2018).

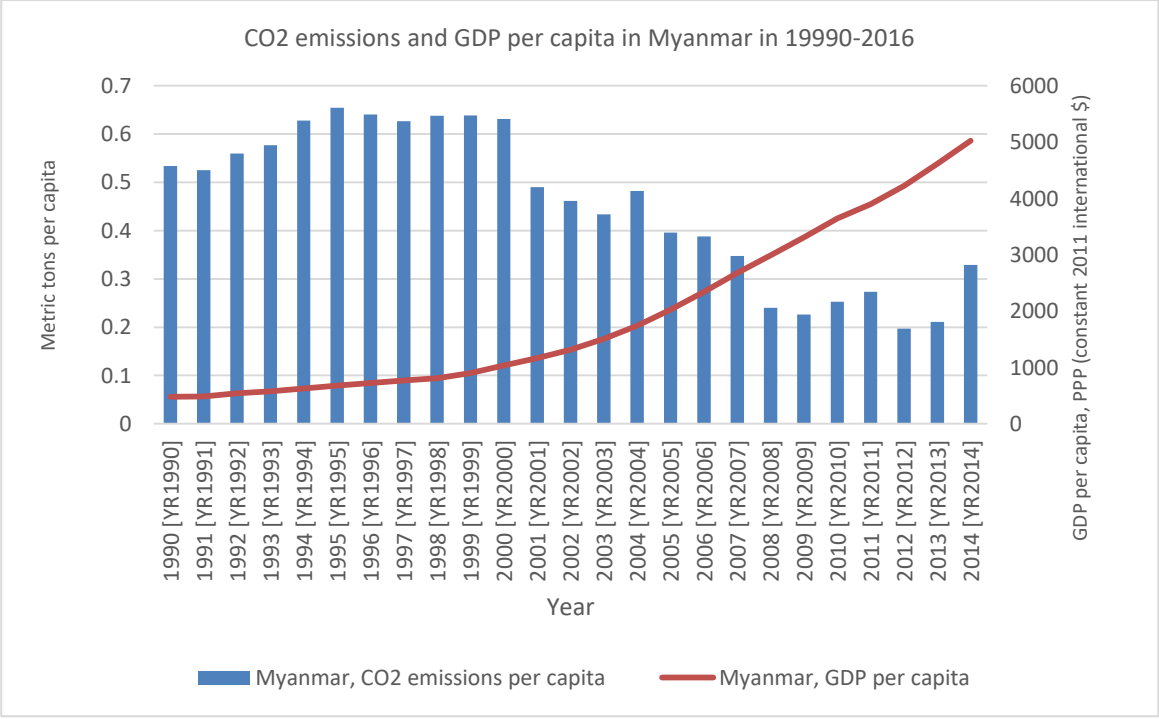

Figure 27. CO_2 emissions and GDP per capita in Myanmar in 19990-2016 (World Bank 2018).

In Fig. 28, long-run developments of forest area (sq.km) in Cambodia, Lao PDR and Myanmar in 1991-2016 are reported (World Bank 2018).

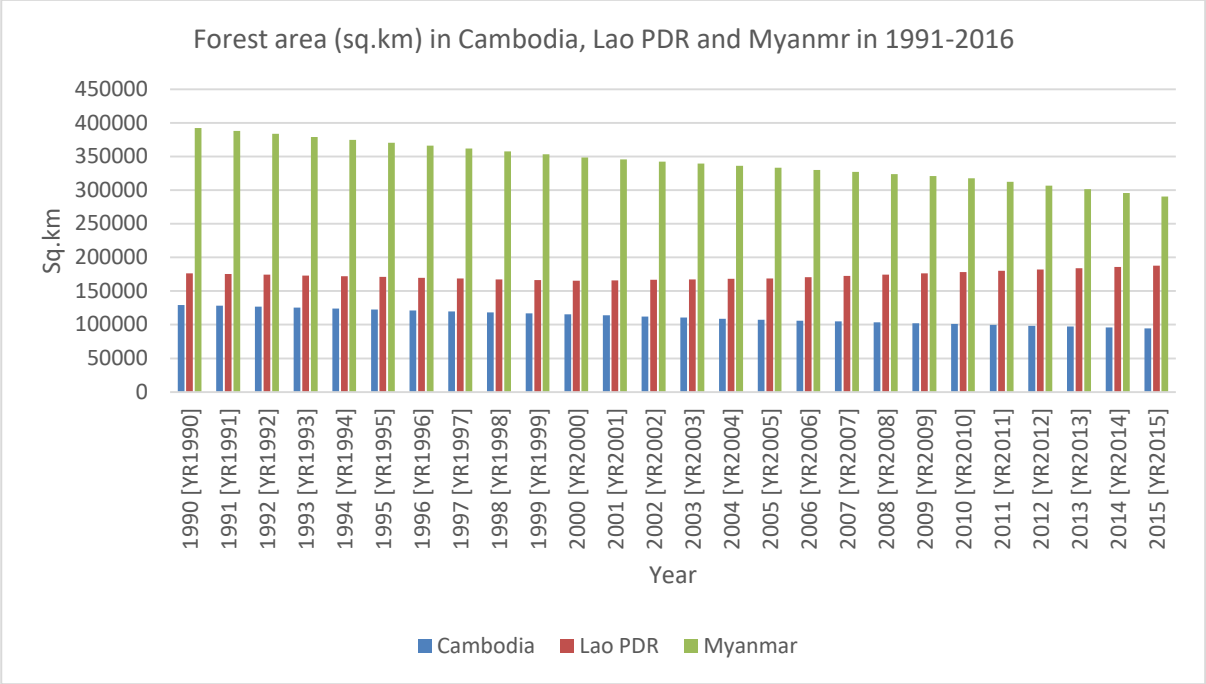

Figure 28. Forest area (sq.km) in Cambodia, Lao PDR and Myanmr in 1991-2016 (World Bank 2018).

In Fig. 29, long-run forest area (% of land area) in Cambodia, Lao PDR and Myanmar in 1991-2016 are reported (World Bank 2018).

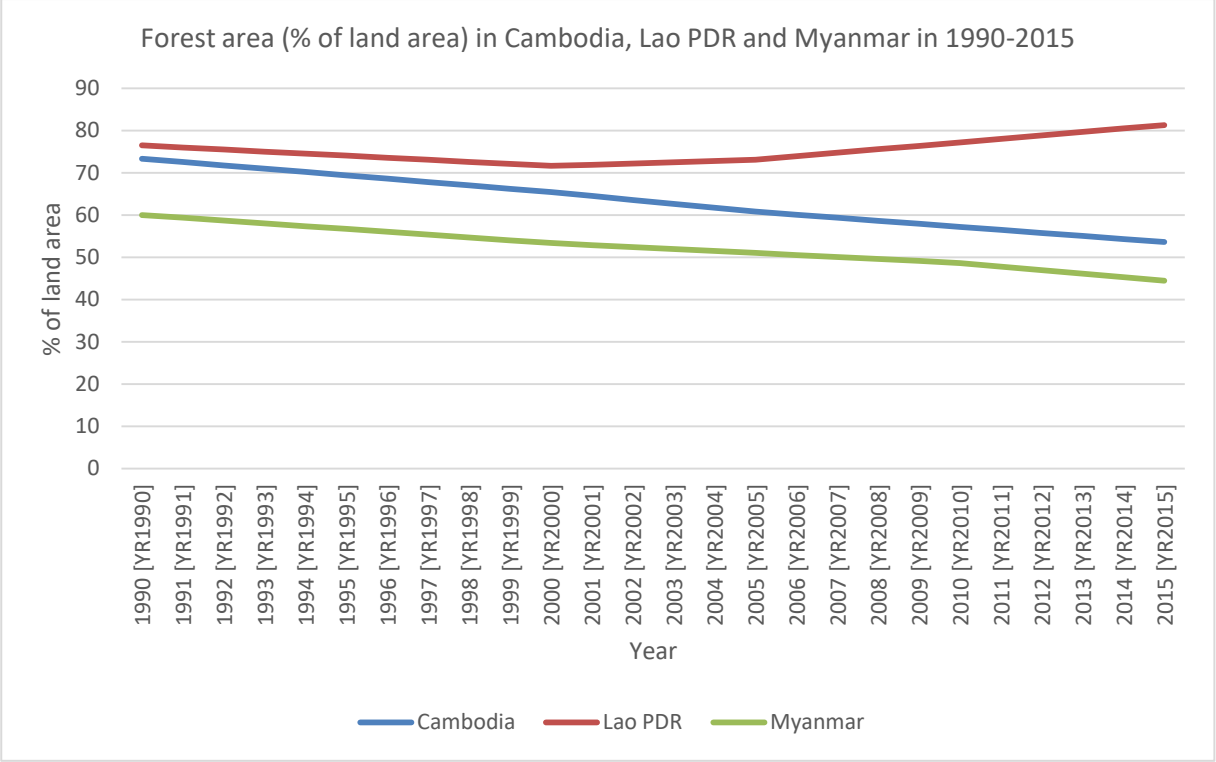

Figure 29. Forest area (% of land area) in Cambodia, Lao PDR and Myanmar in 1990-2015 (World Bank 2018).

In Fig. 30, long-run Forest area loss or increase (yearly, sq. km) in Cambodia, Lao PDR and Myanmar in 1991-2016 are reported (World Bank 2018).

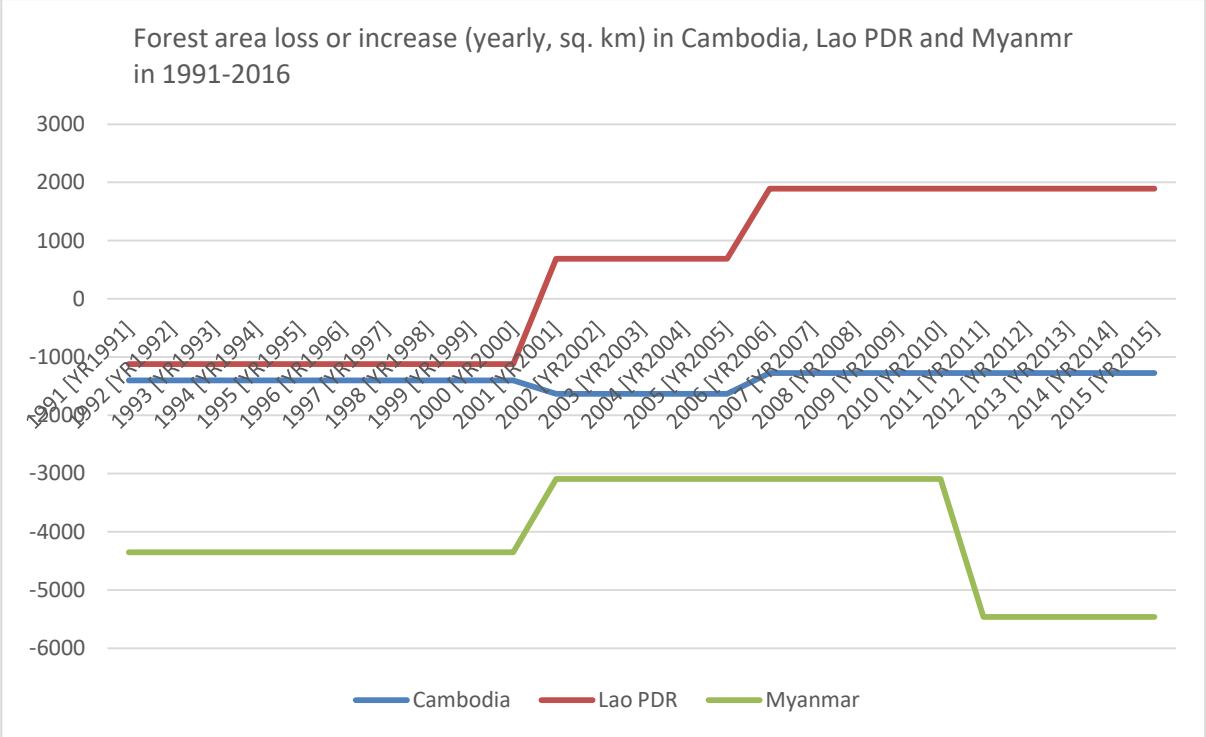

Figure 30. Forest area loss or increase (yearly, sq. km) in Cambodia, Lao PDR and Myanmr in 1991-2016 (World Bank 2018).

In Fig. 31, long-run forest rents (% of GDP) figures in Cambodia, Lao PDR and Myanmar in 1990-2016 are reported (World Bank 2018).

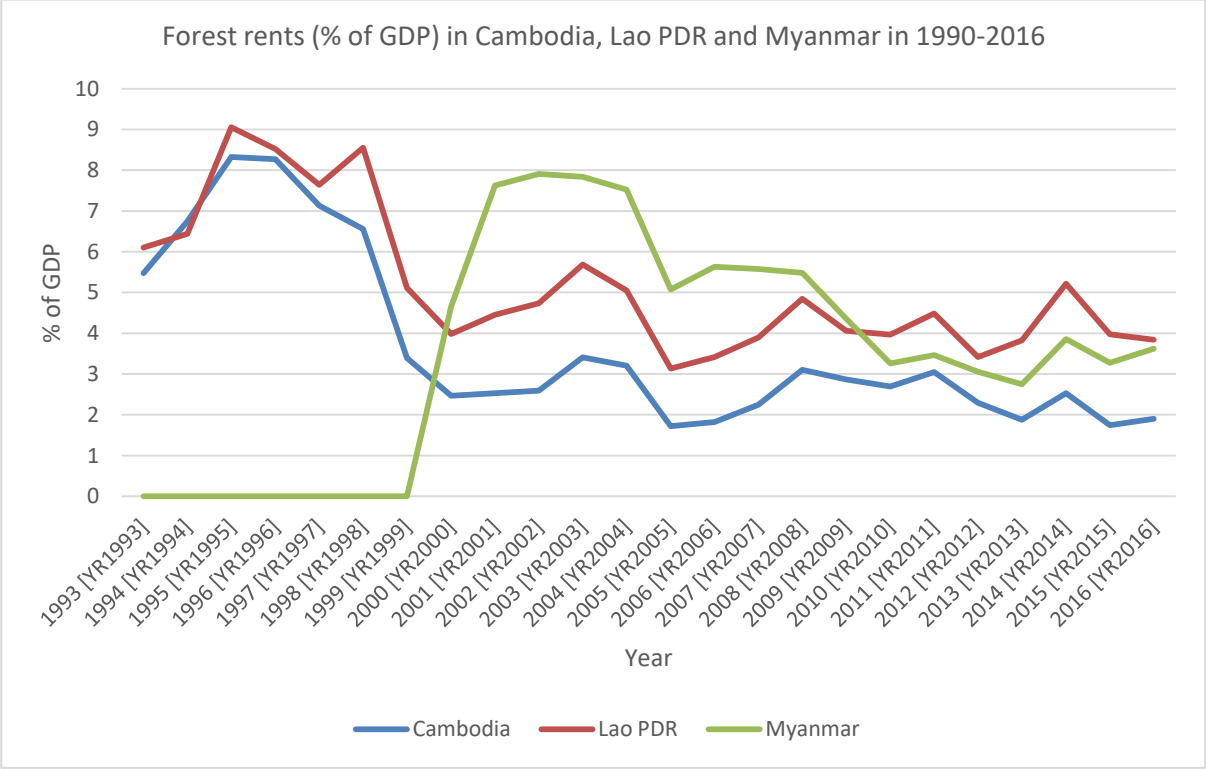

Figure 31. Forest rents (% of GDP) in Cambodia, Lao PDR and Myanmar in 1990-2016 (World Bank 2018).

In Fig. 32, long-run annual deforestration figures (% of change) in Cambodia, Lao PDR and Myanmar in 1990-2016 are reported (World Bank 2018).

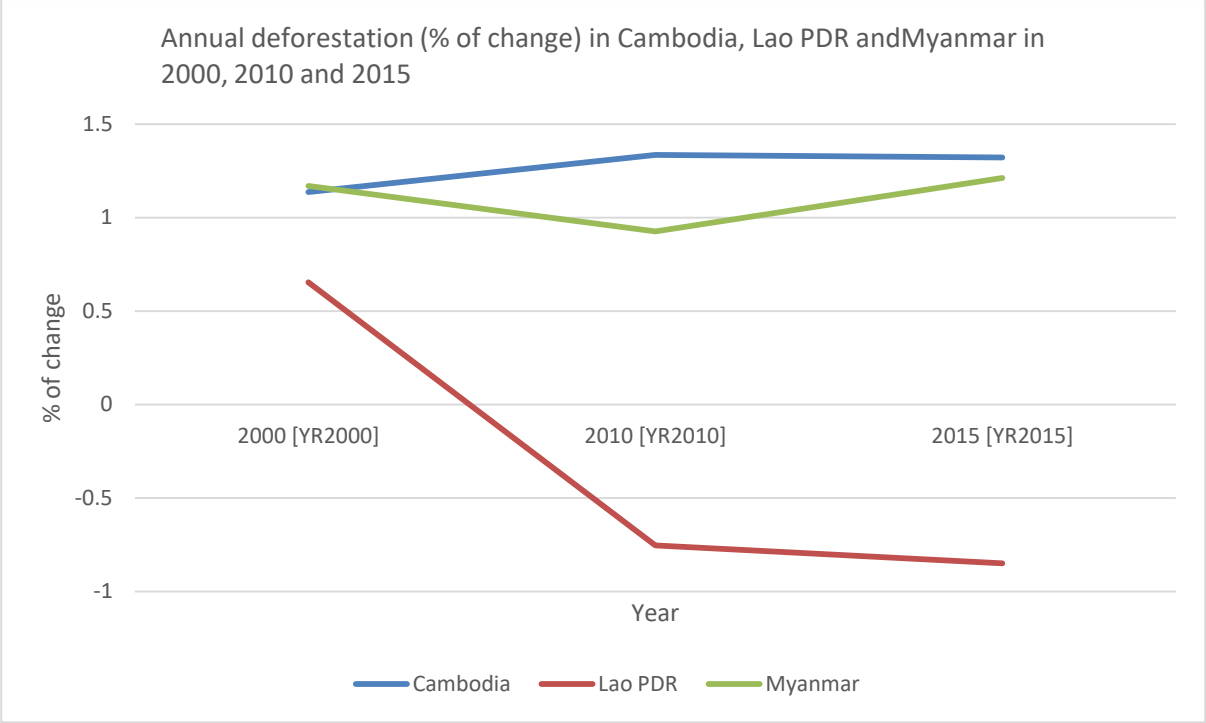

Figure 32. Annual deforestation (% of change) in Cambodia, Lao PDR and Myanmar in 2000, 2010 and 2015 (World Bank 2018).

4. Other sustainability transition challenges

In Fig. 33, long-run total natural resources rents (% of GDP) figures in Cambodia, Lao PDR and Myanmar in 1990-2016 are reported (World Bank 2018).

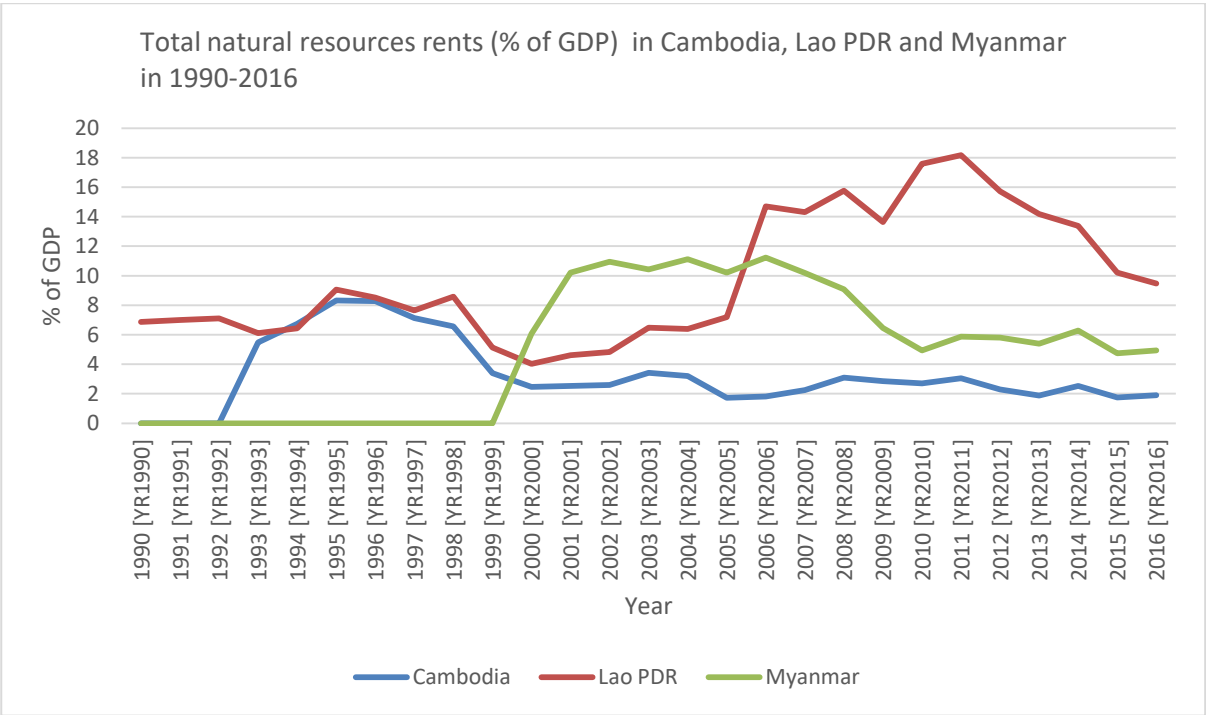

Figure 33. Total natural resources rents (% of GDP) in Cambodia, Lao PDR and Myanmar in 1990-2016 (World Bank 2018).

In Fig. 34, long-run adjusted net savings figures, excluding particulate emission damage (% of GNI) in Cambodia, Lao PDR and Myanmar in 1990-2016 are reported (World Bank 2018).

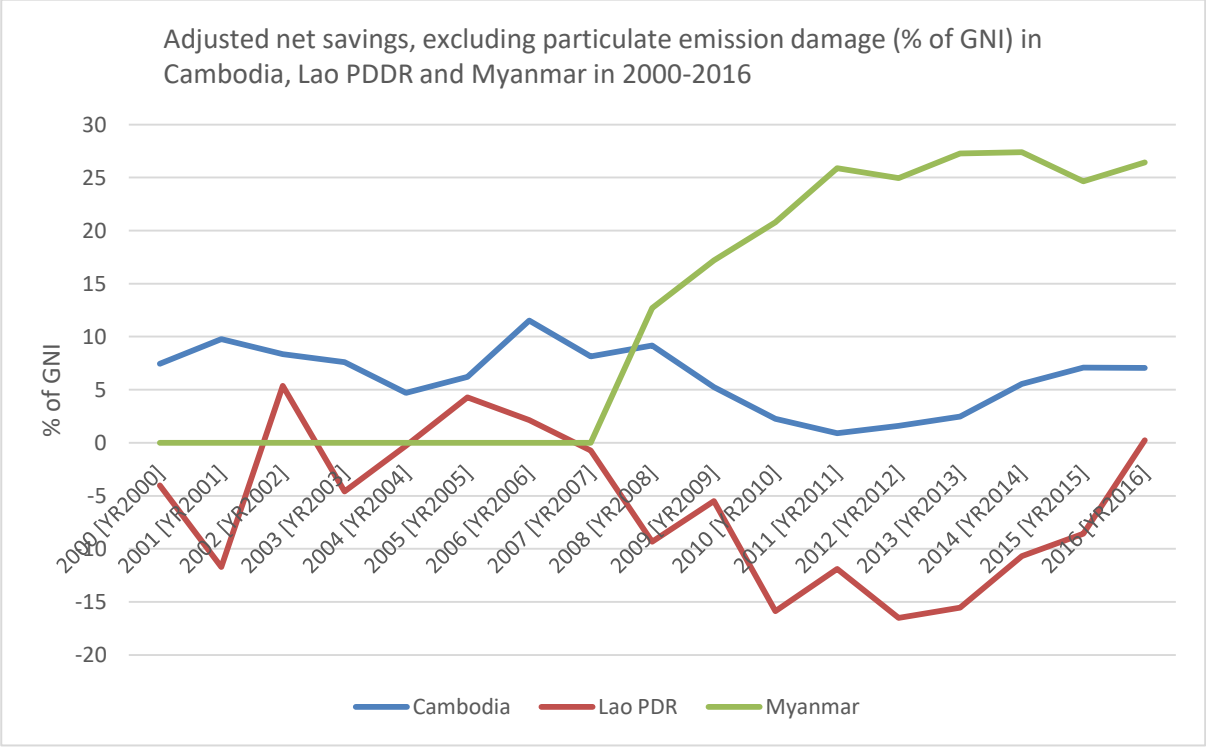

Figure 34. Adjusted net savings, excluding particulate emission damage (% of GNI) in Cambodia, Lao PDDR and Myanmar in 2000-2016 (World Bank 2018).

In Fig. 35, we report the relationship between energy and export intensity indexs (Energy Intensity Index/Export Intensity Index) in Cambodia, Lao PDR and Myanmar in 2000-2015

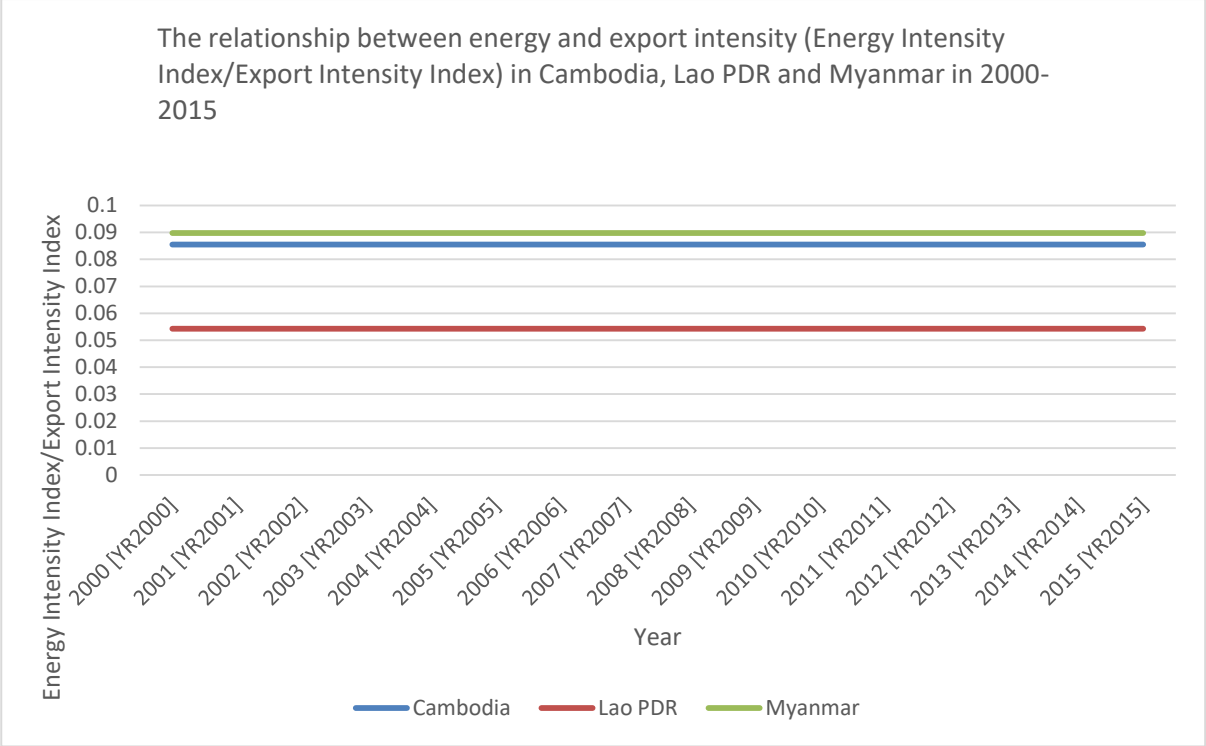

Figure 35. The relationship between energy and export intensity (Energy Intensity Index/Export Intensity Index) in Cambodia, Lao PDR and Myanmar in 2000-2015 (World Bank 2018).

In Fig. 36, long-run PM2.5 air pollution, population exposed to levels exceeding WHO guideline values in Cambodia, Lao PDR and Myanmar in 1990-2016 are reported (World Bank 2018).

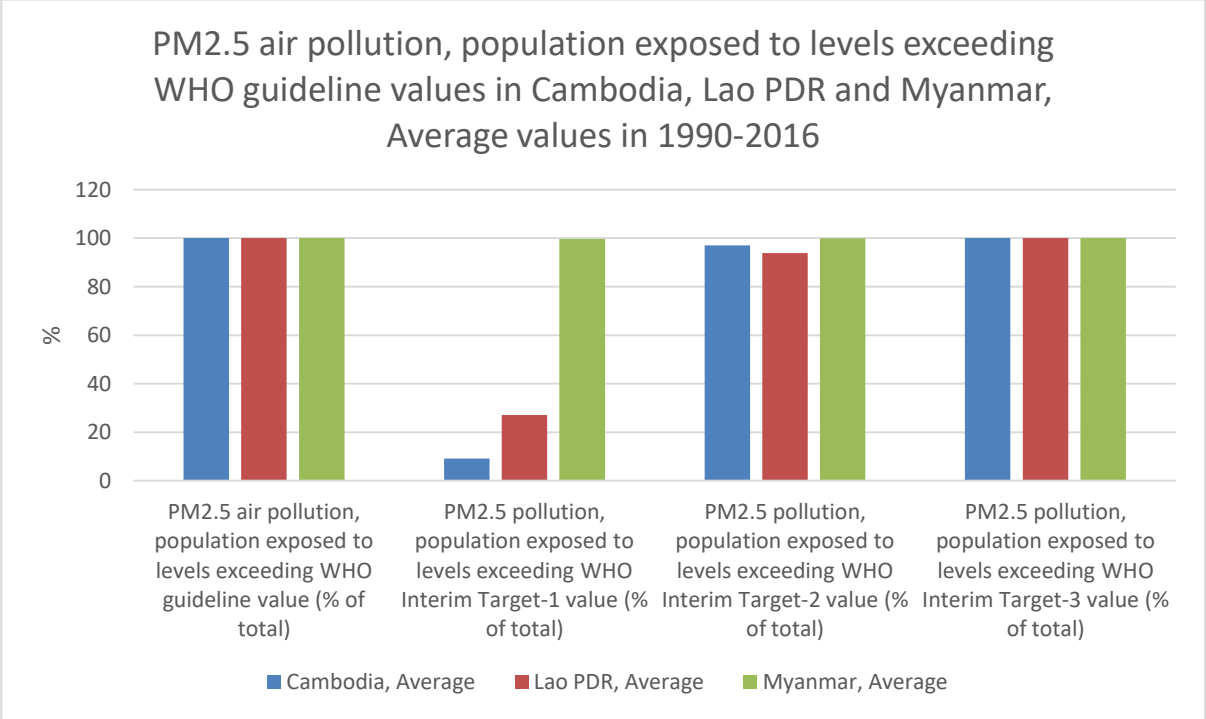

Figure 36. PM2.5 air pollution, population exposed to levels exceeding WHO guideline values in Cambodia, Lao PDR and Myanmar, Average values in 1990-2016 (World Bank 2018).

In Fig. 37, PM2.5 air pollution, mean annual exposure (micrograms per cubic meter), average in Cambodia, Lao PDR and Myanmar in 1990-2016 are reported (World Bank 2018).

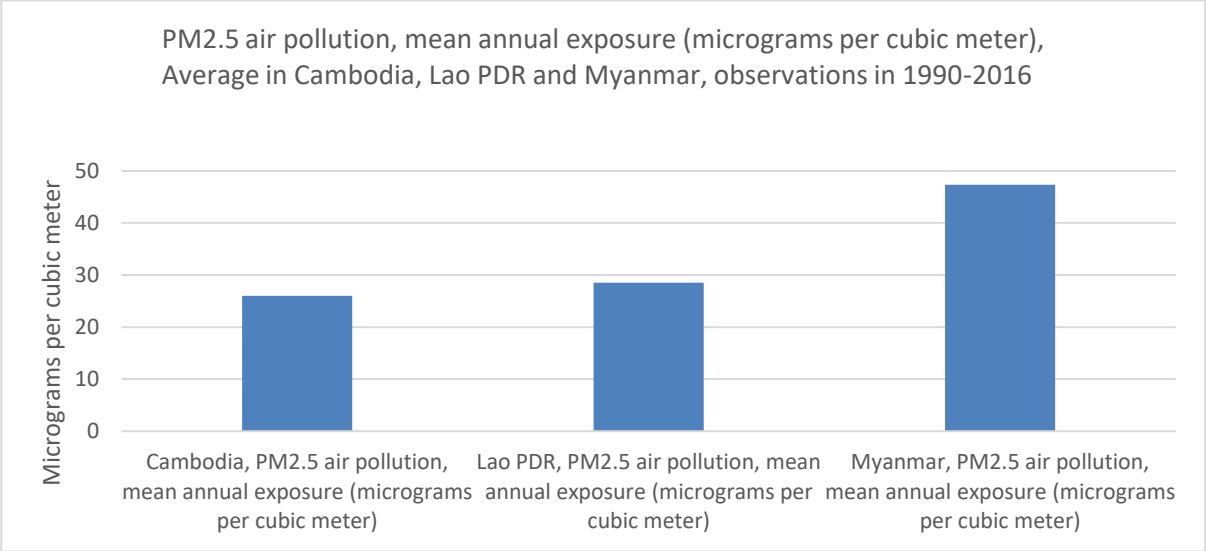

Figure 37. PM2.5 air pollution, mean annual exposure (micrograms per cubic meter), average in Cambodia, Lao PDR and Myanmar, observations in 1990-2016 (World Bank 2018).

In Fig. 38, the statistical figures of the people using at least basic drinking water services (% of population) in Cambodia, Lao PDR and Myanmar in 1990-2016 are reported (World Bank 2018).

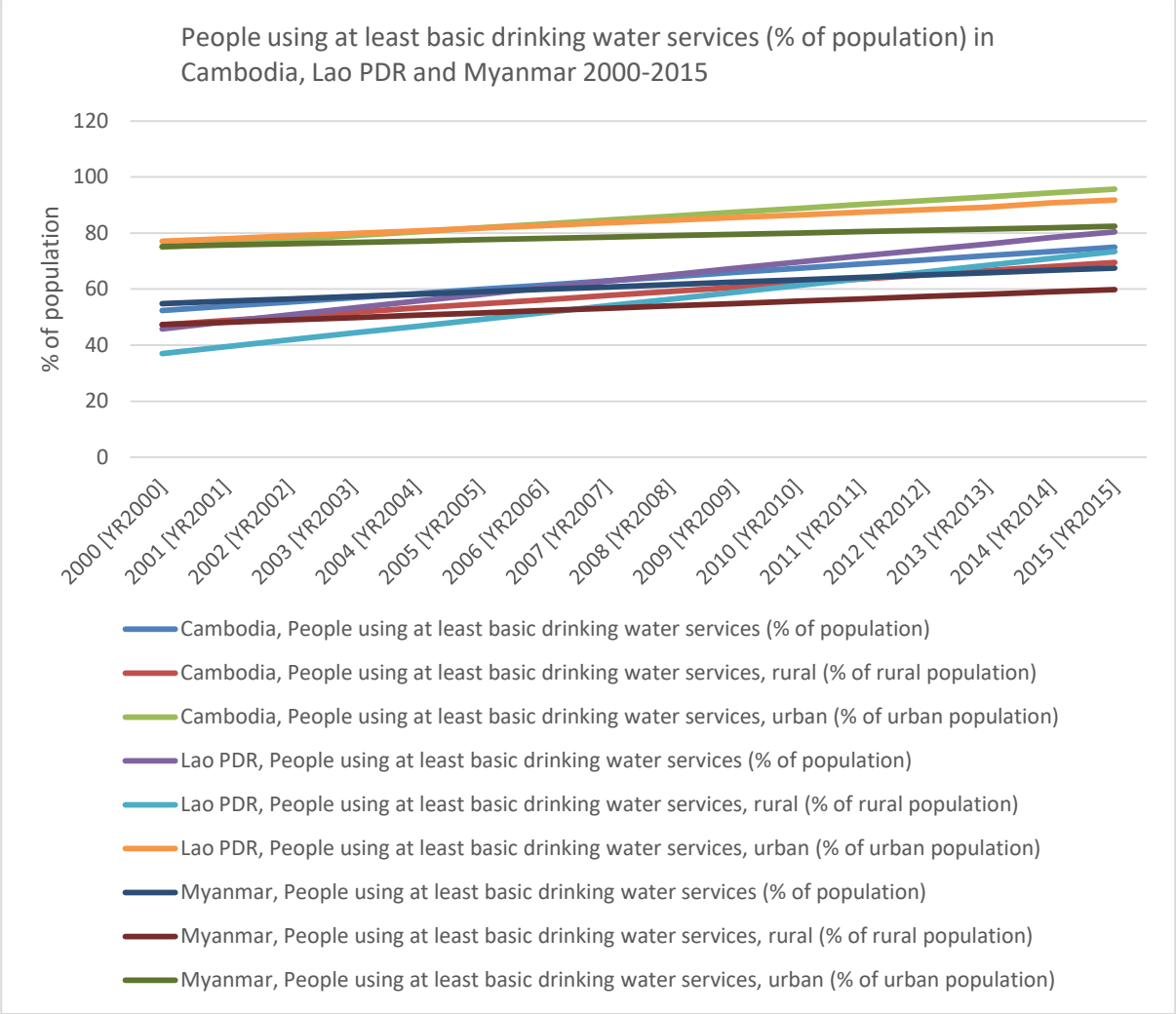

Figure 38. People using at least basic drinking water services (% of population) in Cambodia, Lao PDR and Myanmar 2000-2015 (World Bank 2018).

In Fig. 39, the statistical figures of the people practicing open defecation (% of urban population) in Cambodia, Lao PDR and Myanmar in 1990-2016 are reported (World Bank 2018).

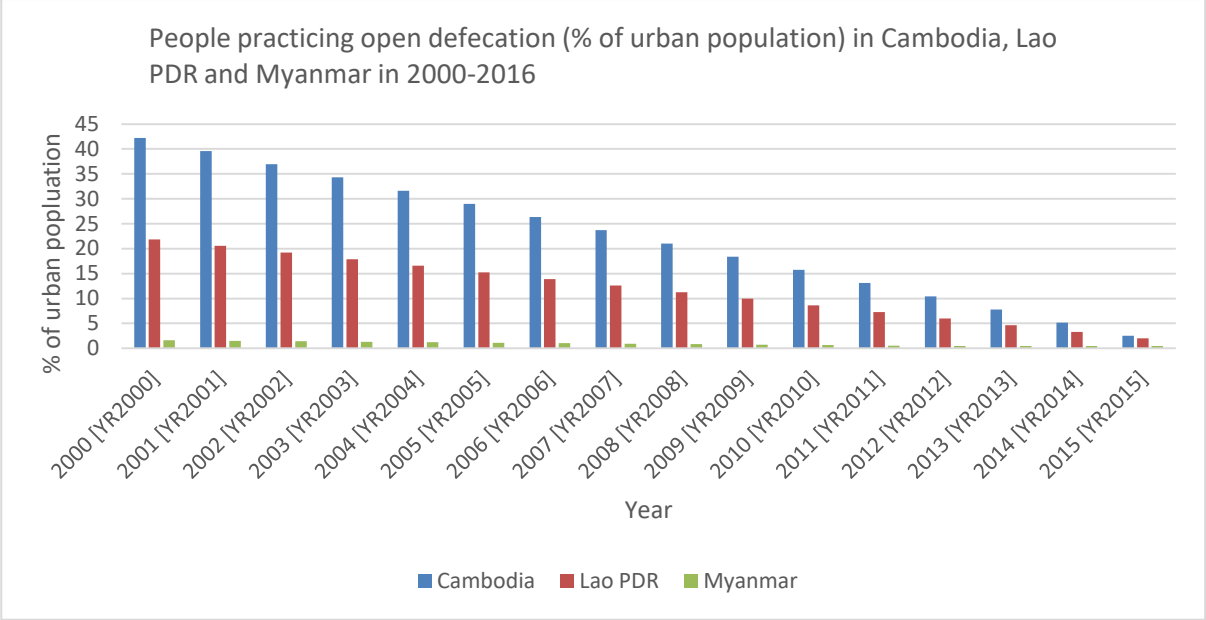

Figure 39. People practicing open defecation (% of urban population) in Cambodia, Lao PDR and Myanmar in 2000-2016 (World Bank 2018).

In Fig. 40, the statistical figures of the people using at least basic sanitation services (% of population) in Cambodia, Lao PDR and Myanmar in 1990-2016 are reported (World Bank 2018).

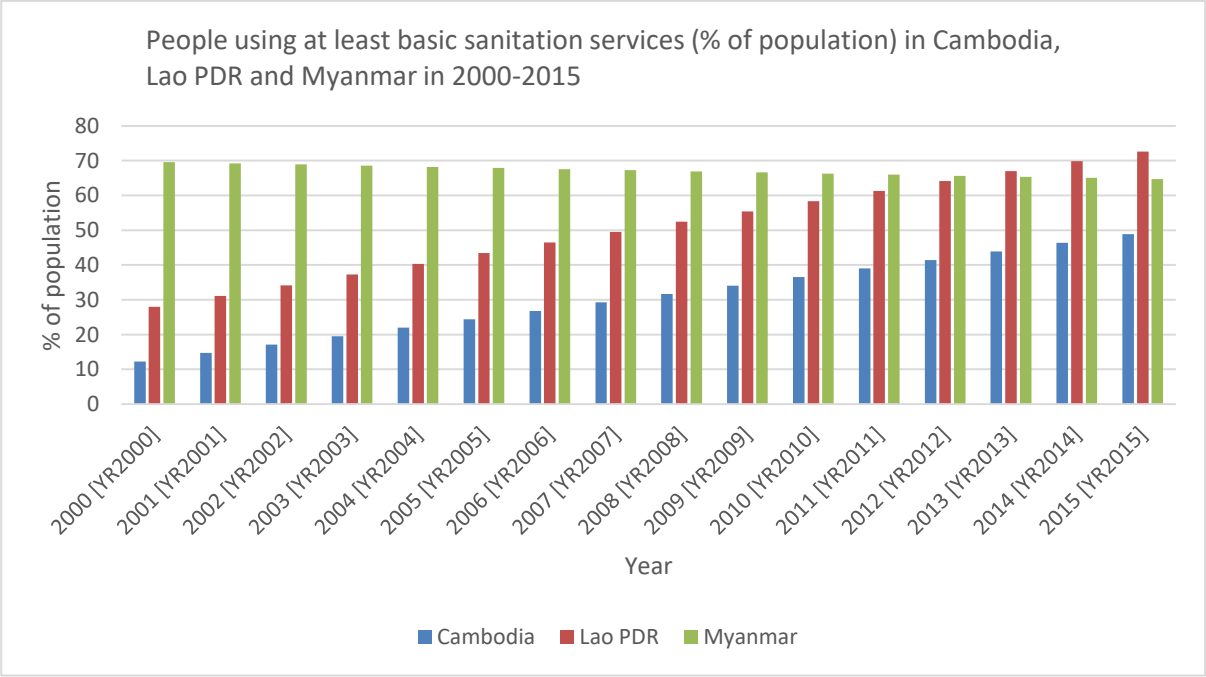

Figure 40. People using at least basic sanitation services (% of population) in Cambodia, Lao PDR and Myanmar in 2000-2015.

In Fig. 41, long run statistical figures of mineral rents (% of GDP) in Cambodia, Lao PDR and Myanmar in 1990-2016 are reported (World Bank 2018).

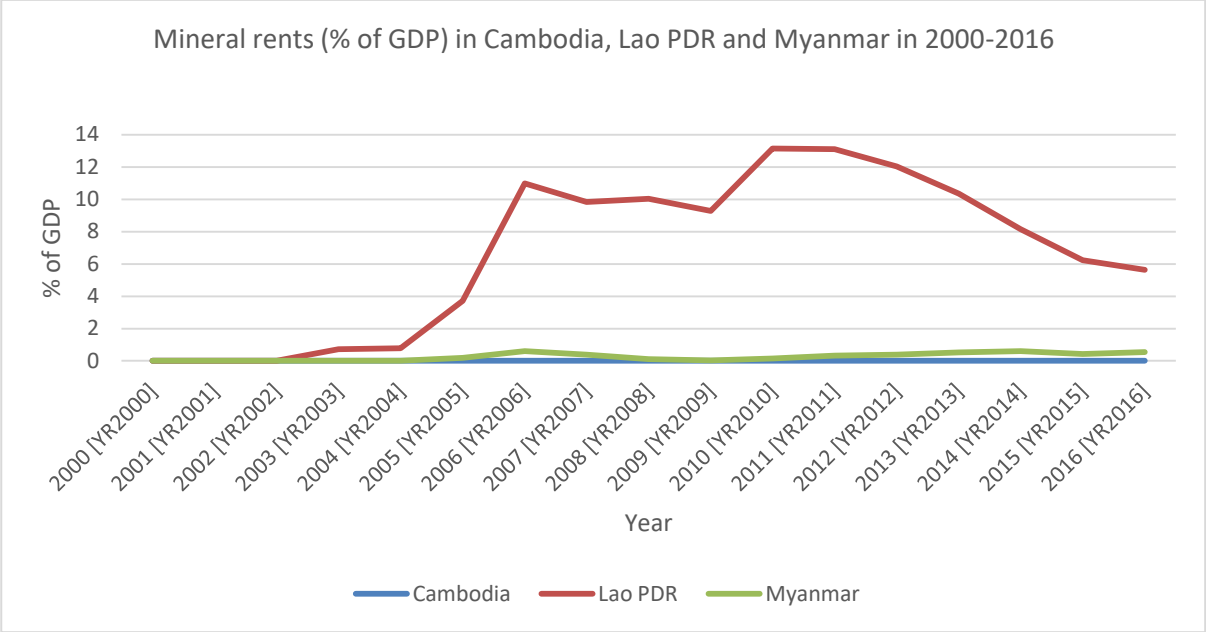

Figure 41. Mineral rents (% of GDP) in Cambodia, Lao PDR and Myanmar in 2000-2016 (World Bank 2018).

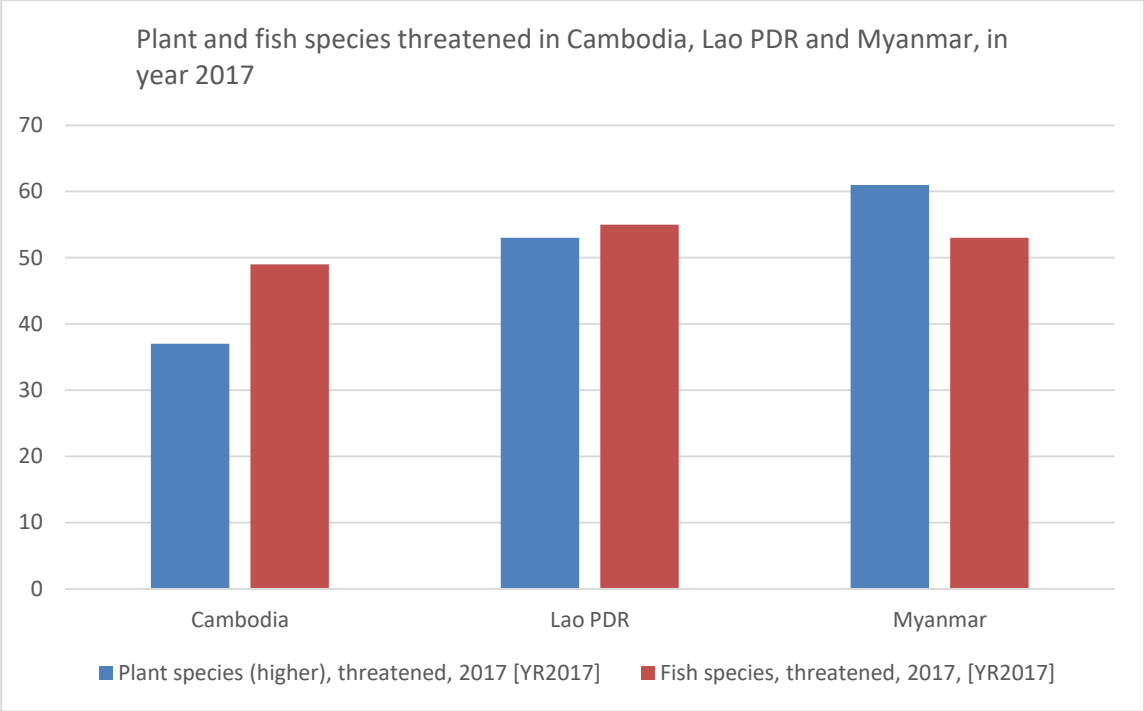

Figure 42. Plant and fish species threatened in Cambodia, Lao PDR and Myanmar, in year 2017 (World Bank 2018).

5. Reflections of green transition challenges in Cambodia, Lao PDR and Myanmar

On the basis of transition analyses presented in previous chapters we can summarize key results of green and sustainable transitions in Cambodia, Lao PDR and Myanmar (Table 1).

Table 1. Green transition and key observations in the study of Cambodia, Lao PDR and Myanmar.

Sustainability transitions	**Cambodia**	**Lao PDR**	**Myanmar**
Demographic transition			
Demographic, population transition	Change in annual population growth in 1960-2016, -0,97 %-units	Change in annual population growth in 1960-2016, -0,89 %-units	Change in annual population growth in 1960-2016, -1,23 %-units
Change in age dependency ratio (% of working-age population) in 1960-2050	-41,88	-36,58	-31,81
Change is life expectancy at birth, total (years) in 1960-2050	+35,86	+31,40	+28,10
Change in urban population, 1960-2050, millions, transition 1960-2050	+7,8 million.	+5,4 million	+30,2 million
Change in urban population share (% of total), transition in 1960-2050	+25,9	+52,8	+35,7
Change in death rare, crude, per 1 000 people, transition in 1960-2050	-14,45	-12,36	-10,01
Economic and social transition			
GDP per capita, transition in 1993-2016	2450,1	4238,7	5143,5
Socio-economic transition, jobs in agriculture, transition in 1990-2016	Employment in agriculture decreases, -53,2 %-units	Employment in agriculture decreases, -24,9 %-units	Employment in agriculture decreases, -28,3 %-units
Socio-economic transition, jobs in industries, transition in 1990-2016	Employment in industries increases, +22,9 % units	Employment in industries increases,+6,4 %-units	Employment in industries increases, +5,6 %-units

Socio-economic transition, jobs in service sector, transition in 1990-2016	Employment in services increases, +30,3 %-units	Employment in services increases, +18,5 %units	Employment in services increases, + 22,8 %-units
Energy transition			
Access to clean fuels and technologies for cooking (% of population), transition in 2000-2016	Improvement, +13,0%-units in 1990-2016	Improvement, +1,6 %-units in 1990-2016	Improvement, 13,7 %-units in 1990-2016
Access to electricity (% of population) transition in 1990-2016	Improvement, +49,8 %-units in 1990-2016	Improvement, +71,8 %-units in 1990-2016	Improvement, +21,3 %-units in 1990-2016
Access to electricity (% of population in rural areas), transition in 1990-2016	Improvement, + 24,2 %-units in 1990-2016	Improvement, +57,2 %-units in 1990-2016	Improvement, + 12,4 %-units in 1990-2016
Access to electricity (% of population in urban areas), transition in 1990-2016	Improvement, +65,2 %-units,, access level is 100%	Improvement, +2,1 %-units, access level is 97,4%	Improvement, +6,6 %-units, access level is 89,5%
Renewable electricity output (% of total electricity output), transition in 2000-2014	Improvement, +60,9 %-units	Improvement, +6,4 %-units	Improvement, 25,4 %-units
Renewable energy consumption (% of total final energy consumption), transition in 2000-2014	Decrease of %-share, -17,6 %-units	Decrease of %-share, -26,5 %-units	Decrease of %-share, -23,7 %-units
Water and sanitation transitions			
People using at least basic drinking water services (% of population), transition in 2000-2015	Improvement +22,6 %-units	Improvemen+34,6 %-units	Improvement+12,7 %-units
People using at least basic drinking water services, rural (% of rural population), transition in 2000-	Improvement +22,3 %-units	Improvement +36,3 %-units	Improvement +12,3 %-

2015			units
People using at least basic drinking water services, urban (% of urban population), transition in 2000-2015	Improvement +20,8 %-units	Improvement +14,7 %-units	Improvement +7,2 %-units
People practicing open defecation (% of population), transition in 2000-2016	Progress, -42,1 %-units	Progress, -6,5 %-units	Progress,-39,9 %-units
People practicing open defecation, rural (% of rural population), transition in 2000-2016	Progress, -41,6 %-units	Progress, -38,6 %-units-	Progress, -7,9 %-units
Peole practicing open defecation, urban (% of rural population), transition in 2000-2016	Progress, 39,7 %units	Progress, -19,9 %-units	Progress, -1,2 % units
People using at least basic sanitation services (% of population), transition in 2000-2016	Improvement, +36,6 %-units	Improvement, +44,6 %-units	Regression -4,9 %-units
Food transition			
Prevalence of undernourishment (% of population), transition in 2000-2015	Progress-13,9 in %-units	Progress -20,5 in %-units	Progress-31,5 in %-units
Global landscape transition and its impacts	International aid ASEAN cooperation	International aid important, ASEAN cooperation	Foreign direct investments important, ASEAN cooperation
Socio-technical systems	Export-oriented STS	Land-locked, more nationally oriented STS	Land-locked, but export oriented STS
Niche-level aspects	Niche activities are mostly agricultural and service-oriented	Niche-activities are mostly agricultural, but partly service-oriented	Niche-activities are both agricultural and industrial

The key results of forest and mineral rents can be reported in Table 2.

Table 2. Forest rents (% of GDP) and mineral rents (% of GDP), transition analyses.

	Cambodia	**Lao PDR**	**Myanmar**
Forest rents (% of GDP), Forest rents are roundwood harvest times the product of average prices and a region-specific rental rate, transition in 2000-2016	Decrease, -0,57 %-units	Decrease, -0,14 %-units	Decrease, -1,0
Mineral rents (% of GDP), Mineral rents are the difference between the value of production for a stock of minerals at world prices and their total costs of production. Minerals included in the calculation are tin, gold, lead, zinc, iron, copper, nickel, silver, bauxite and phosphate. Transition in 2003-2016	0, not measured	Increase, +4,9	Increase, +,5

Our transition analyses indicate that forest rents are decreasing in Cambodia, Lao PDR and Myanmar. Mineral rents are increasing in Lao PDR and Myanmar.

In economic terms, Myanmar has showed largest economic growth potential in absolute financial terms. Cambodia and Lao PDR have one fifth of Myanmar´s growth volume in 1993-2016. This probably means that global landscape is more favourable with FDIs for Myanmar than for Cambodia and Lao PDR in the future.

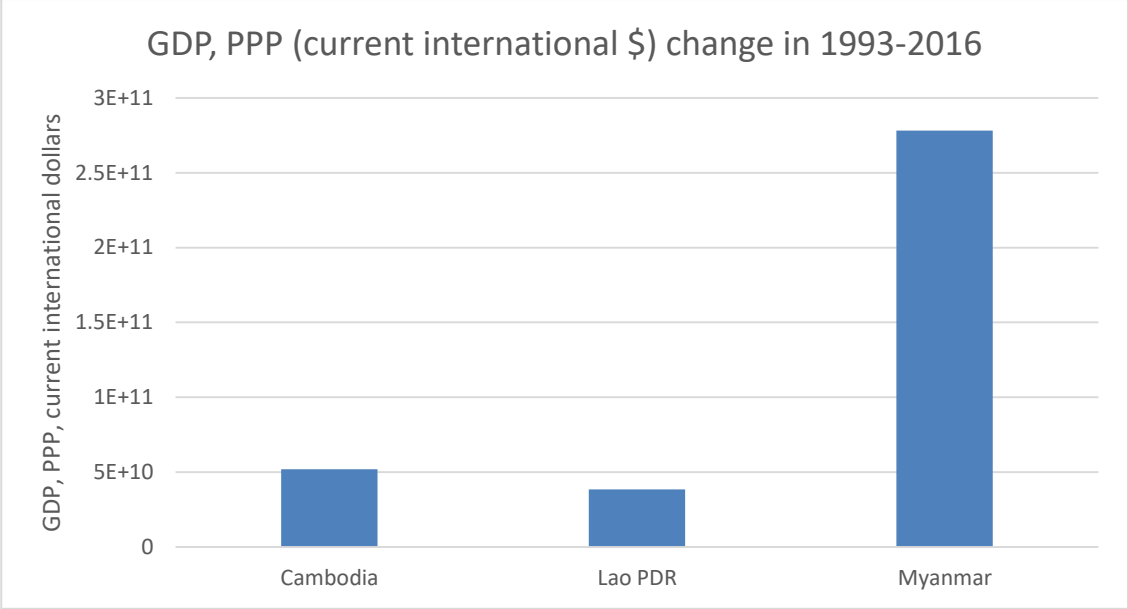

Figure 43. Transition in economic growth potential in Cambodia, Lao PDR and Myanmar, 1993-2016 (World Bank 2018).

In Fig. 44 we have reported a long-run analysis of key governance domains in Cambodia, Lao PDR and Myanmar. This median index analysis reveals that Cambodia has the most advanced governance system of these Mekong countries. After Cambodia come Lao PDR and Myanmar in median index terms. This is information of governance domains is useful, when we analyse the expected sustainability transition processes in these developing countries.

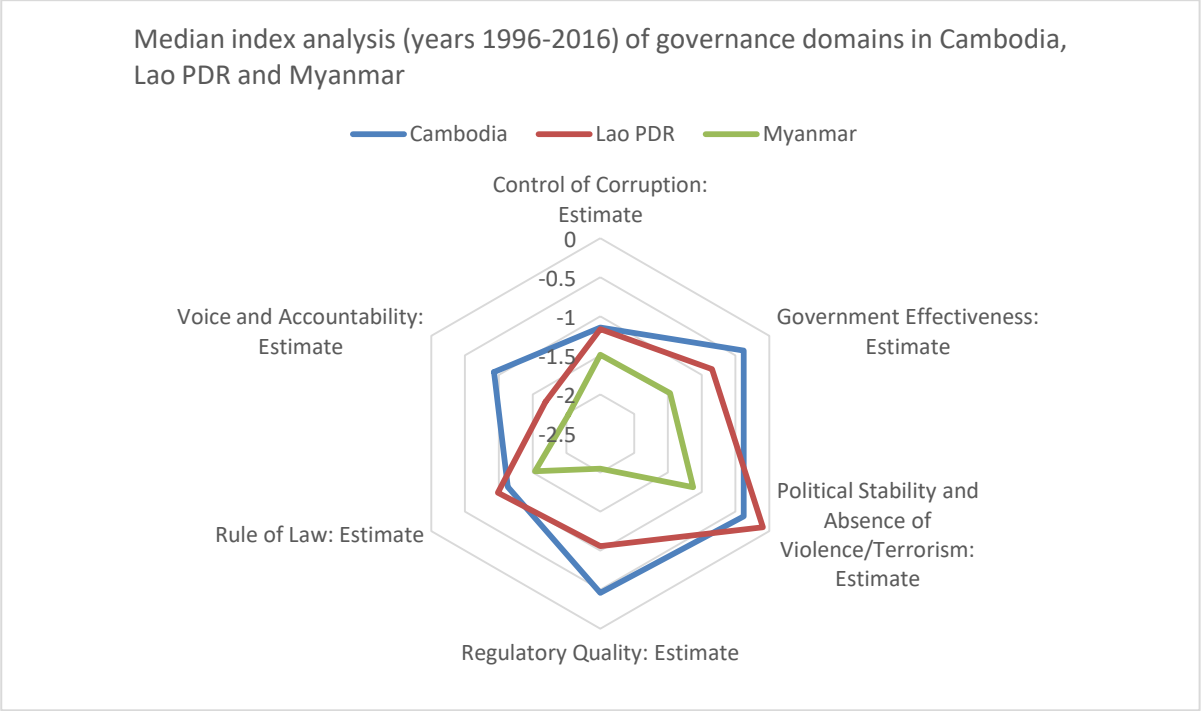

Figure 44. Median index analysis (years 1996-2016) of governance domains in Cambodia, Lao PDR and Myanmar (World Bank 2018b)

When we analyse information Figures 43 and 44, we can note that Myanmar very big potential in economic growth, but its governance systems may bring shadows for future sustainability transitions. Cambodia has quite good growth potential and its governance system is the most advanced of these three countries. From this analysis we can expect that Cambodia could manage its sustainability transition in a successful way. Of course, Cambodia has some problems in its governance structures. Recent report of World Economic Forum (2018) lists the most problematic factors for doing business in Cambodia (see Fig. 45, the analysis of Cambodia. World Economic Forum 2018a). According to WEC-analyses, three key problems are corruption, inadequately educated workforce and policy instability. Other problems have been identified too.

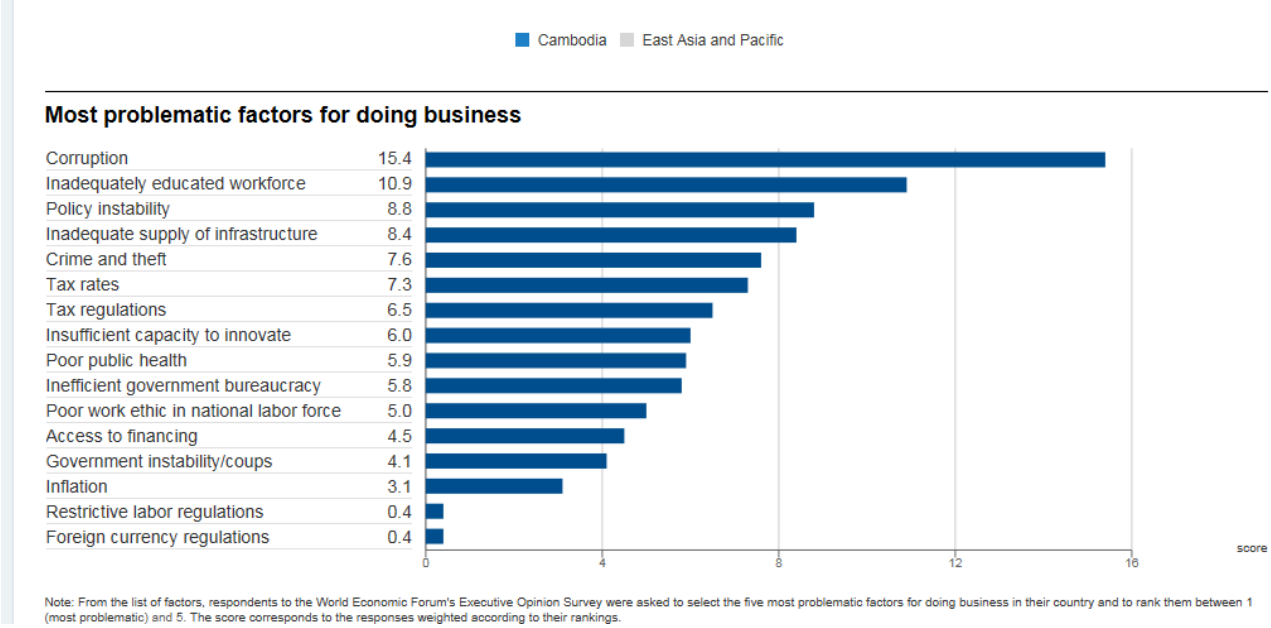

Figure 45. Most problematic factors for doing business in Cambodia. (World Economic Forum 2018a)

Also Lao PDR has some problems in its governance structures. Recent report of World Economic Forum lists the most problematic factors for doing business in Cambodia (see Fig. 46, the analysis of Cambodia. World Economic Forum 2018b). According to WEC-analyses, three key problems are inadequately educated workforce, tax rates and access to financing. Other problems have been identified too.

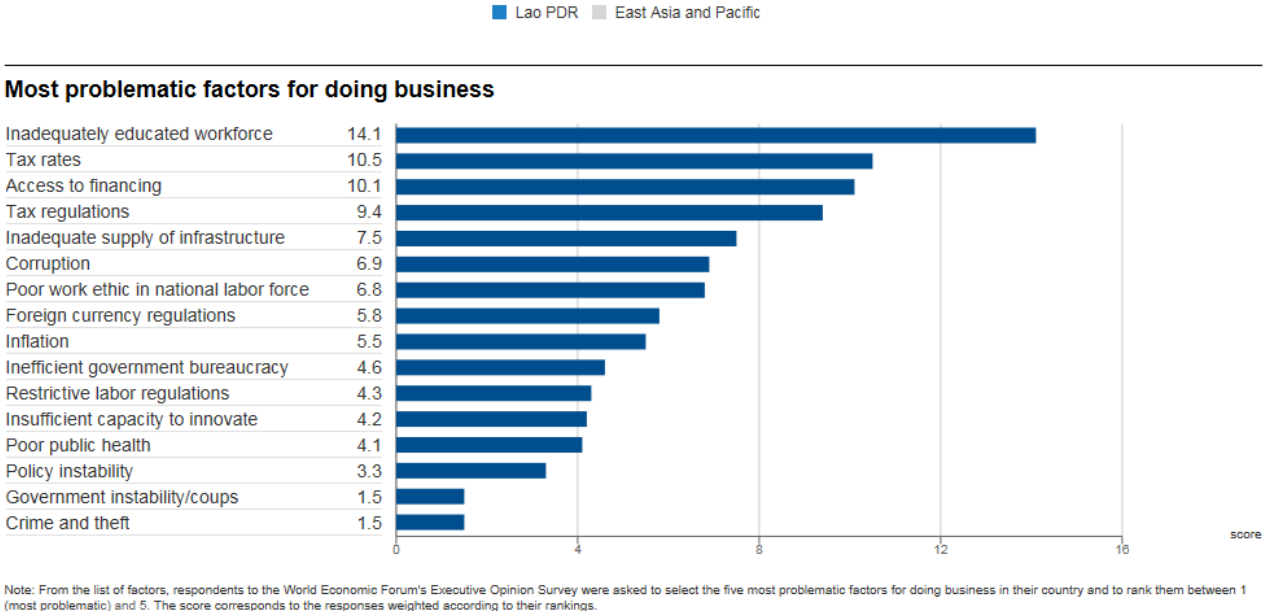

Figure 46. Most problematic factors for doing business in Lao PDR (World Economic Forum 2018a).

World Economic Forum has not published similar analyses about Myanmar, but we can expect that there are some governance challenges in similar domains of governance.

6. Conclusions

In this paper we have presented sustainability transition analyses concerning Cambodia, Lao PDR and Myanmar. Key findings of sustainability transitions were summarized in Tables 1 and 2. Generally speaking, each of the countries surveyed has its own special challenges for sustainable development. The socio-cultural context and historical background define the direction and conditions of sustainable development paths in these three countries. We can conclude that the key variables for evaluation are, of course, (1) demographic change, (2) urban development, (3) economic structure and (4) economic growth in the countries surveyed. It is gratifying to note that these three countries have achieved quite a positive development paths in the Nexus variables (food security, energy security and food security), although biodiversity problems are significant in all three countries. As regards sanitation, development has been positive, especially in cities, and some positive developments have also taken place in rural areas.

If we look at the specificities of these three countries, I can observe the following remarks on Cambodia:

- Cambodia is perhaps the best administrative capacity for sustainable development in the three countries surveyed. Economic growth potential is also quite good, but so far it has remained worse in terms of population prosperity than in Laos and Myanmar.
- If we look at the population's expected life expectancy, its long-term development prospects are the best in Cambodia. This is important for the expected well-being of citizens. This creates, on the one hand, socio-economic pressures on the balance of the dependency ratio in Cambodia. These socio-demographic pressures are the biggest in Cambodia.

- The urbanization pressure in Cambodia is lower than in Laos and Myanmar. Yet urbanization continues to be very strong variable in this developing country. For this reason, the challenges of balanced regional development should be emphasized in the management of sustainable development.
- The deterioration of agriculture and agribusiness is the strongest in Cambodia, and the shift towards service industries and manufacturing industry is particularly strong.
- A major challenge for sustainable development in Cambodia is pressure on the use of forests. This pressure is connected to many changes in urban areas and changes in livelihoods. Even more versatile and resilient food production and supply chain are still a big challenge is Cambodia.

If we look at the specific features of these three countries, we can see the following remarks on Laos:

- Laos have a reasonably good administrative capacity to implement sustainable development,

even though development needs in some areas are obvious. Growth potential is pretty good, especially Laos has been quite successful in improving the average prosperity of citizens.

- The life expectancy in Laos is positive and continues to develop.
- The urbanization process is the same type as in Cambodia and the challenges of balanced regional development should be emphasized in sustainable development management.
- In Laos, agriculture has not deteriorated as rapidly as in Cambodia, and the shift towards industry and services has been sluggish compared to Cambodia and Myanmar.
- A major challenge for sustainable development in Lao PDR is its resource policy, especially for mineral resources. Designing sustainable use of water resources is also a major issue for sustainable development.

If we look at the specific features of these three countries, we can note the following remarks concerning Myanmar:

- The administrative capacity of Myanmar has developed favorably in recent years, although it is still not at the top level. Myanmar's growth potential is the best in the countries surveyed.
- Both the expected strong economic growth and the substantial quantitative growth of the population will create their own special sustainability challenges for Myanmar.
- The life expectancy in Myanmar is not as high as in Laos and Cambodia. This is because healthcare has already reached a good level in Myanmar.
- The direction of change in the business structure in Myanmar has focused on the service economy, even though industry is growing but not as strongly as in Cambodia.
- The greatest challenge for sustainable development is to populate the growing population in growing cities and to build an adequate infrastructure for the urban population. These challenges are of the greatest scale in Myanmar.

If national systems in Cambodia, Lao PDR and Myanmar are evaluated from the MLP point of view, we can say that all three countries are quite dependent on foreign investment either through foreign direct investments or development aid. This is a key assessment issue of the global landscape-level perspective. The socio-technical regimes are quite different in these three countries. Some of the regiments have been inherited from colonial times, some have been reformed with the support of the UN systems and agencies. Yet there are still needs for renewal and developments. Perhaps the biggest challenge for the modernization of socio-technical regimes is the problems faced by the administration and local civil society. The local level is not very strong in these three countries and there is a need for and ordering a national

innovation system with more effective niche innovation activities. However, as a result of the urbanization and ongoing progress of educational systems, we can expect the niche level to be strengthened in all the countries surveyed. It is a matter of time when urbanization and educational level reaches this critical momentum of grass-root niche-innovation development.

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Household Energy Use in Cambodia: A Field Survey Data Analysis

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Abstract: In the classical energy ladder model households in developing countries will move to more modern energy sources as their economic situation improves. In the ladder model, energy sources are ranked from fuels less desirable but easier to get to more expensive but handier fuels. The energy options accumulate in the households when they get wealthier and this approach supports the adoption of the energy stacking model. As modern energy sources are connected with welfare, the ability to use modern energy is a question of equality. The study is based on field survey household data collected in two provinces, Kampong Cham and Pursat. In these provinces modern energy sources are used more in higher income groups, as also the energy ladder model suggests, and this tendency can be seen especially in urban areas. In rural areas incomes influences less to the energy use, and traditional fuels are in important role despite the incomes of a household. Electricity is even surprisingly commonly use in the observed provinces. Key findings of this study provide many useful field observations concerning electrification of rural regions in Cambodia.

1. Introduction

There is ongoing sustainability transition in developing countries. Developing countries are facing these grand sustainability challenges in local contexts of poverty and scarce resources. There are many urgent needs of changes in socio-technical regimes and systems (Ramos-Mejia et al. 2018). This paper is focused on household energy use and access in local conditions of Cambodia. Cambodia has been on the United Nations list of the least developed countries since 1991. Most of its land surface is rural area, about 99 % in 2010 (World Bank 2017). In Cambodia traditional fuels, mainly firewood, are the most common source of energy. Reliable access of adequate energy is universally seen as one of the crucial factors of development and precondition for meeting basic human needs. According to Bhattacharyya (2012) both electricity and cooking energy access have a good correlation with Gross National Income (GNI), but the correlation is even stronger with Human Development Index (HDI). In additions to GNI, HDI contains data from expectancy at birth and mean schooling years. (ibid. 262.) It seems that access to energy does have an influence to economic growth, but its influence is even stronger to the well-being of people. This paper illuminates the current situation with access to energy and also energy usage behavior in Cambodian households and provide background for developing energy services towards the transition to more sustainable energy system.

In the classical energy ladder concept households in developing countries will move to more modern energy sources as their economic situation improves (e.g. Leach 1992, Hosier et. al. 1987). In the **Error! Reference source not found.** energy sources are classified to traditional and modern

fuels as well as based on income of the household. The availability, easiness to access and cost of these different fuels seem to affect to the energy choices. Traditional fuels i.e. plant residues, dung and firewood may be free to collect or cheap to buy but collection and cooking is time consuming. Furthermore, inefficient burning (associated with traditional cook stoves) may cause problems to human health such as respiratory and eye diseases. Instead Liquefied Petroleum Gas (LPG) and electricity, for instance, are harder to get but are more efficient, clean to use and convenient to store (Leach 1992, 118).

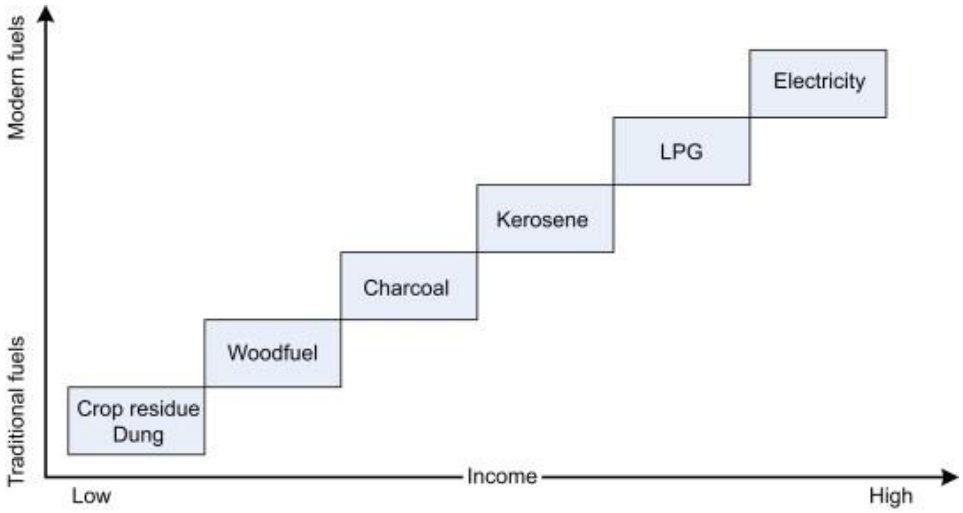

Figure 1. The classic energy ladder (Kowsari & Zerriffi 2011).

Energy ladder concept is often criticized as a way too simplifying theory (e.g. Kowsari & Zerriffi 2011; Ekholm et al. 2010). For example, the theory assumes that when households get wealthier they abandon the inferior fuels. According to Kowsari and Hisham (2011, 7508) this is in contradiction with empirical studies (e.g. Heltberg 2004; Hosier et. al. 1987; Masera et al. 2000). More than changing energy source, the households take new sources besides the old ones. Thus the energy options accumulate in the households when they get wealthier, as can be seen in **Error! Reference source not found.**. (Kowsari & Zerriffi 2011, 7508).

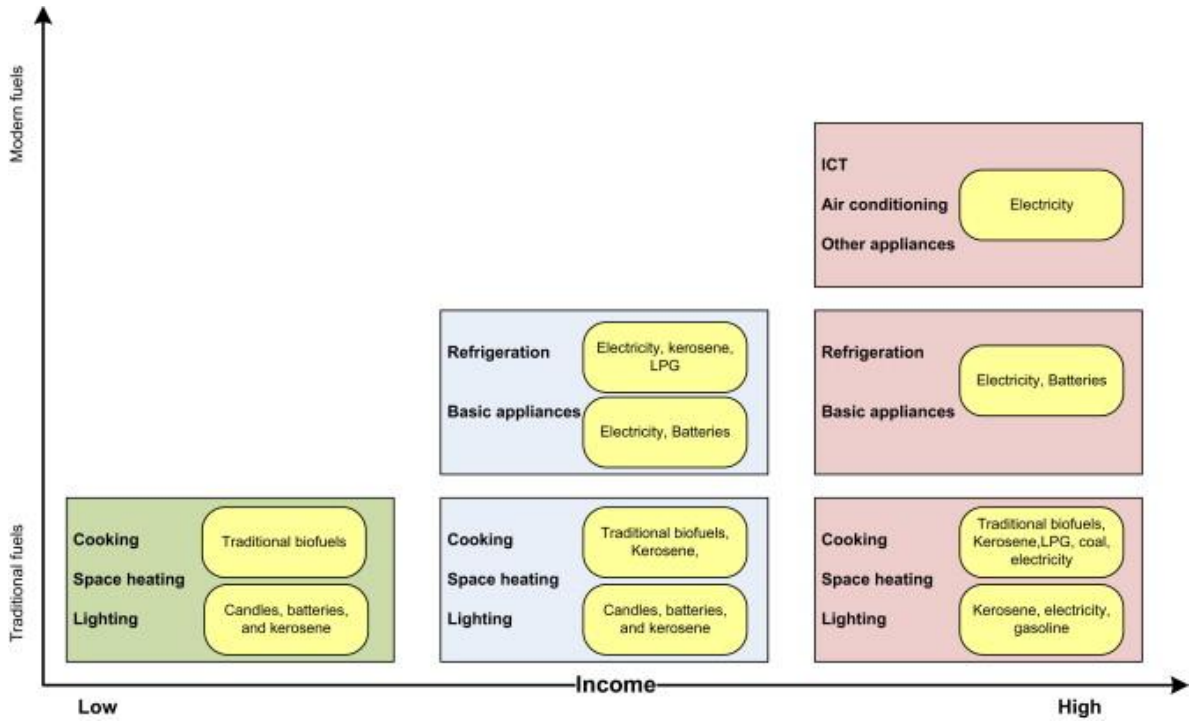

Figure 2. The energy stacking model (Kowsari & Zerriffi 2011).

Kowsari and Hisham (2011, 7509) list multiple reasons why the households haven't given up the former types of fuel they have been using. The traditional fuels give security, when modern energy supplies fail (ESMAP 1999) and when the energy price is fluctuating (Leach 1992). The new energy sources might be inapplicable to habitual cooking methods and preferences (ESMAP 2003; Masera et al. 2000). Also the modern energy sources are associated to be expensive, which prevents people to count fully on them (Davis 1998). Often households use mostly traditional fuels, but use more modern energy sources with small amounts in special purposes (Victor 2002). It is also possible to switch back to use traditional fuels after adopting new energy sources (Kroon et al. 2013, 506). For example, Wickramasinghe (2011) found that in Sri Lanka many have reverted to fuelwood after the price of LPG has highly increased.

This paper is based on a quantitative household survey with a sample of 970 Households in total. The survey data was collected in two provinces in 73 villages. The two survey provinces, namely Pursat and Kampong Cham, were selected by purposive sampling method due to two aspects: 1) differences in many ways e.g. in their economic structure, sources of livelihoods and income levels, geo-physical and abundance of forest resources as well as population densities and urban-rural divide and on the other hand 2) the two provinces, due to their differences complement each other well in representing the whole country better than two similar provinces.

In the analysis, the data was classified based on three independent variables. Two of them are locations: does the household locate in either in Pursat or Kampong Cham province, and whether the location is urban, electrified rural or non-electrified rural area. Third variable is the income of the household, which is further divided into three groups (lower, middle and higher).

The sample was equally distributed across selected provinces after which proportional random selection and proportional household quotas were calculated to districts, communes and villages. The sample was large enough to allow disaggregation into sub-samples that would remain statistically significant, for example, by urban or rural location. The samples within the provinces

were divided on the basis of Probability Proportional to Size (PPS) based on the Cambodian National Census data (2008) and within villages households were selected using a skip interval proportional to village population from a random start point.

2. Results of household field survey study

This section presents the results of the household energy profiles in Pursat and Kampong Cham. From the Table 1 we can see that the use of some energy carriers are dependent in both the household incomes and its location in urban or rural areas. Figures 3 and 4 represents the utilization rate of the six most common energy sources separately in income groups and urban and rural areas. Energy usage is quite similar in the two provinces, as can be seen from Fig. 3. However, plant residues and especially charcoal are more common in Pursat, while gas is used slightly more often in Kampong Cham. Next we treat the content of the table and the three figures. We analyze correlations between the use of energy sources and income groups, provinces and rural or urban location and ponder, what the results are telling about energy access.

Energy source	Urban electrified			Rural electrified			Rural non-electrified		
	Higher	Middle	Lower	Higher	Middle	Lower	Higher	Middle	Lower
Electricity	100 %	100 %	100 %	98 %	96 %	89 %	97 %	96 %	95 %
Firewood	47 %	69 %	86 %	87 %	91 %	96 %	98 %	98 %	97 %
Plant residues	13 %	37 %	50 %	33 %	36 %	33 %	30 %	41 %	29 %
Charcoal	59 %	67 %	71 %	31 %	34 %	13 %	9 %	18 %	7 %
Candles/vegetable oil	25 %	41 %	21 %	31 %	27 %	28 %	9 %	17 %	13 %
Gas	81 %	45 %	29 %	31 %	19 %	17 %	8 %	10 %	3 %
Kerosene	3 %	2 %	0 %	10 %	11 %	11 %	13 %	12 %	10 %
Petrol/diesel for irrigation pump	3 %	10 %	7 %	6 %	8 %	6 %	6 %	5 %	9 %
Solar panel	0 %	0 %	0 %	2 %	3 %	0 %	14 %	8 %	3 %
Animal dung/ biogas	0 %	0 %	0 %	1 %	1 %	1 %	0 %	2 %	1 %

Table 1. Percentage of households using a certain energy source in different areas and income groups in Pursat and Kampong Cham. (Cambodia Survey Database 2015).

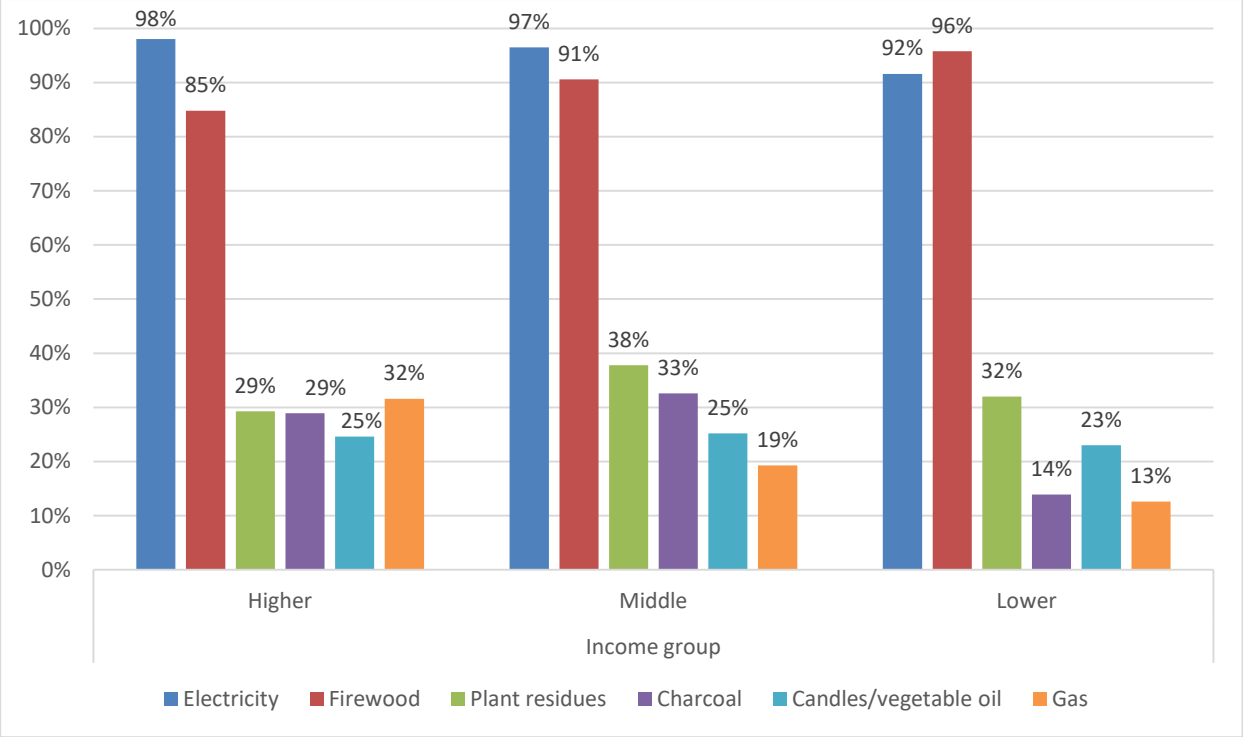

Figure 3. Most common energy sources in income groups in two provinces, in Pursat and Kampong Cham. (Cambodia Survey Database 2015).

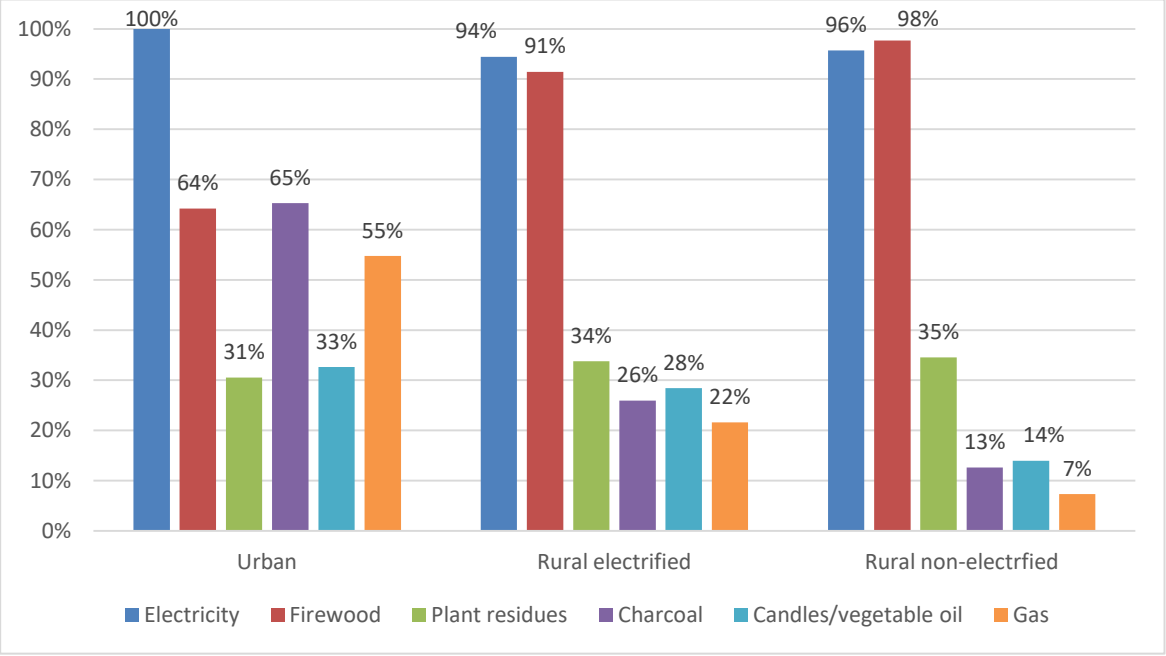

Figure 4. Most common energy sources in urban and rural areas, in Pursat and Kampong Cham. (Cambodia Survey Database 2015).

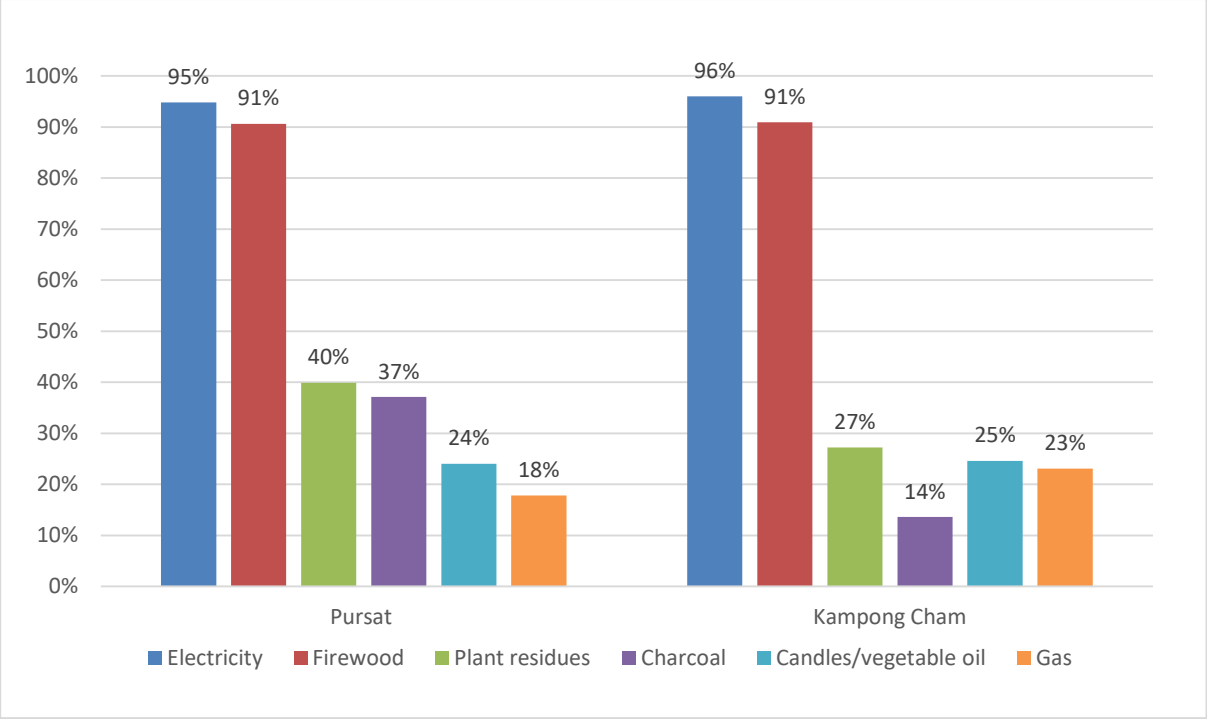

Figure 5. Most common energy sources in Pursat and Kampong Cham. (Cambodia Survey database2015).

Electricity is the most common energy source in use in Pursat and Kampong Cham households: over 95 % of respondents uses it at least some amounts. Fig 5 above shows that 98 % of higher income group and 97 % of middle income group representatives uses electricity. A bit less common the use is in the lower income group, where eight percent does not use it at all. However, in urban areas the difference between income groups can't be seen at all, while everyone there uses electricity (see Table 1). The clearest the difference is in electrified rural areas, where the gap between higher and lower income group is nearly nine percent. Yet there is no clear dependence between the electricity use in rural and urban areas (p=0.054), thus electricity can be said to be used very much everywhere at the inspected areas.

Instead, the source of electricity is clearly dependent on both income group and household location in either urban or rural areas. Grid usage decreases evenly when moving from higher income group in urban areas to lower income group in non-electrified rural areas: in the first group 97 % of households uses grid and 3% batteries, while in the latest 11 % uses grid and 84 % batteries. Many households are using both grid and batteries. When households in non-electrified rural areas answered they use grid, they most often meant local grids with power from solar panels. Batteries are used as much in Pursat and as in Kampong Cham, but in the latter electricity is acquired slightly more often from grid: in Kampong Cham 63 percent of the respondents told that they get electricity from grid while in Pursat the number is 53 percent (p=0.001).

Almost 91 % of the respondents use firewood. Firewood is the most popular among the lower and least among the higher income group (see Fig 3). 85 % of the higher income group said they use firewood in comparison with 91 and 96 percent respectively in other income groups (p=0.000). Fig. 4 shows that also the location influence strongly the fuel wood usage and in non-electrified area, 98 % of respondents use it while in cities the figure is only 64 %. The availability of different energy carriers is surely one reason to this. At the countryside there is usually more forests and bushes nearby where the firewood can be collected and in the urban areas with higher population density the markets of modern fuels are better (Elias & Victor 2005). Also a bit larger share of the population of

the cities is higher income group representatives: 34 %, while in electrified and non-electrified rural areas the higher income group part in the sample is 29 and 21 %, respectively. However, it looks like spatial location is more important factor here. In the non-electrified rural areas, all income groups use almost as much firewood and the percentage value is close to one hundred (see Table 1). The difference between income groups can be seen only when we go to electrified areas, specifically in cities where under half of the urban higher income group respondents use firewood.

The same tendencies can be seen in the usage of plant residues. About 34 % of the households use them as energy source. There is however no dependency within plant residue usage and income groups ($p=0.060$) or urban and rural areas ($p=0.768$). Within the plant residue usage only in urban areas, it is clearly dependent on income group ($p=0.016$). Lower income group there uses plant residues clearly more than middle income group, and middle clearly more than higher income group, as can be seen from Table 1. It seems that in rural areas income group does not influence on the usage of traditional fuels and that can be most clearly seen in the non-electrified villages. Also Heltberg (2005), based on studies in Guatemala, argues that income level doesn't have a significant role in fuel switching in rural areas.

Interestingly, the lower income group seems to use plant residues in urban areas much more than in rural areas (see Table 1). One explanation could be that in cities they compensate the lack of firewood with plant residues, while other groups use more modern energy sources to compensate firewood. Fig. 5 shows that in Pursat 40 % of the respondents use plant residues while in Kampong Cham the corresponding figure is 27 %. In Pursat the use increases as incomes decrease, but in Kampong Cham middle income group seem to use plant residues the most.

Fourthly common energy source is charcoal with 26 % of household using it. As Fig. 4 presents, household location influence to the usage: 65% of urban citizen is using charcoal, when with households in electrified rural areas the value is 26 and in non-electrified rural areas 13%. Charcoal usage is dependent on income group ($p=0.000$) but surprisingly the middle income group seems to make the difference here. Fig. 3 shows that 33 % of the middle income group respondents answered that they use charcoal, while in higher and lower income groups the values are 29 % and 14 %. However, the difference between income groups can only been seen in the rural areas, while in urban areas it is not significant ($p=0.664$). Charcoal is also more common in Pursat (37 %) than in Kampong Cham (14 %), as Fig. 5 reports. This is probably because of the availability of fuel wood for charcoal production in Pursat area as a result of larger forest cover. The middle income group is very strongly represented there, and it can be assumed, that charcoal is common in middle income group because it is in favor in Pursat, not the other way around. When we look at the charcoal usage of the income groups in the different provinces, middle income group is no longer represented stronger than the others.

The use of gas is highly dependent both on the income group and urban-rural location ($p=0.000$). The use increases strongly from lower to higher income group and from non-electrified rural to urban regions (see Figures 3 and 4). Thus the difference between lower income group households in less developed rural areas and urban higher income group is huge: in the first case the gas usage is only 3 % while in the second it is 81 %. Even when we look only lower income group gas usage in urban and different rural regions, the value grows tenfold, as can be seen from Table 1. In Kampong Cham, 23 % of respondents use gas which is a slightly more than in Pursat, where the value is 18 % ($p=0.040$) (see Fig 5). All income groups use gas evenly more in Kampong Cham than in Pursat.

We can note that the field data in these two Cambodian provinces is compatible with both the energy ladder and stacking models, but doesn't fit perfectly to either theory. There are some local special phenomena. Although there are almost twenty percent gas users more in the higher than in lower

income group, there is only ten percent less firewood usage in the higher income group. That means that majority of respondents, who have switched to use more modern energy sources, still use the inferior energy sources too. To put it more accurately 28 % of gas using households do not use firewood anymore, but 72 % are using both the energy sources. As almost every household is using electricity, the correlation cannot be seen as clearly, but same tendency shows there.

Validity of these theories can also be tested by examining if different income groups are using same amounts of energy sources. In other words, if for example higher income group have started to use more modern energy sources but doesn't abandon the old ones, they should have more different energy sources used at their households. According to the survey data this seems partly to hold up: higher income group is using 3.18 different energy sources by mean and lower income group only 2.88. However, surprisingly the middle income group is using most different kind of sources, with 3.25 average. It looks like higher income group can rely more on their new modern energy sources, while middle income group is not willing to abandon the traditional – perhaps they don't trust that they always can afford the fluctuating price of gas or they live in a district, where the grid electricity is not so reliable. In urban areas households use the biggest amounts of energy sources, 3.57 on average. At electrified rural areas the value is 3.16 and at non-electrified even smaller, 2.88. That is most probably because the access of different energy sources is weaker at the less developed areas.

The joint effect of income groups and household location to the amount of used energy sources is shown in Fig. 6. In urban areas also lower income group seem to use many energy sources, even more than higher and nearly as many as the middle income group. Energy access there must be better than in rural areas, when even poorer households can utilize as many sources, but likely not all of the sources are reliable. When we look back to the Table 1, we can assume that some of this phenomenon can be explained by lack of firewood in cities – people have to compensate firewood with other energy sources. The use of plant residues is most common within urban lower income group, but so is the use of charcoal. Plant residues can be classified as less desirable energy source than firewood, and it is probably chosen of necessity, while more desirable charcoal is chosen also because its supply is better. In the Welch test for equality of means there is a correlation between the means and income groups living in rural, electrified rural or non-electrified rural areas (p=0.000).

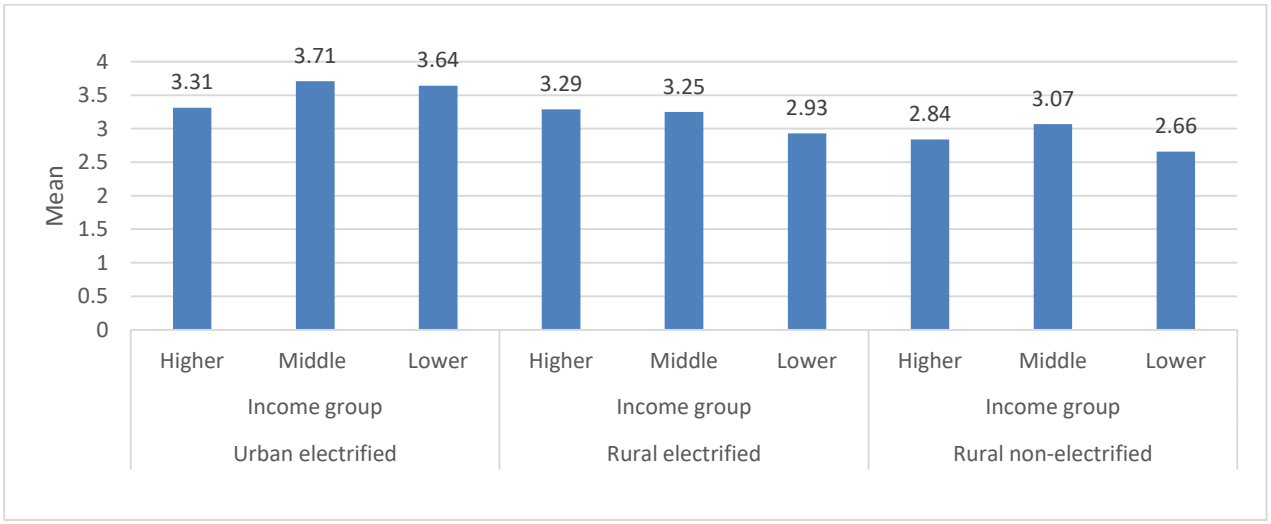

Figure 6. Amount of used energy sources by mean in different income groups and locations in Pursat and Kampong Cham (Cambodia Survey Database 2015).

According to the survey data collected 2015, in Pursat and Kampong Cham households are using energy mostly for cooking and lighting, but also somewhat for heating or cooling and

communication or entertainment. Only one percent of the households in the sample had a washing machine or a dryer. Very few respondents told they use electricity to washing or cleaning, so one may assume these are carried out by manual labor or are purchased services. Electricity, candles and vegetable oils are the main providers for lighting and around ten percent of respondents light also with kerosene and three percent with solar panels. Firewood, plant residues, charcoal and gas are used mostly to cook or boil water. Only about nine percent of the households are cooking with electricity. About four percent of the respondents have an electric stove and ten percent have a rice cooker. Seven percent told they are cooling or heating their homes with electricity. Air conditioners are still a rarity, where as 58 % have a fan or fans at home.

According to Bhattacharyya (2012, 267) especially in rural areas electricity is used mostly to lighting and entertainment and only rarely to wealth producing activities. The survey from Pursat and Kampong Cham shows the theory partly true. Electricity is clearly used more to increase well-being than to income-related purposes. Fig. 6 shows how many electricity-powered devices are used on average in households and reveals that electricity is used more to comfort related purposes. However, in Pursat and Kampong Cham rural households have devices that are meant to income generation as much as urban households have. In addition, income groups don't influence the penetration of income-related devices. Instead, rural households have less devices to comfort and entertainment purposes than urban ones. Same tendency can be seen within income classes. For example, 81% higher income group in urban areas have a color television while only 28 % of lower income group in non-electrified rural areas have one.

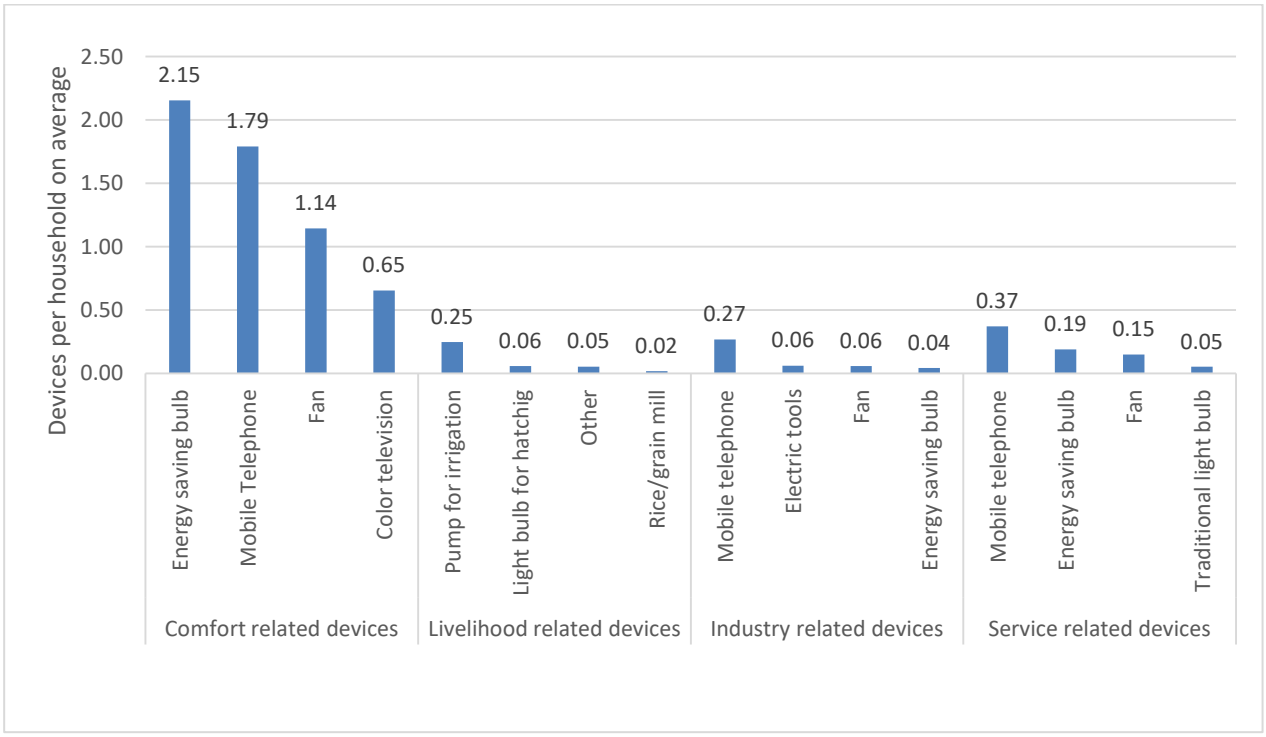

Figure 7. Penetration of four most used electricity devices for comfort, livelihood, industry and livelihood related purposes (Cambodia Survey Database 2015).

3. Conclusions and reflections

This article elaborates energy demand situation in two provinces in Cambodia. It is important to emphasize that local socio-cultural conditions still vary considerably in developing countries and their provinces. Cambodia is undergoing a shift towards more industrialized and service-oriented economy. In this socio-cultural transition process, people are leaving gradually the agricultural economy. Still, in rural provinces, agriculture continues to play a strong role in livelihoods and households. These critical background factors should be taken into account when assessing the shift towards more sustainable energy production and consumption patterns in developing countries. The fact that urbanization progresses at different rates in different provinces in Cambodia, will affect the functioning and organization of the local energy system and household economy. In addition, this field study of households confirms the prevailing general view of the importance of taking account of the special conditions of socio-cultural activity. This critical aspect of sustainability transition should not be forgotten.

Both the Energy Ladder model and the Energy Stacking model can be used as a starting point for assessing the sustainability transition of energy sector development in developing country conditions, but it is good to realize that the conditions are very rarely completely analogous to these idealized heuristic models. These two models can, however, help the energy system planners and decision-makers to see the key features of the sustainable energy transition. When talking about a green or sustainable transitions, one can easily forget the socio-cultural contexts and limit itself to looking at technology changes only. It can cause problems with the management of sustainability transitions.

Energy utility access differences can be seen clearly between urban, electrified rural and non-electrified rural districts. In urban areas households are using in average more energy sources than in rural areas. As energy stacking model suggests, households, even after getting access to modern energy sources, don't often abandon the traditional energy sources.

Electricity is used in surprisingly many households of these Cambodian households. It is used mostly lightning, entertainment or communication and cooling homes with fans, but also somewhat to income related purposes. Electrification alone can't be solution to rural energy access problems, as electricity accounts only for a small share of the energy demand of households (Bhattacharyya 2012, 268). Electricity stoves are used only by four percent of the survey respondents. The investment costs of these devices are huge and if electricity source isn't reliable, food preparation can't be counted on it. Food preparation is one of the most energy consuming activities in households and broad transition to electric stoves would mean a huge rise of electricity consumption and could cause problems to produce enough power. Instead of electrification, clean cooking energy should be raised at the center of energy access developing (see Bhattacharyya 2012, p. 268).

Gas and charcoal are clearly more used in urban than in rural areas. Gas access is better in cities. Charcoal, compared to firewood, takes less storage and smokes less. Electricity is used slightly more in cities, where 100 % of respondents uses it, but almost everyone used it also electrified and surprisingly even non-electrified rural areas. In the latest, the households are using mostly batteries, but also local grids and solar panels are used as electricity source.

Only firewood and plant residues are more common energy source in rural than in urban districts. Although over half of urban households are using firewood, it is still clearly more common in rural areas, where over 90 % of respondents are using it.

Same energy sources that are used more in urban areas, i.e. gas, charcoal and electricity, are more common when household incomes rise. Only charcoal makes a minor exception here, as middle

income group uses it slightly more than upper class. Similarly, firewood and plant residues, which are most common in remote rural areas, are more common when household incomes are lower.

However joint analysis with both income group and urban or rural location shows that among traditional fuels, incomes indeed influences strongly in the urban areas, but they have very little influence in electrified rural areas and even less in non-electrified areas. With modern fuels, like gas, differences between income groups can be seen also in rural areas, even though not as sharply as in urban areas.

In rural areas, poor modern energy access seems to be a significant drag on energy transition. In urban areas, where modern energy access is better, incomes influence remarkably more on energy demand. There financial equality is an important factor with the implementation of modern energy sources.

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Improved water management practices as a step towards sustainable agriculture

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Abstract

On-farm adaptation strategies for climate change can constitute effective ways to increase a farm's resilience and inherently ensure its sustainability of production. Across Canada, supplemental water use is essential in agricultural production. Ontario is one of the Canadian provinces, which may experience dwindling water supplies in the future due to climate change. Cost-share programs have been developed to encourage farmers to adopt cultural practices and technologies that make best use of water resources, while at the same time, being economically viable. To understand the degree to which adoption of an improved water management system can lead to a more sustainable production, we focus on a Canadian case study -- a farm growing tomatoes for processing, located in Southern Ontario. Existing technology of surface drip irrigation system was compared against the new technology of a subsurface drip irrigation system, in terms of their financial, social and environmental impacts. By adopting a subsurface drip irrigation system, the tomato grower reduced annual operating costs. In addition to these results, the grower reduced greenhouse gas emissions. While, there were less labor input required with the new technology, there was an increase in time allocated to managerial decision making. Net present value calculations indicate that the new technology is desirable from an economic standpoint. The study concluded that the new technology – use of sub-surface irrigation system, is closer to a sustainable agriculture system. However, further work is needed to develop information on the spill-off costs or benefits for the new technology to the rest of the society, which may assist policy makers develop appropriate policies for sustainable agricultural systems.

Keywords: sustainable agriculture, climate change, multi-criteria analysis, water use, Ontario (Canada)

Background

Climate Change and Ontario's Agriculture: Need for Sustainability: Ever since the introduction of the phrase 'sustainable' by the Bruntland Commission (WCED, 1987), use of the phrase 'sustainability' has become a common practice, even though its meaning is not always clear or appropriate. Many nations and government bodies (including international agencies) have adopted this as part of its objectives and have required of all countries to include it in developing economic development policies.

A major avenue to bring economic development is through improvement of resource use for an industry. Typically this is accomplished through development of new technologies. Agricultural development is no exception to this. In the context of agricultural production, sustainability relies on many factors but more importantly on water availability and quality, together with soil productivity. In addition there is this threat from climate change that can create problems for agricultural production in some parts of the world. The IPCC report (see Romero-Lankao et al., 2014) notes that an increase in the GHG concentrations is associated with reduced soil moisture in the Northern Hemisphere. Soils with a lower water-holding capacity (i.e., sandy soils) will be more sensitive to climate change (Romero-Lankao et al., 2014). This is a potential threat to agricultural production in Southern Ontario, where soil water availability is likely to decrease by 30% in the summer and fall (Chiotti and Lavender, 2008).

The beneficial management practices (BMPs) are single practice or a bundle of practices, which have been scientifically proven to reduce adverse effects of agricultural production systems on the natural resources (air, water, soil, etc.), while ensuring farm's economic viability (Klimas and Weersink, 2006). Others describe such BMPs as means of increasing agricultural production of ecological goods and services (Trautman et al., 2012), or practical and cost-effective methods used for minimizing environmental impacts (CCA, 2013). There are a multitude of BMPs that can be adopted by farmers in order to better manage water resources; these include either practices (irrigation scheduling, improved soil moisture testing techniques, etc.) or technologies (i.e., drip irrigation systems, subsurface irrigation system, controlled drainage, etc.). All these may impact either the water quantity and/or its quality. Although BMPs are generally designed for a particular purpose, for example to increase the quality or quantity of a certain natural resource, more often it is noticed that their adoption impacts other natural resources, providing multiple benefits.

Within Canada the establishment of eligible BMPs for agricultural producers under the cost-share program is left at the discretion of the provincial governments with collaboration from the federal government. In Ontario, the provincial Ministry of Agriculture, Food and Rural Affairs (OMAFRA) implements these programs through Ontario Soil and Crop Improvement Association (OSCIA 2016). In addition to protecting the environment, on-farm adaptation strategies can also increase farmers' resilience. With increased evidence that climatic conditions are changing in various parts of the world, mitigation strategies are no longer sufficient as climate change policy responses. Increasingly, attention has been given to adaptation strategies. In a broad sense, adaptation can be defined as: "responses by individuals, groups and governments to climatic change or other stimuli that are used to reduce their vulnerability or susceptibility to adverse impacts or damage potential" (Bradshaw et al., 2004). While farmers can implement adaptation strategies, their uptake depends on a mirage of factors – economic, environmental and social.

Agricultural producers across Canada, also acknowledge their responsibility in caring for the environment (Environics, 2006). While this could provide intrinsic motivation for the adoption of BMPs, uncompensated on-farm costs and off-farm benefits spillovers could hinder their adoption. Past experiences and historical data on adoption of these BMPs in the context of Canadian agriculture, confirm that while some agri-environmental practices were adopted more rapidly and more widely, showing positive outcomes, others tend to be modestly adopted and with insufficient effects in reducing the degradation of the natural resources (Bradshaw et al., 2004).

Understanding Sustainability: Typically sustainability can be seen through three pillars – economic, environmental, and social. In order for producers to accept a new technology, leading ultimately to their adoption, the new technology must be evaluated in terms of its impacts on the above three pillars. In other words, the new technology must be economically desirable (adds to the pocketbook of the producer), must be environmentally friendly, and does not create any social issues.

Need for Sustainability for Tomato Production in Ontario: Agricultural production in Ontario is primarily localized in the southern region of the province, surrounded by the Great Lakes. With suitable climatic conditions, water availability, and fertile soils, high value horticultural production has thrived in this part of the province. Within the last decade, however, studies have indicated that Southern Ontario has begun facing increasing issues of water availability (CCA, 2013). Already scarce water resources face increased demand from agriculture, municipalities, and industry. This competition and its associated shortage risks are likely to be exacerbated by changing climatic conditions (Chiotti and Lavender, 2008). In addition, increased agricultural intensification in Ontario's horticultural sector has raised increasing concerns in terms of water quality (Filson, 2004), where the risk of water contamination by nitrogen is following an upward trend.

Tomato production takes place mostly on sandy soils, which means that these agricultural production systems can be at risk in the face of upcoming changes related to soil moisture. Tomatoes are an important horticultural crop in Southern Ontario. They are produced predominantly in Essex, Chatham-Kent and Haldimand-Norfolk counties (LeBoeuf et al., 2008). They are either produced for the fresh market or for processing. Generally, field grown tomatoes are grown for processing, unlike greenhouse grown tomatoes, which are destined for fresh market. This study focuses on tomatoes produced for processing.

In the wake of climate change and water availability, any technology / cultural practice that can improve producer's economic position, coupled with reduction in GHG emissions (leading to mitigation objective of various levels of the governments) and at the same time improve water use efficiency would be a welcome choice. Such technologies applicable to tomato production in Ontario may include (but not limited to): surface drip irrigation, sub-surface irrigation, surface irrigation, sub-surface drainage and irrigation.

At present, much of processing tomato production is undertaken using surface drip irrigation (baseline). This involves drip lines over ground near the roots of the plants. A variation of this technology is sub-surface drip irrigation. In this study, this technology is contrasted with the baseline technology.

Objectives and scope of the Study

The major objective of the study is to evaluate desirability of the sub-surface irrigation technology for tomato production on an Ontario farm from a sustainability perspective. The scope of this investigation includes three pillars of sustainability – economic, environmental (greenhouse gas emission, and water and energy uses) and social (labor requirements leading to time to relax). All these indicators were estimated for the surface drip irrigation technology (baseline technology) and the sub-surface drip irrigation technology (study technology), and the results were contrasted.

Study Technology

In Ontario, tomatoes are grown on raised beds, which dimensions are 1.5m x 8m (5 feet by 26 feet). The soil leveling of the section of the farm dedicated to tomato production is half flat and half undulating. Water source for irrigation is mixed, with water coming from one of three sources: (i) an on-farm reservoir, filled by precipitations; (ii) municipal ditches, and (iii) from Lake Eerie, through a private irrigation project called LADII (Leamington Area Drip Irrigation Incorporation).

The surveyed producer installed the surface drip irrigation system (baseline technology) on half of his tomato production area and a subsurface drip irrigation (study technology) system on the other half. There are two factors, which contributed to this decision: one is the spatial variability of the terrain. The surface drip irrigation system was installed in areas with undulating terrain, whereas the subsurface drip irrigation system in areas where the soil was flatter, or more levelled. Two, the texture of the soil was another factor taken into consideration for deciding which one of the two water systems to install. The grower mentioned that it was more likely to have improved effects if the sub-surface drip system is installed on sandier soils as opposed to loamier ones.

The surface drip irrigation system is installed every year in June and taken out from the field in August, whereas the subsurface drip irrigation is installed in early April and removed every three years after harvest. There are some differences in the materials used for the two systems. For the surface drip system, the tape used is the thinner model (4 mm thickness), which costs between $175 - $180 per acre, whereas for the subsurface system a thicker model of the tape is installed (6 – 8 mm thickness), at a higher cost per acre $230 per acre. The cost of installing the tape for both systems is similar, on average labor requirements amount to approximately 2 hours per acre for 2 people. When including machinery usage and fuel (80 hp tractor), the total tape installation cost adds up to $25 - $30 per acre. The subsurface drip irrigation system comprises of several pieces of equipment and materials. Figure 1 shows the layout and components of a typical subsurface drip irrigation system. Depending on the soil type, tillage practices and crop grown, the low-pressure system is usually installed at a depth of 15 – 20 cm.

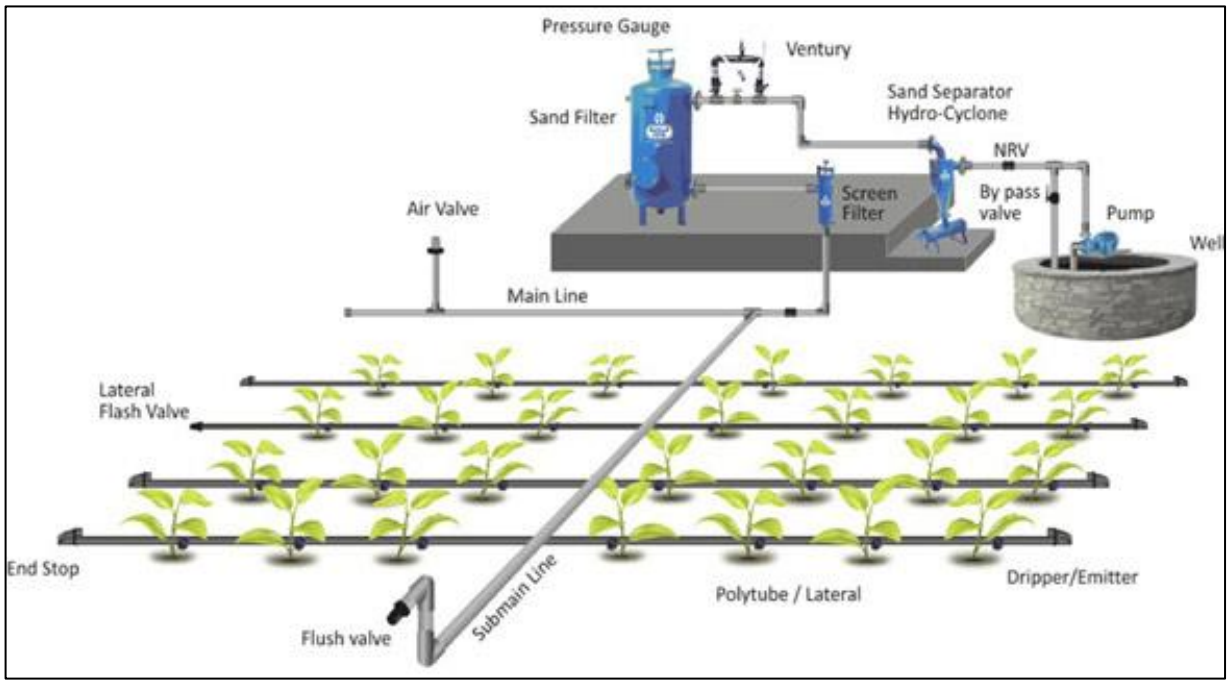


Figure 1. Layout and Components of a Typical Subsurface Irrigation System
Source: Internet, Accessed at: www.gokulplast.com/drip-irrigation-system-layout.html

Study Methodology

In this section methodology adopted to determine sustainability of the study technology is discussed. It included details on the study site and need for the study technology.

Research Site: The research site for this study was located in Leamington, Essex County, Southwestern Ontario (Figure 2). This farm is representative of a large commercial tomato production operations in the Essex County. The size of this farm is approximately 1,000 acres. The farm's land allocation is divided between tomato production, which occupies approximately 10% of the total farm land, seed corn, corn, wheat and soybean (65%). The tomato cultivar grown on this farm is Heinz 9553, used for the processing markets. The crop is in a two-year rotation cycle, with either seed corn or wheat. The soil type is loamy sand. Under the current climate tomato production on loamy sandy soil cannot be maintained without additional irrigation.

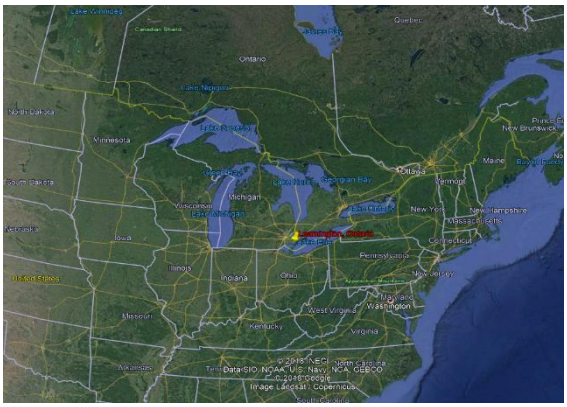


Figure 2. Map of Eastern Canada and United States of America showing Research Site

Characteristics of Tomato Production: Tomatoes on the research site are processed into any one of the following: juice, ketchup, sauces, pastes, packed whole, purees, among others, by a local processor. The growing season for these tomatoes varies between 90-150 days, and requires temperature ranging from 18.5 to 25ºC for optimal growth. The plant can be grown in a variety of soils; however, it performs better in light, well-drained soils (i.e., loams) with pH values between 5-7 (slightly acidic to neutral). Requirements for N, P, K range from 100

to 150 kg/ha, 165 to 110 kg/ha, and 160 to 240 kg/ha, respectively (Jaria, 2012 from Jones, 2007).

Total water requirements across the growing season can vary between 200 mm - 700 mm over a 90-120 days growing period, which extends over May to September. Peak water needs of nearly 6 mm/day are reached after the middle of the season (50-70 days). As soil texture can influence water holding capacity, sandy soils have less water holding capacity than clay soils and they require different water management strategies.

Tomato production preparations start in the previous year, after harvest (September to November). At this stage, primary tillage is performed and the beds are created with the use of a bed shaper. Plantation of seedlings takes place in the first week of May, which is accompanied by an application of starter fertilizer. Throughout the growing season, several applications of herbicides and fungicides for pest control, together with additional fertilization, and multiple irrigation events, if required, are provided. Tomatoes are mechanically harvested. Larger farms use a harvester together with two tractors with trailers, involving up to 7 people -- 3 drivers and 4 manual sorters (Miyao et al., 2008). The harvested tomatoes are then transported to the local processing plant.

Water Use for Irrigation in Tomato Production*:* Across the study area, during the growing season, rainfall patterns are irregular, varying between 200 and 700 mm. Throughout the summer months of June, July and August, irrigation is generally required to consistently meet the plants' water requirements (LeBoeuf et al., 2008). In Ontario irrigation is mainly used for high value horticultural produce -- vegetable and fruit production. In Southern Ontario 43% of cultivated land is under irrigation, out of which 36% under vegetable production and 14% is under fruit production (Statistics Canada, 2012).

Irrigation is scheduled according to the plants' water needs, which is crucial for optimal plant growth but also for water conservation purposes. A study by Dolan et al. (2000) has suggested that the majority of farmers schedule irrigation based on water needs, mostly assessed by measuring rainfall and soil moisture levels. However, Bernier (2008) has noted that producers rely predominantly on their own experience to trigger irrigation, using the "feel and appearance" technique. Evidence suggests that this irrigation practice generally leads to an overestimation of water needs.

Indicators for Sustainability: In the context of a new technology it is conventional to measure sustainability through relevant indicators. In this study these indicators were: (i) Economic --profitability indicators expressing economic desirability of the new technology over and above the baseline technology. (ii) Environmental -- Air quality and climate change, measured through greenhouse gas emissions; (iii) Natural resource use, measured as use of water for production. (iv) Social impact, measured through impact on produce's leisure time. Each of these indicators were measured for the baseline and study technology.

Farm Level Economics of Study Technology**:** Agricultural producers manage agricultural systems with the purpose of achieving their goals, which can vary from increasing the farm's profits to increase leisure time (Boehlje and Eidman, 1984). Climate and market factors (i.e., input/output prices) add another layer of uncertainty regarding future development of agricultural systems, making predictions highly uncertain. Nonetheless economic analysis is important and is primarily concerned with the economic viability of the new technology.

Net margin analysis is a simple method of evaluating the profitability of an enterprise for a single time period. It is used to compare a crop enterprise under different beneficial management practices (BMPs). The net profit margin (NPM) for each enterprise can be calculated by subtracting all variable and fixed costs (VFC) from gross income (GI), as shown in equation (1).

$$NPM = GI - VFC \quad (1)$$

In the case of a technology demanding initial investment with a fixed life, single year estimation of gross margin is not appropriate. It is replaced by a financial analysis of the technology. This analysis is done from the standpoint of the producer. Only those costs and benefits that are incurred / received by the producer are included. A technology is evaluated using one or more indicators.

BMP evaluation indicators: Evaluating a BMP's profitability over its lifespan is essential for agricultural producers and thus, represents a milestone in their adoption decision making process. The financial viability of an agricultural project, is obtained by analyzing net cash inflows and outflows over the investment's planned life (Sell, 1991). The main purpose of comparing costs and benefits of the investment is to help the producer decide which projects are worth being further pursued, and which ones to reject.

There are two commonly used indicators used to evaluate an investment's economic worth: Benefit/Cost Ratio (BCR), and Net Present Value (NPV). Both of these are based on discounted values since costs and benefits accrue over different time period. Selecting a discount rate for the financial analysis is an essential step in evaluating an investment's worth, and it can have a large impact on analysis results (Olsen, 2010).

The Net Present Value (NPV) is calculated by discounting and subtracting all periodic outflows (costs), from the inflows (revenues) of a project, at a predetermined rate of discount throughout the life of the investment. The NPV of a project is the difference between the present value of benefits and costs, as shown in equation (2), where B_t are project revenues in period *t*, C_t are project costs in period *t*, *i* is the selected discount rate and n is the number of years denoting the life of the investment (Boardman et al., 2001). The project with the highest NPV is to be preferred to alternative options; however the simple decision rule is to accept projects with a positive NPV (Brown, 1980).

$$NPV = \sum_{t=0}^{n} \frac{B_t}{(1+i)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+i)^t} \quad (2)$$

Benefit-Cost Ratio (BCR) represents another evaluation indicator, which indicates whether a project should be considered for investment. It is calculated by dividing the sum of discounted benefits by the total discounted costs, as shown in equation (3). A BCR of over 1 suggests that the overall benefits outweigh the costs. However, if the BCR's value is close to 1 then further evaluation is advisable, before deciding to invest.

$$NPV = \sum_{t=0}^{n} \frac{B_t}{(1+i)^t} / \sum_{t=0}^{n} \frac{C_t}{(1+i)^t} \quad (3)$$

Source of data for economic analysis: In order to calculate the value of the above two indictors, several pieces of data were required. Gross income data were obtained through interviews with agricultural producers on prices and yields. Variable costs included land preparation costs (i.e. plowing, bed shaping), cultural costs (i.e. pesticide and fertilizer applications), irrigation costs (i.e. start-up of the system, maintenance) and harvesting costs (i.e., harvester use, labor). These costs were provided by producers. Adoption of the study technology affected the cost of operation of the farm and thereby the overall economic position of the farmer. The subsurface drip irrigation included the following costs: more specialized machinery needed for installation, and increased managerial decision making time, among others.

The initial cost of investment involves long-term costs associated with the adoption of the new technology and it is an essential component in determining the profitability of BMPs. These costs included materials, such as headers, connectors, valves, water pump, water reservoir, installation costs, and other costs associated with the BMP adoption (such as a GPS unit).

Environmental Impacts of the Study Technology: Adoption of a new technology can affect the ecological goods and services enjoyed by the society at large. In this study the technology was hypothesized to impact climate change through emissions of greenhouse gases, availability of natural resources (particularly water), and energy use, which has economic impacts for the producer (already captured in the economic analysis) plus implications for energy sustainability, if any.

Social Impacts of the Study Technology: Some technologies are labor saving while other require more labor input form the producer. Therefore, the study technology was investigated for its impact on producer's leisure time.

Results and Discussion

In this section, appraisal of tomatoes grown in a two-year crop rotation with seed corn or wheat are described. Per study methodology, presentation is made for economic, environmental, and social (leisure time).

***Economic benefits and costs – Effect on yield*:** The most important economic change that can be brought about by the study technology was its impact on the yield of tomatoes. While several studies have looked at yield differences between the two irrigation systems, results are mixed. Jaria and Madramootoo (2013) evaluated these differences on the same research site located in Leamington. Their findings indicated that there were no statistically significant yield differences between the two technologies. Tan et al. (2003) evaluated the difference between surface and subsurface drip irrigation on a 16-acre farm, with sandy loam soil and using the same tomato cultivar, located in Harrow a city located approximately 30 km southwest from Leamington. They found that under subsurface drip irrigation, there was a 5.3% increase in marketable tomato yields, when compared to surface drip irrigation. Tan et al. (2008) evaluated the two systems again, in the same location using the same tomato cultivar (Heinz 9478), and found that the on the sandy loam soil, average marketable tomato yields over a 3-year period increased by 35 to 37% under the surface drip-broadcast fertilizer and surface-fertigated treatments relative to the non-irrigated control treatments, while average marketable tomato yields under subsurface-fertigated and subsurface-broadcast

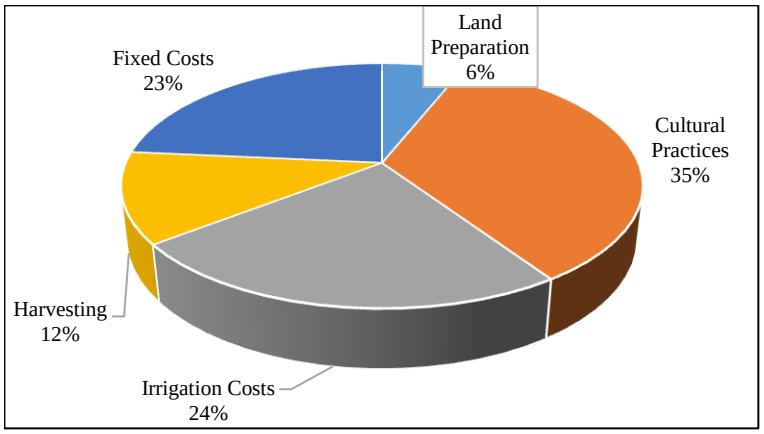
treatments were increased by 43 to 47% relative to non-irrigated treatments (Tan et al. 2008). The same researchers showed that under different soil conditions (i.e. clay loam) the surface drip irrigation had higher yields when compared to subsurface irrigation. Because of the variability in the evidence on yield increases, in this study, the assumption of no yield increase when switching from surface to subsurface drip irrigation was made.

***Economic benefits and costs – Effect on cost of production*:** A related question to the above issue is related to the cost of production under the two technologies. Based on our case study, annual irrigation costs under subsurface drip irrigation are lower when compared to subsurface irrigation. While the subsurface drip irrigation system is in place for three years, the surface drip irrigation gets replaced every year. This reduces the irrigation costs significantly. Our financial analysis of the farm only reflects the differences associated with this replacement pattern. Differences in the major item of cost are shown in Table 1.

Table 1: Difference in cost per acres under the Baseline and Study Technologies, 2015

Particulars	Base Technology (Surface Drip Irrigation)	Study Technology (Sub-surface Drip Irrigation)	Difference (Base minus Study Technology)
Gross Revenue	$4,891.69	$4,891.69	0
Cost of Production			
Land Preparation	$231.32	$231.32	0
Cultural Practices	$1,330.31	$1,330.31	0
Irrigation Costs	$918.43	$436.08	-$482.35
Harvesting	$461.42	$461.42	0
Total Variable Costs	$2,941.4	$2,459.13	-$482.35
Fixed Costs	$904.35	$904.35	0
Total Costs	$3,845.82	$3,363.47	-$482.35
Net Returns (Gross Revenue minus Total Costs)	$1,045.86	$1,528.21	
Net Returns as % of Gross Returns	21.4%	31.2%	
Initial Investment Cost	$1,174.89	$1,269.03	

Both the technologies are similar except for the cost of providing water to the crop. As noted above the yield of tomato crop was assumed to be similar although some higher yields may be realized using the sub-surface drip irrigation. Under the baseline (surface drip irrigation technology) cost of providing water to the crop is the highest item of total cost (Figure 3)



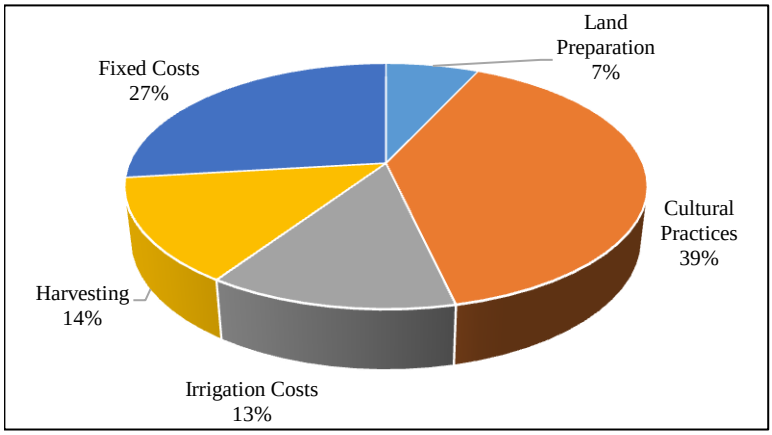


Figure 3. Distribution of total cost by major cost categories, Baseline technology (Top) and Study Technology (Bottom)

Economic Desirability Indicators: As noted above three economic indicators were estimated for the study technology and compared with the baseline technology. Results are shown in Table 2. On both criteria – NPV and BCR the study technology (sub-surface drip irrigation) is a more economic attractive alternative.

Table 2: Measures of Economic Desirability of Study Technology

Particulars	Surface Drip Irrigation	Subsurface Drip Irrigation
Net Present Value @ 5%	$ 6,203.59	$ 6,564.34
Present Value of Benefits	$ 30,218.67	$ 30,305.26
Present Value of Costs	$ 24,015.09	$ 23,740.92
Benefits Costs Ratio	1.26	1.28

Environmental Indicators for the Study Technology: As noted above environmental benefits or damages were measured through change in GHG emissions, as well as through water and energy used. The first question posed was: Does the adoption of a subsurface drip irrigation system lead to a decrease in GHG emissions when compared to surface drip irrigation? Based on Edwards (2014) findings, there were no statistically significant differences between the two irrigation systems. However, anecdotal evidence recorded for

years 2012 and 2013 shows that in both years, fields under subsurface drip irrigation produced 14.47% and 18.32%, respectively, less GHG emissions when compared to surface drip irrigation. In the financial evaluation of the two irrigation systems, differences in GHG emissions were not taken into consideration.

Table 3: Difference in the GHG emissions from Surface Drip Irrigation (Baseline) and Subsurface Drip Irrigation Technology (Study Technology), 2012-13

GHG	2012 Growing Season		2013 Growing Season	
	Subsurface Drip Irrigation	**Surface Drip Irrigation**	**Subsurface Drip Irrigation**	**Surface Drip Irrigation**
N_2O g/m^2	0.17	0.35	0.42	0.40
CH_4 g/m^2	-0.08	-0.08	-0.01	-0.01
CO_2 g/m^2	479.24	517.24	628.61	805.47
$CO_{2\text{-eq}}$ g/m^2	528.38	617.75	754.55	923.80
$CO_{2\text{-eq}}$ kg/ha	52.84	61.77	75.46	92.38
$CO_{2\text{-eq}}$ kg/acre	21.38	25.00	30.54	37.38
Relative Difference		**14.47%**		**18.32%**

The grower in the survey reported that they used the same amount of fertilizer and water, regardless of the irrigation system used. Since other farm operations are not different between the two technologies, no change in energy use was evitable. Previous studies have looked at the relationship between fertilizer use and various irrigation systems. Tan et al. (2003) found that when compared to surface drip irrigation the buried system had higher nutrient N and P use efficiency. Jaria and Madramootoo (2013) evaluated irrigation water use efficiency under the two systems and found no statistically significant differences between the two. European studies have also supported this conclusion (Martinez and Reca, 2014), although in terms of water use efficiency the irrigation water amount was a statistically significant variable in the first two years but not in the third year, although there were clear differences.

Social Impacts of the Study Technology: Major social impact of the technology was measured in terms of labor requirements, leading to leisure time available to the producer. The question raised was: Does subsurface irrigation increase or decrease hired labour, when compared to a surface drip system? When compared to surface drip irrigation, the subsurface irrigation system requires less hired agricultural labour. This is in part due to the increased mechanization of the subsurface drip system, but also due to the fact that the retrieval of the system from the field is done once every three years, as opposed to every year, as it is the case with a surface drip irrigation system.

Related to the farmer's leisure time, the question posed was: Are there any farm owner lifestyle changes involved when moving from surface to subsurface drip irrigation? Based on our anecdotal evidence, from the case study farm, there is an increase in time spent by the farm owner or manager related to decision-making. The producer with the study technology, indicated that the subsurface drip system requires more decision time and more specialized knowledge. The grower spends on average approximately 36 hours per growing season, gathering data, interpreting it and taking decisions regarding water needs.

Future considerations under changing climatic conditions

Climate projections indicate that by 2050 the annual temperatures in Ontario will increase between 2.5°C to 3.7°C from the baseline 1961-1990 (Government of Ontario Ministry of Environment, 2011). Furthermore, in Southern Ontario annual average precipitation has declined by approximately 225 mm in the last 20 years (Tan and Reynolds, 2003). Precipitation projections for the upcoming 45 years do not indicate large variations in the total amount of precipitation, however extreme events are expected to become more intense and more frequent, (Chiotti and Lavender, 2008). These changes would have mixed effects on agricultural production. Tan and Reynolds (2003) indicate that in Southwestern Ontario, an increase in water deficits throughout the growing season, ranging from 80-275 mm, was observed over the last 20 years, with crops already showing yields decreases due to water stress. Water availability, given future climate conditions will be further limited, requiring adoption of water conserving technologies.

Besides water quantity issues, the region is likely to face water quality challenges as well. Increased use of agricultural inputs (i.e. fertilizers, pesticides, etc.) help enhance the productivity of agricultural systems. However, overuse or inefficient use of these chemicals is one of the most common causes of damage to water resources worldwide. Surpluses of nitrogen, phosphorus and pesticides in the soil can pose enhanced environmental risks, due to possible leaching into ground waters or by reaching surface water bodies through runoff (De Jong et al., 2010, pg. 80). Transportation of these surpluses into water resources diminishes water quality. Some of the most common effects associated with water contamination by nitrogen are: eutrophication (affecting aquatic life) and increased human health risks (drinking water issues). In Ontario the risk of water contamination by nitrogen is following an upward trend.

Summary and Conclusions

Results of this study suggest that the tomato production in Ontario using sub-surface irrigation is not only economical but also environmentally friendly and helps leisure time for the producer. These are the major pillars of sustainable practices. Thus, adoption of this technology is a step towards achieving the goals of sustainable agriculture. A summary is shown in Table 4.

On three of five types of indicators, the study technology – sub-surface drip irrigation, had a more desirable change on the producer and / or society. For two indicator types no difference between the two technologies was noted. The overall conclusion is that the study technology is a more sustainable way of growing tomatoes in Ontario. Hopefully this technology would appeal more to the tomato producers.

Table 4: Comparison of Baseline and Study Technologies on Sustainability Indicators

Indicator	Baseline (Surface Drip Irrigation) Technology	Study (Sub-Surface Drip Irrigation) Technology	Difference in two Technologies (Study – Baseline)
Economic (NPV)	$6204	$6564	>0
Economic (BCR)	1.26	1.28	>0
GHG Emissions	37	31	Positive reduction

Water Use	No change due to farm practice		
Energy Use	No change due to farm practice		
Social Impact (Leisure time)	++	-	Positive reduction
Sustainability	Lower	Higher	Positive

Selecting the better technology among the two technologies described above is highly dependent on bio-physical conditions, particularly the levelling and type of soil. The subsurface technology works better for sandy soils. This factor is an important determinant of economic benefits from the adoption of the technology. Furthermore, this surface drip irrigation technology can also create some logistical issues, such as access to the field for heavy machinery when the system is in place.

One of the limitations of this study is related to rotational assumption used for the economic evaluation. It was assumed that the second crop following tomatoes (typically corn) is not irrigated (in spite of the fact that the system is in place). This may have led to underestimation of the economic desirability of the above technologies. However, this may not have affected the marginal difference between the two technologies.

Adoption of new technology by producers is a complex issue. In order to improve the environment's condition, appropriate policy tools need to be used to determine agricultural producers to account for their actions (Weersink, 2002). If economic attributes of a technology are unable to convince a producer to adopt it, appropriate and differentiated policy instruments might be needed for their improved uptake by agricultural producers. Agricultural producers through their production activities can have a positive impact on the environment (i.e., GHG emissions sequestration) or a negative one (i.e., GHG emissions). Costs of GHG emission are external to an individual farmer's agricultural production system and with no incentives to internalize those costs; it is unlikely that the agricultural producer will change cultural practices. Conversely, the benefits of on-farm GHG emissions sequestration cannot be completely internalized by the agricultural producer.

Acknowledgements

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Improvement of Performance Evaluation Formula for Infiltration Trench in Korea

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Abstract

To efficiently manage stromwater and nonpoint pollutants in small-scale urban areas by using Low Impact Development (LID) facilities such as infiltration trench, accurate evaluation of performance of LID facilities is required during the design step. Currently in Korea, the performance evaluation formula designed for Non-point Pollution Reduction (NPR) facilities is applied to LID facilities without any modification to estimation Stormwater Interception Ratio (SIR) and Load Reduction Ratio (LRR), which are the performance evaluation indicators of the facilities (NIER, 2014). However, there are various limitations and problems to evaluating LID facilities with different properties than NPR facilities using existing method. Therefore, in this study, new performance evaluation formula suitable for infiltration trench LID facility was devised using use Storm Water Management Model (SWMM). As a first step, the behavior of hydrologic and water quality in some impervious area, where observed stormwater and TP discharge load data exist, was reproduced using SWMM. Next, infiltration trench was constructed in the area using LID module, and the processing performance for stormwater and TP load was estimated through a long-term simulation. Finally, based on the simulated results, the empirical SIR and LRR formula for infiltration trench were newly derived. In addition, as compared with the existing methods, the existing method is likely to overestimate the stormwater handling performance of infiltration trenches. On the other hand, it has been shown that it is possible to underestimate the reduction performance of TP loads. Therefore, it is expected that the method proposed in this study provide a more accurate evaluation of the performance of infiltration trench LID facility.

Keyword : Infiltration trench; Low Impact Development; SWMM; Performance evaluation.

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Investigation of public attitude towards renewable energy sources

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Abstract

Similar to other EU member states, the use of renewable energy sources is growing rapidly in Hungary. The National Energy Strategy places great emphasis on increasing usage of renewable energy sources not only in the industrial sector and public institutions, but also in households. However, the positive attitude of the population to this question is very important. Having relatively little knowledge of this, we have tried to assess the attitude of the Hungarian population about renewable energy sources through a comprehensive research. We conducted the survey in six Hungarian settlements using the word association method. We have examined whether the population is aware of the meaning of renewable energies and their potential usage. The word association method is also suitable for revealing the attitude of the population to renewable energy sources. We have found that the conceptual structure of the population about renewable energy sources is rather superficial, but people with a higher education level and younger ones have a more accurate knowledge about this topic. Besides, it can cause optimism that the public's attitude to renewable energy sources is clearly positive.

Keywords*: renewable energy sources, word association method, conceptual structure, public attitude*

1. Introduction

In connection with the protection against global climate change, the issue of using renewable energy sources is becoming more and more important (Andreas et al, 2017, Hafeznia et al., 2017; Sinha, 2017; Tsai et al. 2017). It is well-known that the main source of emission of greenhouse gases is the burning of fossil fuels and if these can be replaced by renewable energy sources, that would decrease the rate of emission of greenhouse gases to large degree (Szabó et al, 2014; Ito, 2017; Jordaan et al., 2017). Today the renewable energy sources are becoming more and more easily accessible to the public as well, since more efficient and relatively low pay-off solutions appeared in the market (Magda, 2011; Afonso et al., 2017). However, to make the decision to invest into a renewable energy sources solution, one should be familiar with the types, options, benefits and disadvantages of renewable energy resources. The more information the people has about the renewable energy sources, the greater the probability is that they start utilizing a renewable energy source. However, very little is known about the knowledge and attitude of people regarding renewable energy sources. The so-called word association method is an excellent tool to investigate the above, since with this the conceptual structure and the relation to the calling concepts of the investigated target group can be mapped with great precision, evidenced by a great number of publication in the field (Kent & Rosanoff, 1910; Geissler, 1917; Fazio et al. 2000; Kovács, 2011; Aitchison, 2012). The method can be used to investigate the development and expansion of the conceptual structure of the pupils, and thereby drawing conclusions on the effectiveness of education (Kluknavszky & Tóth, 2009). Revákné et al (2016/a, 2016/b) also applied the word association method to investigate the conceptual structure of the elementary school students regarding renewable energy sources. They concluded that students have only superficial knowledge about the topic and they lack the practical skills which could be applied in their everyday life.

Therefore, the situation elementary schools are far from satisfactory, and we assume that the adult population do not have in-depth knowledge regarding renewable energy sources either. In order to validate our assumption, we carried out a survey in six settlements, and in this study, we will present the results of the word association methods applied as part of the survey. Our intention was to find answers to the following questions:

1. How can the conceptual structure of the population of the investigated settlements be characterized regarding renewable energy sources?
2. What was the ratio of associations directly connected to renewable energy sources versus the irrelevant associations?
3. What was the ratio of surveyed people presented positive associations (e.g. environment-friendly, inexpensive, economical, sustainable etc.) and negative associations (expensive, pointless, unnecessary etc)?
4. How does the investigated background factors (age, gender, level of education) affect the quantity of associated concepts, and the strength and nature of the relationship with the calling concept?

2. Materials and methods

During the investigation, we selected six Hungarian settlements (Biharnagybajom, Hajdúszovát, Sárrétudvari, Recsk, Nagyréde, Kisköre) with approximately equivalent population (permanent inhabitants of around 3000) and socio-economic status. Using a quota sampling we assured that the respondents are represented according to gender and age in the population of the settlements above the age of 19. The sampling elements were 50 people in each settlement.

During the word association test, we investigated the strength, quantity and nature of the relationship between the calling concept (renewable energy sources) and the associated concepts. In the word association test, we asked the participants to tell us about the concepts they can think of when hearing the phrase “renewable energy sources”. They had to list maximum three words. According to the above, the 50 respondents from each of the six settlements could have listed 900 words in total, however, 16.7% of the respondents could not tell even one word, whereas 21.0%, 26.3% and 36.0% of the respondents was able to list one, two and three word association, respectively. Therefore 534 words were analyzed in total.

We investigated the number of repetitive associations, based on which we determined the strength of the association. Considering the repetitive associations, 230 different associations were mentioned during the survey. In order to realistically determine the strength of each association, we grouped the similar association together, such as (sun, sunlight, ray of sunshine, sunshine) or (low-cost, cheap, cheaper, cheapness, lower cost). As a result of the above, we reduced the number of associations to 149. We drew the conceptual networks using this 149 associations. In the conceptual network we only included the terms which had a relative frequency of at least 5% during the test. The conceptual network regarding the full sample was compiled based on the frequency values included in Table 1 (Kluknavszky & Tóth, 2009).

Table 1 Strength and indication of relative frequencies in the conceptual network

Relative frequencies of associations	Strength of connection	Indication
Below 5%	Very weak	Not included
5.0-12.0%	Weak	- - - - - - - - - - - - - - - - - -
12.1-20.0%	Moderate	———————
Above 20%	Strong	▬▬▬▬▬▬▬▬▬

Then we established other groups based on the 149 associations in order to further clarify the conceptual structure of the respondents and nature of the relationship with the renewable energy sources. Finally we grouped the associations into the following 7 categories:

1. Description of the type of renewable energy source,
2. Tools to use to renewable energy sources,
3. Positive characteristics associated with the renewable energy sources,
4. Negative characteristics associated with the renewable energy sources,
5. Concepts related to energy production,
6. Irrelevant concepts,
7. Concepts related to energy but not renewable energy sources.

The categorization of the associations helps to evaluate the attitude of public to renewable energy sources, as well as to draw conclusions on the depth of knowledge and potential misconceptions. In the study we also investigated the impact of age, gender and the level of education on the conceptual structure of inhabitants regarding renewable energy sources.

3. Results and discussions

3.1. Conceptual structure

During the compilation of the conceptual structure, we considered the associations with a relative frequency of at least 5%, and we depicted them in accordance with the strength of the relationship (Table 2, Figure 1).

A relative frequency higher than 5% was determined in the case of 11 concepts. Due to the great variability of the associations, strong relationship, that is, a relative frequency higher than 20%, was not observed regarding any concept, and a moderate relationship (relative frequency of 12.1-20%) was observed only in two cases: regarding the terms “sun” and “environment-friendly”. Therefore, when hearing the term renewable energy sources, the public primarily associate to the concepts of sun and environment-friendliness which means that they aware of the fact this type of energy production is considered an appropriate solution from an environmental protection standpoint.

Table 2 Number and relative frequency of association in the full sample

Association	Number of Associations	Relative Frequency
Sun	56	18.7
Environment-friendly	51	17.0
Water	32	10.7
Cheap	30	10.0
Wind	26	8.7
Energy saving	23	7.7
Solar panel	23	7.7
Environment protection	18	6.0
Renewable	18	6.0
Expensive	17	5.7
Useful	16	5.3

Even though the frequency of the remaining nine concepts was between 5% and 12%, these also suggest a positive attitude from the part of the public, since five of them has a positive connotation (renewable, cheap, energy saving, useful, environment protection), two of them pertains to specific types of renewable energy sources (water, wind) whereas one refers to a device needed for the use of solar energy, the solar cell. Only one negative association was listed among the 11 concepts ("expensive"). This presumably to refers to the purchase and establishment of the equipment required for the use of renewable energy sources which indeed has a high investment cost, therefore it is understandable that many people think of expensiveness in connection with renewable energy sources.

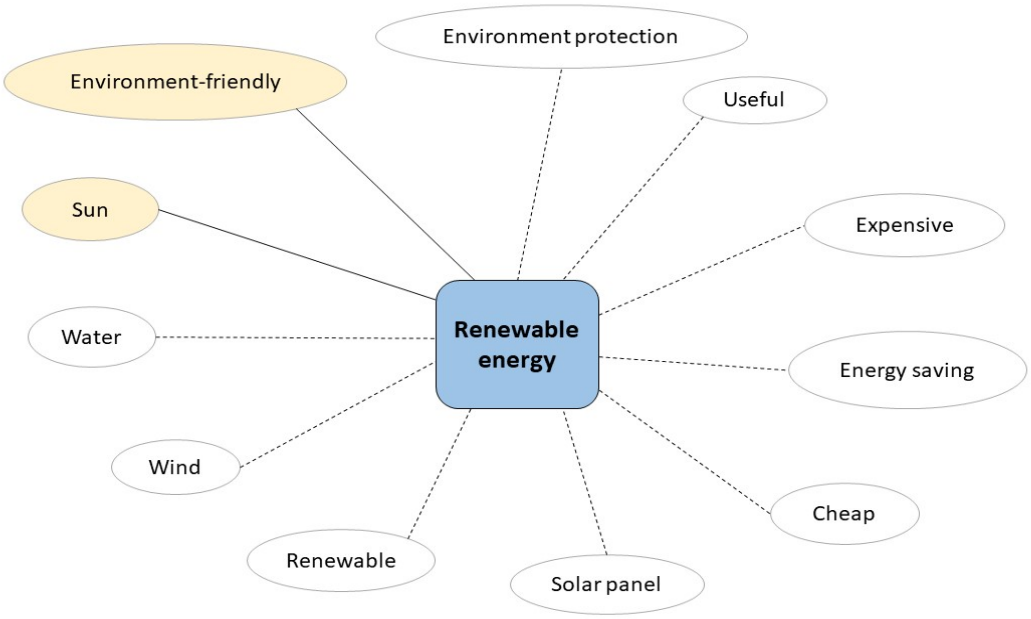

Figure 1 Conceptual structure of the investigated settlements based on the relative frequency of the associated terms. (Beige: moderate relative frequency, white: low relative frequency.)

Irrelevant concepts were not included in the conceptual structure. Based on the conceptual structure of the six investigated settlements it can be concluded that the public is more or less familiar with the concept of renewable energy sources, their potential uses as well as the environmental and economic advantages of these solutions.

In Table 3 we included the number of associations classified among each group by settlements.

Table 3 The ratio of concepts classified among each combined category by settlements

Settlement	Description of the type of renewable energy source	Tools required for the use	Positive characte-ristics	Negative character-ristics	Energy production	Irrelevant concepts	Concepts related to energy but not renewable energy sources
Biharnagybajom	23.9	5.6	43.7	11.3	4.2	5.6	5.6
Nyíracsád	19.8	11.3	53.8	2.8	4.7	6.6	0.9
Hajdúszovát	18.3	5.4	60.2	5.4	6.5	2.2	2.2
Nagyréde	27.0	2.7	48.6	8.1	4.1	8.1	1.4

Recsk	10.4	28.6	35.1	9.1	11.7	0.0	5.2
Kisköre	45.8	5.9	31.4	3.4	3.4	7.6	2.5
Settlements in Total	**25.4**	**9.6**	**45.3**	**6.1**	**5.6**	**5.2**	**2.8**

It can be seen that 45.3% of the associations refers to a positive characteristic, such as cheap, environment-friendly, useful, clean etc. The positive associations were predominant in every settlement which shows that the public attitude towards renewable energy sources is clearly positive. This is evidenced also by the fact that the average rate of negative associations is only 6.1% regarding all settlements.

It is also useful to review the most frequent associations among the listed types of renewable energy sources, since this suggest the best-known renewable energy sources among the population. In the cases of the six investigated settlements, 136 associations referred to a certain type of renewable energy source. Within this category, most people thought of solar energy (41.2%), followed by water energy (23.5%) and wind energy (19.1%) (Figure 3):

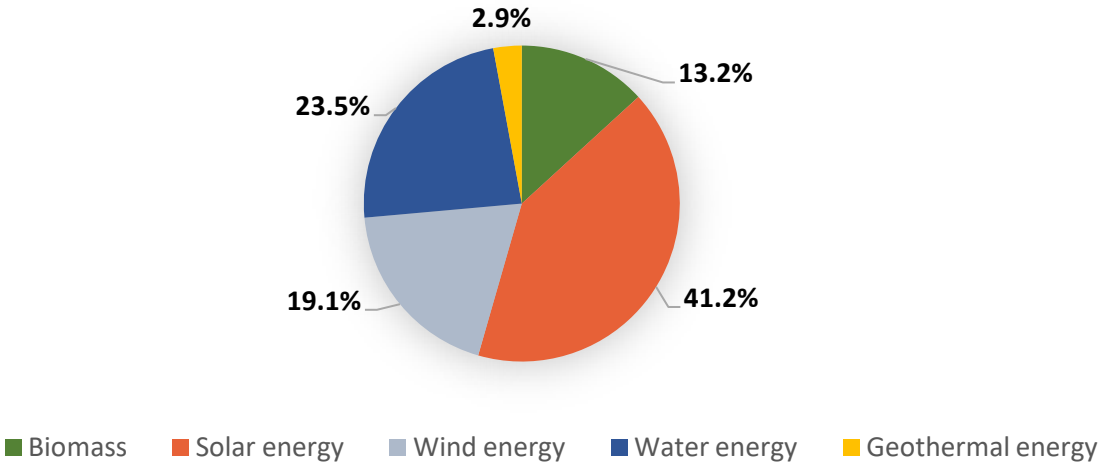

Figure 3 The ratio of certain types of renewable energy sources regarding to associations to renewable energy sources.

The associations in connection with the utilization of biomass made up only 13.2% of the total number of this category, and it is also interesting that geothermal energy appeared only in 2.9% of the associations referring to certain types of renewable energy sources (Figure 3).

Approximately 10% of the associations provided by the respondents referred to equipment required to utilize renewable energy sources. Within this category, most associations pertained to solar cells (44.2%) and relatively many people named solar collector as well (19.2%). This is in agreement with our conclusion that the best-known type of renewable energy among the respondents was solar energy, and presumably that was the reason why equipment used to utilize solar energy was mentioned most frequently. Fewer people associated to wind farm (15.4%) and to water plants (5.8%) within this category.

3.2. Conceptual structures of men and women

In order to assure the representativity of the sample, during the survey we took into account the genders of the inhabitants, therefore 144 men and 156 women were enrolled into the study in total. Since the number of male and female respondents were not equal, we indicated the percentage rate of answers given by men and women on Figure 4.

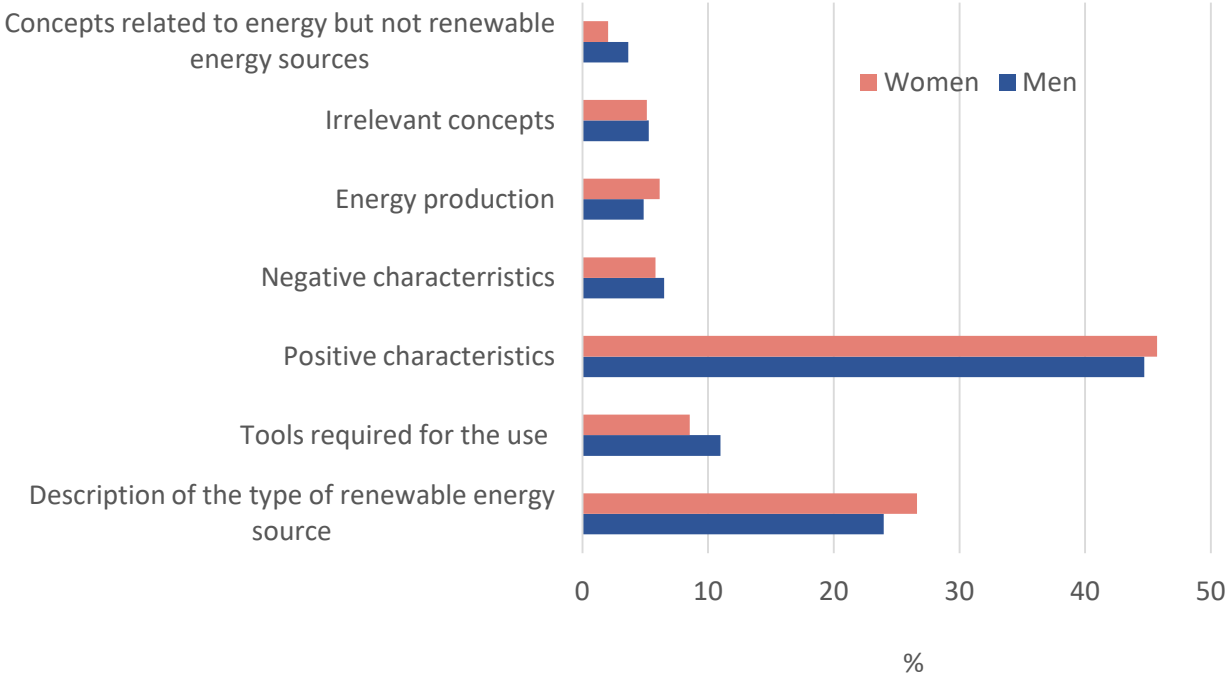

Figure 4 Percentage distribution of associations classified among each concept group by genders

It can be seen that men and women primarily associated to positive characteristics in connection with renewable energy sources, and second most frequent association were a name of certain type of renewable energy sources in both genders. In the case of both genders, equipment used to utilize renewable energy sources was the third most frequent association. Negative characteristics were mentioned with a frequency of around 5% in the case of both genders, and smallest group was “the concepts related to energy but not renewable energy sources” in both genders as well. Therefore, upon investigating the differences between genders we can conclude that there is no relevant distinction between the conceptual structures of men and women.

3.3. Conceptual structures of different age groups

Just as we did not find significant differences between men and women, fundamentally similar associations can be observed across age groups as well, even though in certain cases significant differences were occurred (Figure 5).

The most significant difference was observed in connection with the negative associations regarding renewable energy sources by the age groups. It is apparent that in the youngest age group (between 18 and 25) a great number of people named a negative characteristic, and they primarily referred to the high costs of utilizing renewable energy sources. In this age group the ratio of negative associations was 15%, whereas in the other age groups the ratio varied between 3.5% and 6.0%. This can be explained by the fact that younger people were recently finished their education and their knowledge is relatively up-to-date. This means that even though they are aware of the

positive features of renewable energy sources, they also learned about the often expensive investments cost of these solutions.

The fact that the ratio of irrelevant associations is the lowest in the youngest age group along with the extremely high rate of association regarding the utilization of renewable energy sources (15%) further support our assumption that this age group is most knowledgeable in terms of renewable energy sources and their utilization potentials.

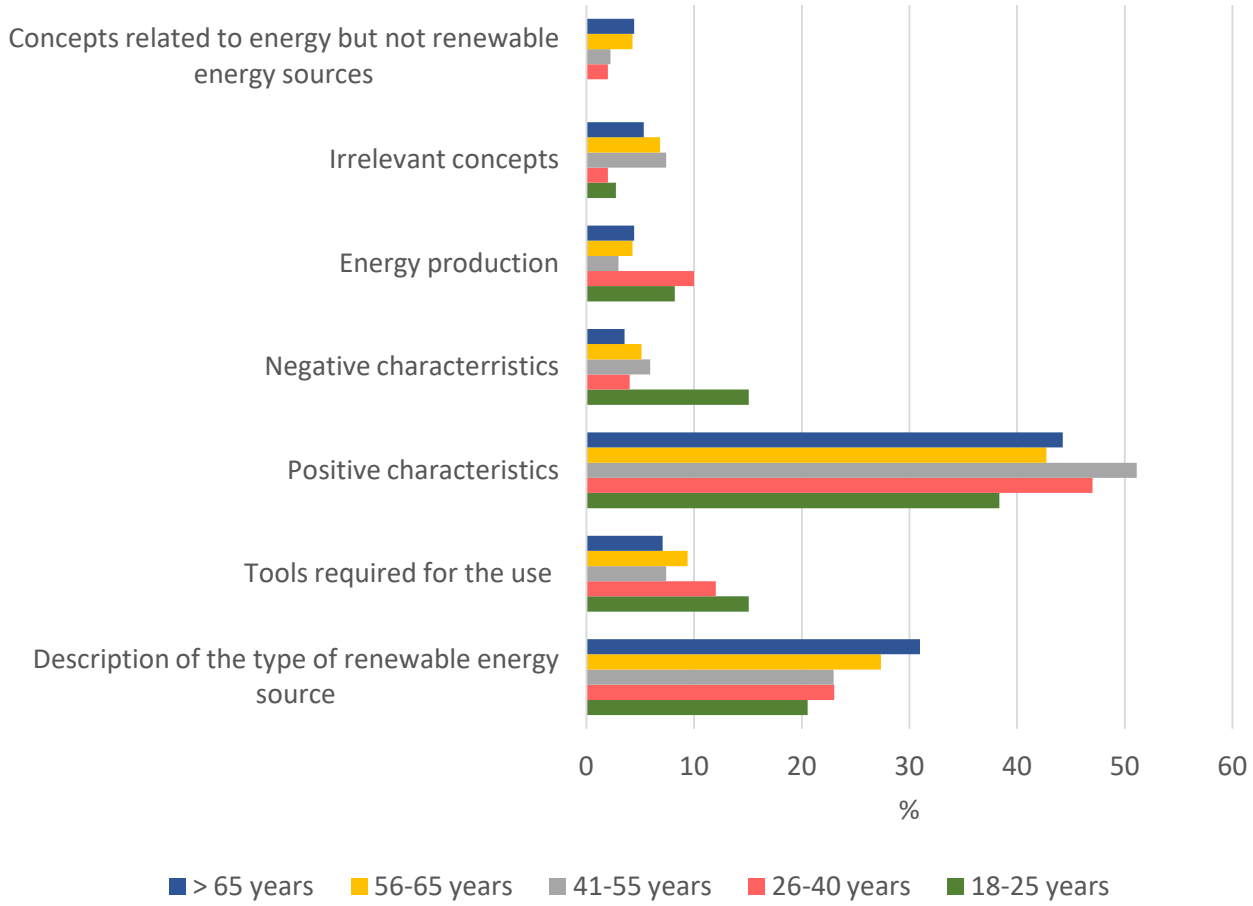

Figure 5 Percentage distribution of associations classified among each concept group by age groups

3.4. Conceptual structures of respondents with different education levels

Based on the ratios of irrelevant concepts, and the concepts related to energy production but not to renewable energy sources we can infer the depth of knowledge regarding renewable energy sources. In the case of respondents without elementary school education, the number of associations in both categories were relatively high which suggest a lack of information (Figure 6).

It is surprising that among the respondents with technical certifications, the ratio of irrelevant associations was relatively high (15%).

The ratio of negative associations was under 10% in every category, and the highest ratio was observed among the respondents with vocational training (9%). The ratio of positive associations, however, was the highest among the respondents with higher education (62.7%), whereas the ratio of associations was significantly lower in other categories (between 39% and

47%), therefore the members of the most qualified group are most familiar with the benefits of renewable energy sources which means the level of education impacted the results in this aspect.

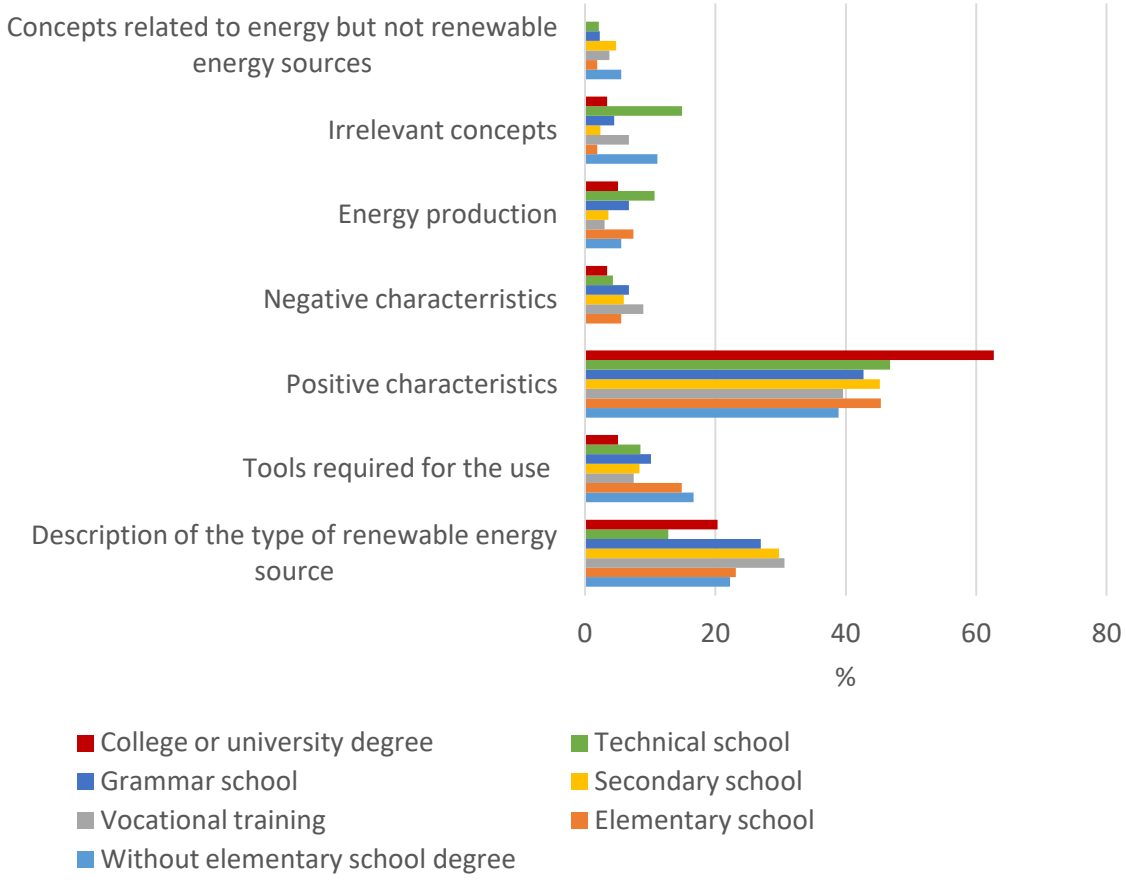

Figure 6 Percentage distribution of associations classified among each concept group by education levels

4. Conclusions

Based on the word association method, we concluded that the knowledge of the population on renewable energy sources is somewhat superficial. The respondents mainly associated to traditional renewable energy sources (solar, wind and water energy) and among the associations regarding the utilization of renewable energy sources the most frequently mentioned terms were related to solar energy (solar cell, solar collector), so we can also conclude that the solar energy is the most familiar to the public. The ratio of associations regarding biomass and geothermal energy were much lower, therefore these types are not that integrated into the conceptual structure of the inhabitants regarding renewable energy sources.

It is encouraging that attitude of public toward renewable energy is clearly positive, since the most frequently mentioned associations referred to positive characteristics. Among the negative associations, only the term “expensive” was relatively high, which can be understandable considering the generally high investment costs.

Upon investigating the differences between genders, we can conclude that there is no relevant distinction between the conceptual structures of men and women. However, between

certain age groups differences could be observed. We concluded that among the investigated age group, the youngest group (between the age of 18 and 25) is most familiar with the renewable energy sources. It was also revealed that there are significant differences in terms of education levels. The rate of irrelevant association was the highest among the respondents without elementary school education, which can be explained primarily by the lack of information. However, the ratio of positive associations regarding renewable energy sources was the highest among respondents with higher education (college or university diploma), which suggests that this group is the most familiar with the benefits and opportunities regarding renewable energy sources.

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Management Accounting and Control of Sustainable Business Value Creation

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Management Control of Sustainable Business Value Creation

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Abstract

The purpose of a sustainable enterprise is not to make a short-term profit as in classic theories of the businesses. Sustainable business focuses on long-term value creation for all stakeholders and for society. In a sustainable society, there is a need for less use of resources that creates demand for resource-efficient business models. Product sales are replaced by new concepts of contact-based services that satisfy customer needs of product functions. Such service sales models partly eliminate some sales of new products and lower the use of resources.

This transformation to a green circular economy has an impact on future value creation in sustainable business of tomorrow. Managers of enterprises need to include sustainable stakeholder values in management accounting and control systems. A model for sustainable value management control is presented.

Key words: Sustainable business, value creation, circular business models, management accounting

- **Introduction**

Sustainable value management is a vast area of concern to stakeholders of enterprises. Many different views of value and sustainable business exist Many scholars discuss value recognition and measurement. This paper's starting point is Sewall, 1901 who argued: "Economists are interested in the value of things and distinguish between 'value in exchange' and 'value in use'". Value in use refers to the specific quality of a new job, task, product, or service as perceived by users in relation to their needs, such as the speed or quality of performance of a new task or performance features of a new product or service. As Bowman and Ambrosini (2000) note, such judgments are subjective and individual specific. The second type of value, exchange value, is defined either as value realized from a past transaction or unrealized, calculated exchange value.

Creating value is a process activity and it is not always clear what value the final product or service will achieve. The value created must also be controlled and captured by the entity that creates the value. Many values are difficult to control, for example, effects of marketing activities and marketing values l "spill over" to other business operations nearby.

In the future, business value creation is often the shift from selling products to selling a specific function that is needed by the clients that uses the products, so called functional business contract. Instead of selling a product, the new business aim is to satisfy needs of clients. Buying product is not the only way to satisfy a need. The "function business" when client needs are satisfied by contract based supply of service to the client is one way to minimize the use of resources in our societies.

Sustainability of products has value for some clients that like to buy sustainable products or "functional business" contracts. Companies selling products must convince buyers that products are created in sustainable ways from raw materials to use of the product and later when recycling or disposing of products. Sustainability management must follow a circular product life cycle. In a "green" economy sustainability is capital or value in the market. Products that are not sustainable are at risk of being less attractive to clients and other stakeholders and companies in the business ecosystem and in the supply chain. However, for products that meet demands of sustainability there are many opportunities that must be considered in management control systems.

The idea behind sustainable business is that consumption of raw material must decrease in an environmentally friendly way. New business models need to be set in order to achieve a higher level of sustainability. Recycling and disposal are key elements illustrated by the term circular economy and must be incorporated into management control systems. The figure below demonstrates circular product life cycles.

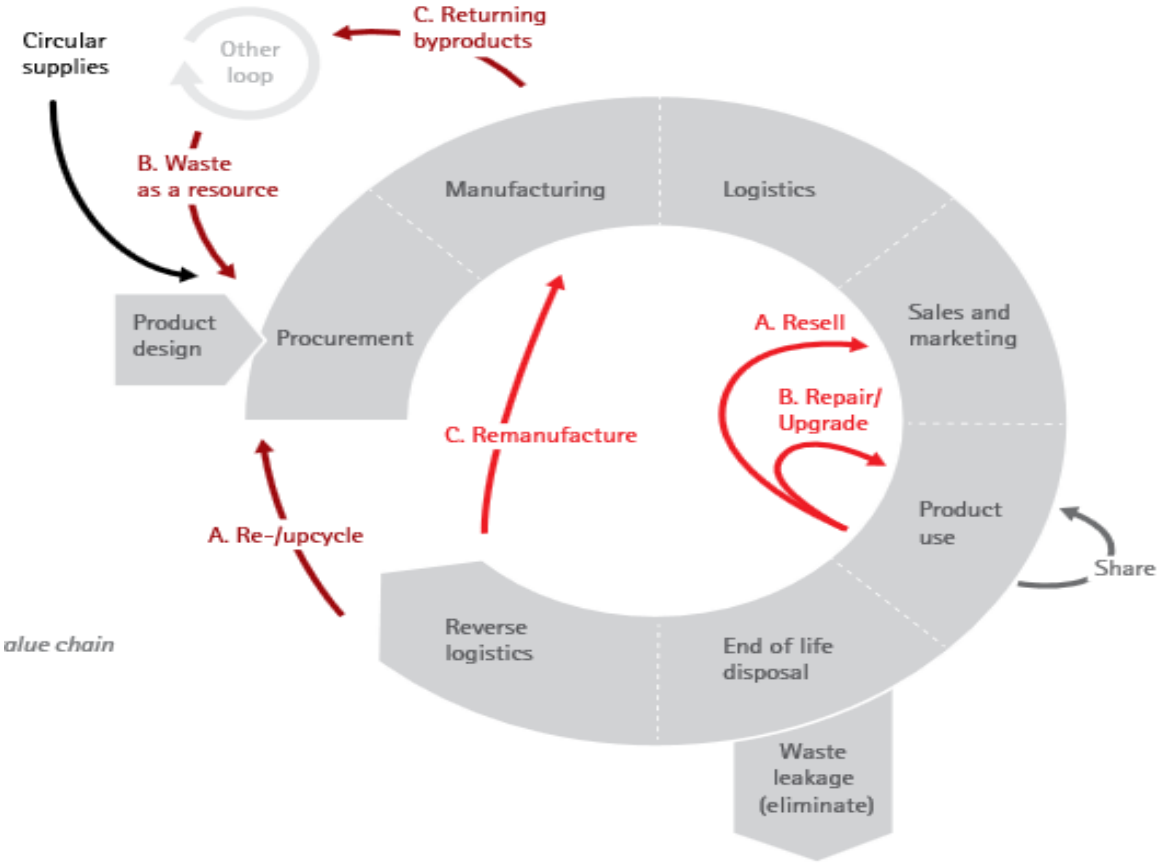

Figure 1 Circular “green” economy

The choice of raw material is important. What values can companies achieve if they use either recycled material or new material? Whether a supplier is a sustainable supplier is another question that affects companies’ material decisions. When an agreement is made to deliver material, the terms of transport are agreed. Sustainable companies need to consider not only the price of transport but also whether transport is environmentally friendly or not.

In construction and production of products companies must include sustainable technology in the product and in involved fabrication processes involved. Products must also include recycling friendly solutions. In markets, products must meet competition not only in terms of price but also competition includes sustainability factors of products. The declarations or information of content and functions of products are sustainable reports made for buyers. This fact is important because it creates values in competition processes. When products are used selling or producing companies remain responsible. Several risks are involved using products and they can damage values of the product brand and sellers. When product life cycles end, information about recycling or disposal must be available to owners of products. Recycling firms need to have information about products in order to detoxify and recycle products. Which company will pay for detoxication and keep toxic material is a very important question. The value of toxic material depends on technology in order to return products back into a safe new life cycle. Disposals must be kept in secure deposits until new technology is found for recycling of the disposals.

- **Stakeholders and their value preferences**

In the stakeholder model below some stakeholders and the enterprise are in green colour. Stakeholders depend on sustainable life and sustainable business enterprises. The green colour indicates areas where sustainability values "spill over". This "spill over" needs to be managed by the enterprise and the stakeholders and incorporated in management control systems.

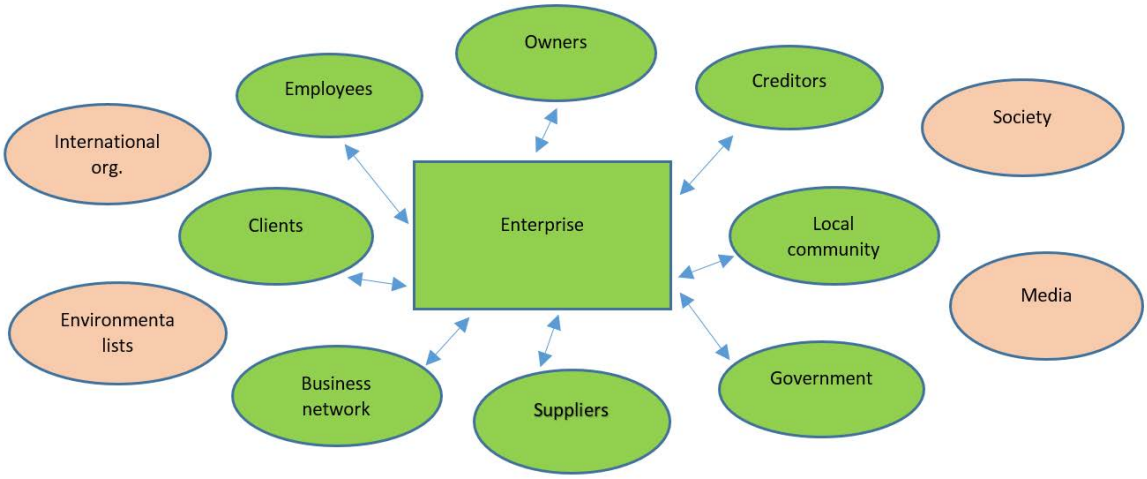

Figure 2 Stakeholder view of a sustainable enterprise (Developed from Freeman, 1984).

Value has different meanings for different stakeholders. Stakeholders who 1) create value by bringing in resources and capabilities, which are firm specific, causally ambiguous and socially complex, and 2) appropriate some of the value created in their relationship with the firm (Coff, 2010). This broader stakeholder-based view of value creation activity offers a theoretical foundation to a stakeholder approach to economic valuation in which some stakeholders do obtain positive net present value—i.e., rents—in their interaction with firms (Asher *et al*., 2005). In this sense, total value created by enterprises must also include value captured by stakeholders.

One of the arguments against the theory is that stakeholder theory does not give the management of enterprises guidance on how various interests from various stakeholders are met by management. Various stakeholders favour their values and look for what they can receive from enterprises. Jensen (2001) suggested an enlightened stakeholder theory: "*Enlightened stakeholder theory adds the simple specification that the objective functions—the overriding goal—of the firm is to maximize total long-term firm market value. In short, the change in the total long term market value of the firm is the scorecard by which success is measured"* (ibid p.17). This enlightened stakeholder theory adds a very important restriction – the long-term business market value must be based on sustainable conditions. This restriction is based on value creation that is made in different levels of ecosystems.

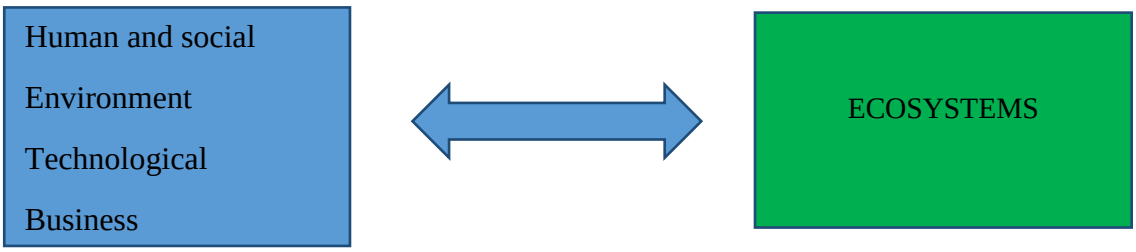

Figure 3 Ecosystems in different levels

One ecosystem is the businesses network, another one is the environmental ecosystem, a third one is the technological ecosystem, and finally the human and social ecosystem. An enterprise cannot create long-term business value without harmony among other levels of ecosystems.

- **Shareholders' view of a sustainable business value creation**

The owners of enterprises, shareholders, have legal rights over the net assets of enterprises. How enterprise values of net assets develop is centrally important for the value of their stake in the enterprise. The growth of the business, profitability and other ratios is used as tools to understand "classic" value of firms. On top of classic value, payment of dividend paid is importan for value of shares.

Methods of net asset valuations are based on various assumptions, postulates. The going concern or continuity postulate for financial accounting and reporting is based on the assumption that a company continues its activities for the forseeable future and is able to complete its planned financial activities and meet its financial obligations. This concept affects valuationw of assets and liabilities on financial reports. When the going concern assumption does not apply, other valuation methods must be applied.

> *Sustainability, in principle, is based on the same idea as the traditional financial reporting continuity postulate, but the period is includes the time necessary to complete sustainability objectives, including materials acquisition, product manufacture and/or service provision, disposal including recycling, environmental clean-up, etc. in addition to meeting financial commitments. If a company has trouble meeting its obligations related to the resources linked to the company's sustainability social and human resources, environmental resources, and technological resources, the business cannot continue indefinitely. As it relates to sustainability, the continuity postulate is based on the idea that operations should continue for the near future and that the company can meet its commitments, both financial and sustainability, including but not limited to product and service life cycle, recycling, disposal, and clean up. (Fagerström et al 2017, pp 47-48)*

The continuity postulate also impacts capital maintenance because companies must have enough capital to cover both financial risks and sustainability risks. Hicks´s (1939) "well off" concept includes the sustainability dimension in a broader context, even if not discussed explicitly.

sustainable enterprises' value for shareholders depends on sustainability risks and possibilities. Failure in management of sustainable risk has a major impact on economic sustainability, going concern, of firms. A good example is:

> *Volkswagen has confirmed it has negotiated a "concrete draft" settlement with US authorities that will see it pay [US]$4.3bn (£3.5bn) in civil and criminal fines in the US over the "diesel gate" emissions scandal. (The Telegraph, 2017)*

Over and above fines imposed by courts, large losses result from loss of reputation, which affects t sales and profits globally.

- **"Green" finance sustainable value creation**

The finance sector provides various forms of capital for enterprises' financial needs. In return, financial firms receive interest and in some cases a portion of the value in the investment. However, a tendency over the last decades is financial firms' growing interest in sustainability and corporate social responsibility, CSR. Not only in the financial firms itself but also in their product portfolio. Encouraging environmentally responsible investments and prudent lending is one of the responsibilities of the banking sector. Further, those industries that have already become green and those that are making serious attempts to become green are accorded priority in lending by banks. This method of finance is called "Green Banking", an effort by banks to encourage industries to be green and in the process restore the natural environment. (Biswas 2011). One definition by PWC (2013)

> *For the banking sector, green finance is defined as financial products and services, under the consideration of environmental factors throughout the lending decision making, ex-post monitoring and risk management processes, provided to promote environmentally responsible investments and stimulate low-carbon technologies, projects, industries and businesses.*

One example of green banking is the Swedish bank SEB that has an investment fund Global for ethical and sustainable investments. When the fund invests it actively searches for companies with not only good returns on investment but also is best in class on three sustainable aspects, low use of CO_2, low water consumption and no toxic pollution. (www.seb.se 2016). Sustainability adds value to SEB bank´s product and is a good example of sustainable value diffusion from one company to another.

- **CSR and business value creation**

Corporate Social Responsibility (CSR), also called responsible business, is a form of corporate self-regulation integrated into a business model. CSR is a self-regulatory mechanism in which a business monitors and ensures its active compliance with the "intended meaning" of the law, ethical standards and national or international norms. The aim of CSR is to increase long-term profits and shareholder trust through positive public relations and high ethical standards to reduce business and legal risk by taking responsibility for corporate actions.

Creating Shared Value or CSV comes from the idea that corporate success and social welfare are interdependent. A business needs a healthy, educated workforce; sustainable resources and adept government to compete effectively. For society to thrive, profitable and competitive businesses must be developed and supported to create income, wealth, tax revenues and

philanthropy. The link between Competitive Advantage and Corporate Social Responsibility provides examples of companies that have developed deep linkages between their business strategies and CSR. CSV acknowledges trade-offs between short-term profitability and social or environmental goals, but emphasizes opportunities for competitive advantage from building a social value proposition into corporate strategy. CSV gives the impression that only two stakeholders are important, shareholders and consumers.

A common approach to CSR is corporate philanthropy. This philanthropy includes monetary donations and aid given to non-profit organizations and communities. Donations are made in areas such as the arts, education, housing, health, social welfare and the environment, among others, but excluding political contributions and commercial event sponsorship. Another approach to CSR is to incorporate CSR strategy directly into operations. For instance, procurement of Fair Trade tea and coffee.

Many companies employ benchmarking to assess their CSR policy, implementation and effectiveness. Benchmarking involves reviewing competitor initiatives, as well as measuring and evaluating the impact that those policies have on society and the environment, and how others perceive competitor CSR strategy.

- **Government and local community business value creation**

Society needs products and services and businesses rely on infrastructure and governmental service. From society's perspective, a flow of revenue comes from businesses, such as income tax from companies, special product taxes, tax deducted from employees' salaries, value added tax and other service charges. On the other hand, companies generate costs for society for infrastructure, social welfare and medical care. Without businesses, revenues disappear but most of the costs remain. Interdependence between businesses and society is complex. In cost benefit analyses, is it possible to calculate the net value a company generates for the society where it operates. There must be a balance between society and companies in a sustainable economy.

- **Suppliers and business networks, business ecosystems' value creation**

Suppliers and supply chains give input values for companies in terms of service and materials. If companies' strategies include sustainability it is their responsibility to choose suppliers that are documented as being in line with sustainability demands. Companies have the power to select suppliers; as a result they benefit from the value of sustainable suppliers or in the worst case suffer in markets due to non-sustainable suppliers. Customers are judges.

In supply chain and other networks, value flows among the parties involved. One company captures some values; other values "spill over" to other parts of the network. It is a common strategy to establish shops near larger shops in order to attract many customers. Another issue is value creation and capture of values in business ecosystems. The concept of business ecosystems, or business networks, was originally defined by Moore (1993), who defined them as consisting of co-evolving interdependent and interconnected actors: customers, agents and sellers of complementary products and services, suppliers, and the firm itself. Innovation and business ecosystem are often a form of a business entity in which firms create values jointly. How can each firm in the ecosystem capture value creation? This question does not have a simple answer, but the question should be kept in mind.

- **Clients and sustainable value creation in markets**

The classic market function in which supply meet demand measured in quantity and price does not include all factors that sales transactions generate. These other effects or externalities are not included in prices. For example environmental effects in general are not included in the sales prices of products. Governments implement special product taxes in order to reduce the demand of products with negative impacts. Good example are alcohol and tobacco taxes intended to reduce negative externalities these products have on society. Other products might have positive externalities on society and the environment, for example planting trees. These externalities or factors are important to include in markets if society as whole is to be more sustainable.

- **Recycling businesses and sustainable value creation**

Recycling enterprises are part of sustainable business networks as well as suppliers of goods and services. All are a part of business ecosystems even if they are located in different parts of the world. Recycling firms are important to minimize the amounts of material that do not get back into new products or keep materials in safe storage while new technology is developed for future recycling. Another important role of recycling firms is to detoxify waste in a safe way before it returns to new production or to storage.

The role of recycling enterprises changes over time if society changes towards a circular economy. The change will be from firms in the storage business to a firms that supply raw material and knowledge to the industry. These new roles for recycling firms need legislation on national and international levels. Recycled material should not be discriminated against compared to material from natural sources by differences in tax or other fees.

Value creation of recycling firms is important because of high costs in recycling processes. Some values are easy to identify, for example supply of raw material detoxication has a value for the society at large but is more difficult to recognize and quantify. Knowledge about recycling processes has value for construction of new products in order to make future recycling as smooth as possible.

- **A model for sustainable value creation in an enterprise**

Traditionally, values are discussed from shareholder perspectives, but from a sustainable enterprise perspective, value includes values for a broader group of stakeholders. Based on resource theory, resources linked to capital sources illustrate different values. The model presented in the figure below gives an overview of value creation in an enterprise.

Resources 1 - 4	Value indicators accounted as:	Values (capitals) (1 – 4)	
1. Human and Social	Expenditures / remuneration cost for labour	1a. Human capital	Sustainability values
	Social costs for labour. taxes paid.	1b. Social capital	
2. Ecological	Expenditures / costs for the environment are seldom specified in the accounts.	2. Ecologic (environmental) capital	
3. Technological	Expense / cost for Research and Development. Production costs of various types.	3. Brands, patent and rights	
4. Economic	Cost, expenditures, revenues, assets, liabilities and equity	4. Result and equity capital (net assets)	
		Values above 1- 4 plus various macro factors and psychology give ⟹	Stock market value

Table 4. Values in an enterprise,

In the table, ecological environmental, resources are seldom systematically specified in traditional financial accounting reports. Other resources are reported in terms of expenditures or expenses, income, assets and liabilities to create the bases for values in Table 2. One way to measure the relevance of traditional balance sheets is to divide the market value of equity, i.e. market capitalization, by the book value of equity. This ratio is often called market to book or M/B. Normally, the M/B-ratio is less than one because market values include other values than those traditionally reported in the balance sheet.

It should be noted that traditional accounting is based on the assumption that values are created as a function of expenditure, an input value. Independent valuations give other perceptions of values such as exit values. Independent valuation is based on other value indicators than those traditionally found in financial reports. As a result, traditional reports need to be expanded with additional value indicators, sustainability indicators. The market capitalization of a company may, at a given time, be considered to reflect different shareholders' aggregate valuations of the company. The market value is an objective measure that reflects shareholders' perceptions of a company's value. When equity investors estimate the market value of a firm, it is often an assessment of the company's sustainability, i.e. values 1 – 3 in table 4.

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Mesoporous Spinel-Type MAl_2O_4-Supported Nickel Catalysts in Dry Reforming of Methane

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ABSTRACT

Ni/Al_2O_3 is one of the most commonly used catalysts because of relative low cost and its active ability. However, it's prone to face deactivation problem due to particle agglomeration or coking. Dry reforming of methane by CO_2 using magnesium aluminate ($MgAl_2O_4$) and calcium aluminate ($CaAl_2O_4$) as supports of catalysts was investigated. Two mesoporous spinel supports were firstly synthesized by solution combustion. The Ni/MAl_2O_4 (M = Ca and Mg) catalysts were prepared via impregnation method. The structural and textural properties of various catalysts were characterized by X-ray diffraction (XRD), Brunauer-Emmett-Teller surface area analysis (BET), temperature programmed reduction (TPR) and scanning electron Microscope (SEM) techniques. The methane dry reforming using Ni/MAl_2O_4 catalysts have been performed at reaction temperatures of 700, 800, and 900 °C. Experimental results of reforming reaction indicated that using $Ni/CaAl_2O_4$ exhibited better catalytic activity.

KEYWORDS: spinel, mesoporous material, supported nickel catalyst, dry reforming of methane.

Scaling up farmer preferred rice varieties through participatory varietal selection by women self help groups for diverse environments in mid plain zone of Uttar Pradesh, India.

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ABSTRACT

Limited availability of farmer preferred improved variety quality seed has been a major impediment in increasing rice (Oryza sativa L.) productivity in mid plain zone of Uttar Pradesh, India. The poor farmers are also not able to afford the seed cost when purchased from market. Keeping these factors in view "Informal Seed Systems" project implemented by Rajiv Gandhi Mahila Vikas Pariyojna, under the tutelage of Bill and Melinda Gates Foundation, USA, efforts were made to create awareness on the use of preferred variety quality seed and its impact in increasing the productivity per unit area. With this aim, the present study was undertaken at representative locations in which a group of varieties according to the planting situations viz., low rainfall (5), high rainfall (6) and salinity affected areas (4) were evaluated through participatory varietal trials in pilot phase during monsoon season of 2016-17. Farmer preferred varieties from pilot phase and other new varieties released for such ecologies were included in main evaluation phase during monsoon season of 2017-18 where 46 PVSs comprising five varieties each including farmer's local were conducted in low and high rainfall as well as in salinity environments at 24, 17 and 5 locations respectively. Total 415 farmers were involved in the study at 50 locations. The exercise provided farmers to make their choice in a structured questionnaire for subsequent analysis to enable identification of preferred rice varieties and rank them. Data were analysed for all the three ecosystems for grain yield, maturity duration, number of tillers per plant and number of panicles per plant. Preference ranking and preference indices were worked out for four characters observed by PVS farmers and farmers participated in field days separately for all the three ecologies. Simultaneously, seed production programme of farmer preferred variety Sahbhagi and BPT-5204 identified from pilot phase was also undertaken with women farmers for their use in the next season. Main PVS trials of rice varieties during Kharif 2017-18 revealed that Sahbhagi for low rainfall and salinity, BPT-5204 and Damini for high rainfall were found promising on the basis of farmers' preference ranking and preference index. Seed availability of rice variety Sahbhagi and BPT-5204 was made possible through this informal seed system. Basket of choice comprising Sahbhagi, BPT-5204 and Damini was given to them and provided opportunity to choose the most suited variety for the ecology in which they cultivate rice.

Key words: Oryza sativa L., Participatory varietal selection, Rice ecologies, Farmer preferred varieties, Preference ranking,

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important staple food crop throughout the world and so in the Southern Uttar Pradesh of India. The farming system is characteristically subsistence in small land holdings with poor yield and unknown varieties. Low yields and small land holding size means that farmers in this region are not self sufficient in food grain production. Lucknow, Amethi, Raebareli, Pratapgarh, Sultanpur, Unnao and Fatehpur districts of this region are characterized by diverse rice planting ecologies. The advantages of new agricultural developments and technologies are yet to percolate to areas dominated by small and marginal farmers and grapple with their adoption.

One way of increasing the adoption of new rice varieties is to help farmers test for themselves a wide range of novel cultivars in their own fields. This process is termed Participatory Varietal Selection (PVS). In PVS, the cultivars should be selected carefully to match the traits that farmers require. To do this we ask farmers what qualities are required in the varieties that are important to them. They may, for example, specify that any new variety of rice must be early maturing; high yielding and acceptable grain quality. Participatory varietal selection specifically refers to testing of released varieties, inbred and land races by farmers at their fields under their management. PVS approaches can be used to identify the best suited variety for a given location in a reduced time period at lesser cost. It allows the farmers to evaluate varieties for important traits and to make tradeoff between traits and tests varieties across more of the physical niches in which the crop is grown because the trials are replicated across more locations (Witcombe et. al.)[7]. Farmers are increasingly and actively participating in evaluation process as development workers become more aware of the philosophy of "farmer first and its effectiveness". One of the great strengths of PVS is that it is both an extension and a research method. A successful participatory varietal selection programme has four phases: (a) participatory evaluation to identify farmer' needs in a cultivar; (b) a search for suitable varieties to test with farmers; (c) evaluation on their acceptability in farmers" fields and (d) wider dissemination of the farmer preferred cultivars. In the process of identifying a farmer preferred variety, farmer participation is seen as key to increase the probability of adoption of new varieties due to their evaluation in target environment (Witcombe and Yadavendra)[6]. Keeping in view the wide gap between the demand and supply of quality rice seed and limited varietal profile, the present study was undertaken to evaluate rice varieties procured across diverse agro ecological situations in participatory mode. We have used already released cultivars, not only from the target region but from other regions of the country. There are many varieties in other crops that have been released and widely grown only in a single state, yet have the potential to be useful in others. Using already released cultivars saves time because sufficient seed is usually readily available. Farmer participatory varietal selection is used to address the problem of limited varietal choices available to cultivators. The resources available to farmers can be a very important factor in their adoption of varieties. Resource poor farmers may have restricted access to new varieties and may be less willing to invest in, or risk, growing new varieties (Yadavendra and Witcombe)[6].

MATERIALS AND METHODS

The present investigation was undertaken in two phases; (a) Pilot phase *Kharif* 2016-17 and (b) Main assessment phase *Kharif* 2017-18. Pilot as well as main investigation phase was undertaken under three ecologies representing the actual rice growing conditions of the crop like (a) low rainfall, (b) high rainfall and (c) salinity situations. In pilot phase for low rainfall situations, five varieties in four PVS trials, for high rainfall situations six varieties in two PVS trials and for salinity situations four varieties in three PVS trials for the respective ecology were evaluated. In main assessment phase four different varieties (NDR 3112, Moti,

Sahbhagi and Damini) and farmer local were evaluated at farmers fields in 24 PVS trials for drought situation, 17 PVS trials for flood situation where Swarna Sub-1, Moti, BPT-5204, Damini and farmer local were included and five PVS trials comprised CSR-35, Moti, Damini, sahbhagi and farmer local for salinity situations. The details of the varieties included in different ecologies are given in the Table 1 below:

Table 1. Rice varieties included in PVS for diverse environments in pilot phase (*Kharif* 2016-17) and main phase (*Kharif* 2017-18).

Pilot Phase *Kharif* 2016-17		
Low rainfall situation (n=4)	**High rainfall situation (n=2)**	**Salinity situation (n=3)**
Sahbhagi	Samba Masuri Sub 1	CSR 43
DRR 42	Bina 11	CSR 36
DRR 44	Swarna Sub 1	Narendra 359
Damini	Swarna	Sarju 52
Narendra 97	Samba Masuri	Farmer Local
Farmer Local	Moti	
	Farmer Local	

Main Assessment Phase *Kharif* 2017-18		
Low rainfall situation (n=24)	**High rainfall situation (n=17)**	**Salinity situation (n=5)**
NDR 3112	Swarna Sub 1	CSR-36
Moti	Moti	Moti
Local	Local	Local
Sahbhagi	BPT-5204	Sahbhagi
Damini	Damini	Damini

Each trial was a single replicate as it had only one plot of each variety. They not only served as demonstration plots or focal points for discussions, but provided quantitative, analyzable data on grain yield, maturity days, number of tillers per plant and number of panicles per plant. PVS assumes that varieties exists that are better than those currently grown, but farmers have not had the opportunity to test them. For statistical analysis purpose each trial was treated as a replication and data were analysed by method used for completely randomized block design. These varieties were chosen on their preference in the pilot phase and certainty of seed availability. Locations of the trials were identified to represent the typical diverse agro ecological situations of the respective locations. Similarly, farmers who showed the interest in conducting the participatory varietal selection trial were chosen across locations. For each location one kilograms seed of each varieties mentioned above and own local seed of respective farmers for nursery raising and then planting during rainy season. Trials were laid out by farmers in their own fields. This approach has been employed to evaluate, identify and disseminate different varieties on farmer's field as per farmer's management regarding various traits and their perception and aspirations about varietal specifications. On the basis of the feedback from the farming community, characters which determine the preference for a variety were considered viz., grain yield, maturity duration, number of tillers per plant and number of panicles per plant to collate the observations. In PVS trials, actual yield and days to maturity observations were recorded whereas preference

ranking for number of tillers per plant and number of panicles per plant were considered by the farmers who conducted them. Farmers who participated in field days at the PVS sites were requested to provide their perceptions on the relevant four characters in the pre-structured questionnaire given to them during the field days. Constant support was given to the PVS farmers and interactions during field days. The participating farmers were monitored by the field staff to minimize the error while recording the observations by the farmers. The mean preference score was worked out separately for all the four characters for 46 PVSs and two field days at village Janesara on 16 October 2017 and at Pipargaon on 27 October 2017 to arrive at cumulative average preference rankings and indices for varieties. The preference score index was calculated as described by (De-Boef and Thijssen)[2], Ceccarelli[1] and (Shaikh et.al.)[4] as under:

Preference Index =	No.of farmers gave first preference–No.of farmers not gave first preference Total number of farmers participated in scoring

Average preference rankings as well as preference index were used to compare varieties for their superiority for all four traits by the farmers. Early maturity has been considered better over late maturity. Individual participants rank the varieties for each character separately More number of farmers preferred a variety is given the first rank and accordingly. It allows the understanding of choices between a set of varieties with identification of characteristics that distinguish them in addition to identification of criteria used by farmers to distinguish varieties. Results of these ecologies are presented in the result part of this paper. In order to arrive at a conclusion the most farmers preferred variety (ies) for respective ecology have been identified.

EXPERIMENTAL RESULTS

(A) PVS pilot evaluation phase *Kharif* 2016-17

Seven pilot participatory varietal selection (PVS) trials on rice (*Oryza sativa* L.) were conducted in *Kharif* season of 2016-17 at seven locations (four in low rainfall, two in high rainfall and one in salinity affected areas) in mid plain zone Uttar Pradesh. Five varieties in drought, six in flood and four in saline situations were included in these seven PVSs. The findings from pilot PVSs are given below in Table 2. In the tables below, results are given ecology wise for preference of PVS farmers and perceptions based on farmers' preferences given while visiting the PVSs on the field day. Preference indices were derived from the preference rankings given by farmers during field days. No field day was organized for PVS under salinity situation.

Table 2. Farmers' perceptions of varietal preference from paddy pilot phase PVS trials conducted during *Kharif* 2016-17 in different ecologies.

Variety	Low rainfall situation		
	Average PVS farmer preference index (n=4)	**Average preference ranking by farmers participated in field day (n=135)**	**Average preference index for farmers participated in field day (n=135)**
Sahbhagi	0.50	1	-0.32
DRR 42	-0.50	2	-0.32
DRR 44	-1.00	3	-0.72
Damini	-1.00	5	-0.82
Narendra 97	-1.00	4	-0.81
High rainfall situation			
Variety	**Average PVS farmers preference index (n=2)**	**Average preference ranking by farmers participated in field day (n=131)**	**Average preference index for farmers participated in field day (n=131)**
Sambha Mansoori Sub 1	-1.00	4	-0.98
BINA 11	1.00	2	-0.30
Swarna Sub1	-1.00	5	-0.94
Swarna	-1.00	6	-0.91
Sambha Mansoori	-1.00	3	-0.48
Moti	1.00	1	-0.39
Salinity situation			
Variety	**Average PVS farmers preference index (n=3)**		
CSR 43	-1.00		
CSR 36	-1.00		
Narendra 359	0.33		
Sarju 52	-0.33		

From the above results under drought conditions PVS farmers' index was in favour of Sahbhagi and DRR-42 and other three varieties were not preferred by these farmers. Preference ranking by 135 farmers during field days was also in favour of these two varieties over other three which was further supported by preference index. In the two PVS trials conducted by farmers under flood situation, they preferred Bina-11 and Moti varieties and rejected the others. During field day also the visiting 131 farmers also preferred Bina-11 and Moti varieties for flood situation which was strongly supported by the preference index also. In salinity situation from the sole PVS the preference of the farmers was for Narendra-359 and Sarju-52. Based on their preference and preference indices varieties were identified for inclusion in the main PVS trials for the next season.

(B) PVS main evaluation phase *Kharif* 2017-18

During monsoon season of 2017-18, different rice varieties including farmers' local were evaluated through PVSs under low rainfall, high rainfall and salinity growing situations in the mid plain zone of Uttar Pradesh. Twenty four PVSs under low rainfall, seventeen in high rainfall and five in salinity affected areas were conducted at farmers fields. All the farmers who conducted the PVSs were requested to take the observations in pre designed questionnaire on four characters viz., days to maturity, and number of tillers per plant, number of panicles per plant and grain yield per plot. The grain yield per plot was converted into quintals per hectare. Field days were organized at one of the PVS site each in low rainfall and high rainfall situations. All the farmers who participated in field days were requested to fill up the pre structured questionnaire provided to them during the field days. Results thus obtained from PVS farmers and field day participating farmers are given for three growing situations separately as under.

(i) Low rainfall situation

Twenty four PVSs were conducted at different locations representing drought conditions in Lucknow, Amethi, Raebareli, Pratapgarh, Unnao, Sultanpur, Hardoi and Sitapur. Results obtained from the farmers and who conducted the PVSs and who participated in field days are explained character wise below:

(a) Grain yield (t/ha): In PVSs, the actual grain yield was recorded by the farmers in kilograms and the same was converted to tones per hectare for better understanding. There was no significant difference amongst the varieties for grain yield. However, on the basis of the observations (Table 1) it was evident that in less rainfall areas variety Sahbhagi was the highest yielding (24.53t) followed by farmers local, Moti, Damini and Swarna Sub-1. It was interesting to observe that the farmers own local was also found to be good yielding. Mostly farmers use the seed which readily available in the local retail market and that was also found to be Damini in majority cases. While working on the observations of preference ranking by farmers who conducted the PVSs, again it was Sahbhagi. The preference index of PVS farmers again favored Sahbhagi. The preference index was lowest for Moti. When the data for average preference ranking based on farmers' perceptions during field day it was interesting to know that Sahbhagi and were the least preferred varieties. Damini and Moti were the most preferred by the farmers. Similar trend was observed for preference index for grain yield.

Table 3. Character wise details in main evaluation phase of paddy varieties in PVSs, field days and PVS visits by farmers under low rainfall situations during 2017-18.

Grain yield					
Variety	**PVS farmers actual average yield qtls*\ha. (n=24)**	**PVS farmers average preference ranking (N=24)**	**PVS farmers average preference index (n=24)**	**Average preference ranking based on farmers participated in field days (n=116)**	**Average preference index based on farmers participated in field days (n=116)**
NDR-3112	22.16	5	-0.67	4	0.78
Moti	23.49	3	-0.83	2	0.86
Local	23.68	2	-0.50	1	0.93
Sahbhagi	24.53	1	-0.25	5	0.64
Damini	23.33	4	-0.58	3	0.79
	GM= 23.43	**F= 0.35**	**SE(m)= 1.46**	**CD= 4.08**	**CV (%)= 30.45**
Maturity days (number)					
NDR-3112	124.79	4	-0.92	1	0.76
Moti	129.96	2	-1.00	2	0.78
Local	129.92	3	-0.83	4	0.86
Sahbhagi	116.17	1	0.67	3	0.81
Damini	130.04	5	-0.83	2	0.78
	GM= 126.18	**F= 13.62**	**SE(m)= 1.63**	**CD= 4.57**	**CV (%)= 6.34**
Number of tillers/plant					
NDR-3112	18.33	5	-0.58	2	0.90
Moti	19.00	3	-0.42	1	0.91
Local	19.33	2	-0.50	3	0.88
Sahbhagi	18.75	4	-0.58	4	0.86
Damini	19.96	1	-0.50	5	0.78
	GM= 19.75	**F= 0.19**	**SE(m)= 1.41**	**CD= 3,94**	**CV (%)= 36.12**
Number of panicles/plant					
NDR-3112	16.83	5	-0.58	4	0.69
Moti	17.50	3	-0.58	1	0.91
Local	17.29	4	-0.33	2	0.90
Sahbhagi	17.75	1	-0.50	5	0.64
Damini	17.50	2	-0.08	3	0.81
	GM= 17.37	**F= 0.60**	**SE(m)= 1.37**	**CD= 3.85**	**CV (%)= 38.71**

*=qtls= Quintals (100kg)

(b) Days to maturity: Number of days taken by a variety to mature for harvest is considered to be the days taken for maturity. The farmers who conducted the PVSs recorded the total number of days when the variety was ready for harvest. Whereas, early maturity was the preference of majority farmers who participated in field days. The preference ranking as well as index for maturity duration observed by PVS farmers was positive for Sahbhagi, Moti and farmers local and was low for other varieties. Observations from the field day perceptions it was evident that the varieties which matured early had a better ranking as shown for Moti, Damini,and Sahbhagi further supported by preference indices.

(c) Number of tillers per plant: Observations on number of tillers per plant was based on the average of actual number counted by the farmers from five plants. The best tillering varieity based on PVS farmers observations were Damini, farmer local and Moti whereas Sahbhagi and NDR-3112 had less tillers. The same trend was evident from average preference ranking as well as average preference index. The results from the observations made by farmers participated in field days have preference for farmers local, Moti and NDR-3112 over Sahbhagi and Damini. Similar pattern of expression for number of tillers per plant was visible in average preference index from field day results.

(d) Number of panicle per plant: The actual number of tillers per plant observed by PVS farmers was maximum for Sahbhagi, Damini and Moti whereas minimum for NDR-3112 and farmers local. This was also evident from the average preference ranking and index as well from the observations by PVS farmers. While analyzing the results of the observations made by the farmers who participated in field day showed that Moti, farmer local and Damini have higher preference ranking over NDR-3112 and Sahbhagi for number of panicles per plant.

(ii) High rainfall situation

Seventeen PVSs were conducted at different locations representing high rainfall situations in Lucknow, Raebareli, Amethi, Sultanpur and Fatehpur districts. Results obtained from the farmers who conducted the PVSs and who participated in field days are given character wise as under:

(a) Grain yield per hectare: In high rainfall growing conditions farmers who conducted the PVSs found BPT-5204, farmer local, Moti, Damini and Swarna Sub-1 in order of preference for their yielding ability. Though BPT-5204 and farmer local were higher yielding over others but the results did not differ significantly. The average preference index of the PVS farmer also indicated the similar pattern of results. The preference of farmers during field day also preferred famer local, Damini which was further supported by their preference index but not the BPT-5204. Sahnhagi has the last preference expressed by field day farmers as evidenced by their preference rankings well as indices.

Table 4. Character wise details in main evaluation phase of paddy varieties in PVSs, field days and PVS visits by farmers under high rainfall situations during 2017-18.

Grain yield					
Variety	**PVS farmers actual average yield qtls*\ha. (n=17)**	**PVS farmers average prefence ranking (n=17)**	**PVS farmers average prefrence index (n=17)**	**Average preference ranking based on farmers participated in field days (n=112)**	**Average preference index based on farmers participated in field days (n=112)**
Swarna Sub-1	21.55	3	-0.76	4	-0.25
Moti	22.05	2	-0.53	3	0.45
Local	21.07	4	-0.65	2	0.84
BPT-5204	24.55	1	-0.18	5	-0.41
Damini	19.74	5	-0.76	1	0.93
	GM= 21.79	**F= 0.58**	**SE(m)= 0.31**	**CD= 6.50**	**CV (%)= 43.67**
Maturity days (number)					
Swarna Sub-1	140.82	5	-0.88	1	-0.16
Moti	130.35	1	-0.29	2	0.57
Local	131.82	3	-0.29	4	0.80
BPT-5204	137.00	4	-0.76	2	-0.21
Damini	131.76	2	0.06	5	0.89
	GM= 134.35	**F= 4.08**	**SE(m)= 2.19**	**CD= 6.15**	**CV (%)= 6.71**
Number of tillers/plant					
Swarna Sub-1	21.29	3	-0.53	3	0.64
Moti	20.76	4	-0.76	1	0.50
Local	22.06	2	-0.41	4	0.79
BPT-5204	22.47	1	-0.53	2	0.63
Damini	20.41	5	-0.65	5	0.86
	GM= 21.40	**F= 0.39**	**SE(m)= 1.37**	**CD= 3.87**	**CV (%)= 26.46**
Number of panicles/plant					
Swarna Sub-1	20.76	2	-0.29	4	-0.30
Moti	19.65	5	-0.88	3	0.46
Local	19.71	4	-0.65	1	0.91
BPT-5204	21.65	1	-0.29	5	-0.32
Damini	19.76	3	-0.53	2	0.89
	GM= 20.31	**F= 0.38**	**SE(m)= 1.41**	**CD= 3.97**	**CV (%)= 28.65**

*=quintals=(100kg)

(b) Maturity days: There was significant difference in the maturity duration of the rice varieties. On the basis of the PVS farmers' observations, Moti, Damini and farmer local matured earlier as compared to BPT-5204 and Swarna Sub-1. This was further evidenced in average preference ranking as well as index in respect of PVS farmers. Reviewing the results from field days, it was observed that Swarna Sub-1, Moti and BPT-5204 farmer local was ranked first and Damini and farmer local matured in the last. Damini and Moti were at par in maturity based on the preference ranking and index from observations from the field day.

(c) Number of tillers per plant: Observations of PVS farmers revealed that there was no significant difference in the number of tillers of all the five varieties. Based on the PVS farmers' observations BPT-5204, farmer local and Swarna Sub-1 were having more tillers when compared with Damini and Moti. Average preference ranking and index based on field day farmers observations suggested the better tillering ability of Moti, BPT-5204 and Swarna Sub-1. During field day, farmers average preference ranking was in favour of Moti, BPT-5204 and Swarna Sub-1 followed by farmer local and Damini.

(d) Number of panicles per plant: Observation on number of panicles per plant for PVS farmers showed the highest preference for BPT-5204 followed by Swarna Sub-1. This was also evident from the average preference ranking as well as index. Average preference ranking and index based on observations made by farmers participated in field day indicated maximum panicles for Damini, farmer local and Moti and minimum for Swarna Sub-1 and BPT-5204 respectively.

(iii) Salinity situation

Five PVSs were conducted at different locations representing salinity situations in Raebareli, Sultanpur, Fatehpur, Unnao and Amethi, districts. As no field day was organized for the PVSs which were conducted in salinity situations hence only results obtained from the farmers who conducted are given character wise as under:

(a) Grain yield per hectare: Grain yield per hectare differed significantly amongst varieties grown under salinity prone situations. Based on the actual observations of five PVS farmers, Sahbhagi was the highest yielding followed by Damini and farmer local. CSR-36 was found to be poor yielding in such growing situation. Average preference ranking and index were also in favour of Sahbhagi, Damini, farmer local and Moti over CSR-36.

(b) Maturity days: These five varieties differed significantly in their maturity duration when grown under salinity situation. Sahbhagi was the first in maturity followed by Moti and farmer local whereas Damini and CSR-36 were last to mature. The average preference ranking and index also reflected the similar behavior except CSR-36 which had better ranking and index over farmer local and Damini.

Table 5. Character wise details in main evaluation phase of paddy varieties in PVSs, field days and PVS visits by farmers under salinity situations during 2017-18.

Grain yield			
Variety	**PVS farmers actual average yield qtls*\ha. (n=5)**	**PVS farmers average preference ranking (n=5)**	**PVS farmers average preference index (n=5)**
CSR-36	21.60	5	-1.00
Moti	25.05	4	-1.00
Local	25.64	3	-0.20
Sahbhagi	28.22	1	-0.20
Damini	26.80	2	-0.60
GM= 25.46	**F= 0.30**	**SE(m)= 4.51**	**CD= 13.32**
			CV (%)= 39.65
Maturity days (number)			
CSR-36	129.60	3	-0.60
Moti	125.60	2	-1.00
Local	129.40	4	-1.00
Sahbhagi	112.40	1	1.00
Damini	130.60	5	-1.00
GM= 125.52	**F= 7.04**	**SE(m)= 2.86**	**CD= 8.43**
			CV (%)= 5,09
Number of tillers/plant			
CSR-36	18.00	2	-0.20
Moti	18.00	3	-0.60
Local	16.80	5	-1.00
Sahbhagi	18.60	1	-0.60
Damini	17.60	4	-0.60
GM= 17.80	**F= 0.14**	**SE(m)= 1.75**	**CD= 5.15**
			CV (%)= 21.95
Number of panicles/plant			
CSR-36	16.00	2	-0.20
Moti	15.80	3	-0.60
Local	15.40	4	-0.60
Sahbhagi	14.80	5	-1.00
Damini	17.20	1	-0.20
GM= 15.84	**F= 0.42**	**SE(m)= 1.38**	**CD= 4.06**
			CV (%)= 19.44

*=quintal=(100kg)

(c) Number of tillers per plant: There was no significant difference amongst varieities for number of tillers per plant. The PVS farmers observed that Sahbhagi, CSR-36 and Moti had more tillers as compared to Damini and farmer local. The average preference ranking and index have also shown the similar pattern of observations for this character.

(d) Number of panicles per plant: Number of panicles per plant also did not differ significantly from variety to variety. However, varieties Damini, Moti and CSR-36 were having more panicles per plant over Sahbhagi and farmer local. The average preference ranking and index have also shown the superiority of Damini, Moti and CSR-36over Sahbhagi for panicles per plant.

DISCUSSION

Rice (*Oryza sativa* L.) is the most important staple food crop cultivated in major part of the globe. In India, Uttar Pradesh is the one of the main state contributing to the rice bowl of the country. The present study was undertaken in Lucknow, Amethi, Raebareli, Pratapgarh, Sultanpur, Unnao and Fatehpur districts of southern Uttar Pradesh to find out the farmer preferred varieties of rice for general cultivation and alleviating farm economy by them. Further, to provide a basket of varietal choice to farmers to select most suitable variety for cultivation as per their requirement (Joshi and Witcombe)[3]. Five varieties of rice including the farmers own variety (local) was evaluated in participatory varietal selection system under diverse agro-climatologically conditions. Five varieties were identified from a pool of varieties developed and released for different ecologies of India to meet their requirements in these districts.

Preference ranking from both farmers who conducted the PVS trials and who participated in field days organized at different places in low and high rain fall growing situations was worked out. In salinity situation results were based only on observation of PVS farmers. Four characters were considered while obtaining the preferential score from both the categories of farmers. These were the four characters which farmers considered important while selecting a variety. On the basis of the preference rankings and indices from both categories of farmers it has been found clearly that Sahbhagi was the most preferred variety. Other preferred varieties were Damini and Moti.This was mainly due to early maturity and yield potential of Sahbahgi which attracted farmers to select it. In rain deficit areas as compared to high rainfall areas, early maturity variety is a better choice of farmers. In high rainfall areas Daminin and Moti along with farmer local were the preferred varieties as Sahbhagi did not out yield these. The rice varietal choice of farmers in salinity affected areas in order of preference was Sahbhagi. This was primarily due to the fact that when crop start affected by salinity most, Sahbhagi attained its maturity hence less succumb by abiotic stress like salinity.

In the high rainfall agro climatic conditions, preference ranking was slightly deviated from low rainfall areas. The varieties Damini and Moti were preferred over others as evidenced by their preference ranking and indices by field day farmers. While analyzing the preference rankings and indices for yield obtained from PVS farmers it was Sahbhagi which surpassed all other varieties. For days to maturity Sahbhagi in low rainfall and salinity situations Damini and Moti in high rainfall situation were preferred by PVS farmers. The varieties Damini, farmer local and Moti in low rainfall, Sahbhagi , farmer local and NDR-3112 in high

rainfall and Sahbhagi, NDR-3112 and Moti in salinity situation were preferred by PVS farmers. Farmers who participated in field days preferred Moti, NDR-3112 and farmer local in low rainfall, Moti, Sahbhagi and farmer local in high rainfall growing conditions. The preference ranking along with preference index for number of panicles per plant by PVS farmers favoured Sahbhagi, Damini and Moti in low rainfall, Sahbhagi, NDR-3112 and Damini in high rainfall and Damini, NDR-3112 and Moti in salinity situations. While farmers participated in field days, their preference ranking and index were in favour of Moti, farmer local and Damini in low rainfall, farmer local, Damini and Moti in high rainfall conditions.

It was amply clear from the observations of PVS farmers that in low and high rainfall agro climatic conditions varieties Sahbhagi excelled over others for all characters except for number of tillers per plant. This indicated that in Sahbhagi majority of the tillers had panicles unlike other varieties. Over all findings from the study indicated that varieties Sahbhagi, Damini and Moti superior in all the three growing conditions. The findings also indicated that from the field day studies, farmers' perceptions were more inclined towards Damini and Moti over Sahbhagi. The reason expressed by farmers was that the grain quality of Damini and Moti is better than Sahbhagi and will fetch better market price. This deviated the results from PVS farmers where the results were based on actual observations and not perceptions. It was interesting to realize that the local variety was also found good as expressed by preference rankings and indices. This was primarily due to the fact the seed purchased by farmers from the local retailers is also the variant of Damini or Moti. This investigation provided farmers with a large selection to make their choice for subsequent analysis to enable identification of preferred rice varieties (Virk et.al.)[5.] The maximum preference rank and index for Sahbhagi, Damini and Moti varieties suggested their preference by farmers hence areas having a low rainfall and saline conditions can select these. No one rice variety had all the attributes farmers preferred. Hence, to compensate, most farmers may grow more than one variety. The study also showed that when farmer participatory approaches were used to evaluate and disseminate the better rice varieties, farmers may use more than one variety depending upon their requirement. Farmers use a complex set of criteria to select the rice varieties they grow so they should also be more closely involved in selecting a variety (Yadavendra et.al.)[8]. Criteria used are maturity, yield, number of tillers per plant and number of panicles per plant there is a need to also consider grain quality while evaluating the different rice varieties through farmers' preference.

For scaling up the seed supply of farmer preferred variety like Sahbhagi (as this is not readily available in the local market) seed production was undertaken by the women farmers in the target areas to make it available to the growers. Since the seed of Damini and Moti is available in the local market hence their seed production progarmme by women farmers was not considered.

CONCLUSION AND WAY FORWARD

On the basis of the findings from the present investigation, it was found that for better grain yield Sahbhagi variety was a better choice for diverse environments in mid plain zone of Uttar Pradesh. Damini and BPT-5204 are the other varieties which are also suitable for diverse environments but better suited to the high rainfall areas hence their superiority during

drought seasons remain questionable. For the low rainfall areas, variety Sahbhagi has been the best choice of the PVS as well as field day farmers than the other varieties due to its short maturity duration. For scaling up the use of farmer preferred varieties for an impetus in boosting the farm economy of farmers, making the seed available at the door step of the farmer at right time at an appropriate seed price is the foremost requirement. The "Informal Seed System" has initiated an all out effort to meet this challenge. However concerted efforts are needed by the developmental agencies to scale up the informal seed system model to minimize the gap between the seed demand and supply of the farmer preferred varieties of rice.

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Situations and practices on water use and water conservation behaviors in household: a case study of condominiums in Bangkok, Thailand

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ABSTRACT

Water demand management has a great potential to address water security issue nowadays. Demand-side solution to enhance water-use efficiency will be a promising strategy to address a global water crisis. Consequently, to develop evidence-base water use management policies and programs, a clear understanding of users' information is essential. This study aims to investigate current situation of water-use and practice on water saving. The study uses questionnaire survey and interview approach to collect primary and secondary data for analysis. The scope focuses on two kinds of water use behavior and one-time water use behaviors of residents in condominium. A case study is based on condominiums located in Bangkok, Thailand. The findings present insightful information of condominium residents on water use and water saving practice. Influences of socio-demographic to water use and water conservation behaviors are analyzed. The results provide information useful for policy makers to design policy to promote water use plans and practices. This research develops recommendation to reduce water demand and increase water use efficiency in household that can be applied in other cities as well.

KEYWORDS

Household water use, Condominium, Water saving practice, Water conservation behavior

1. INTRODUCTION

Population increase and urbanization cause rapid growing of water demand. Especially, as expansion of public transport system in urban area of Bangkok, Thailand, the number of condominiums along the train lines has been raised as well. In 2017, there are 180,000 units of condominium in nearby the train system in Bangkok. There are new 40,000 units of condominium will be completed in 2018 [1]. Moreover, according to the information of water metropolitan water authority (MWA), there is an upward trend of water demand from 2007 to 2017, approximately 14 percent [2]. Water consumption has increased in relation to the living trend in urban areas. Consequently, reducing water consumption at water user is seem to be a practical approach to address water security issue nowadays. Demand-side solution to enhance water-use efficiency is needed to address a global water crisis. To develop evidence-base water use management policies and programs, it is essential to have a clear understanding of users' information. Therefore, this study focuses on investigating current situation of water use patterns and water saving practices in condominiums.

2. METHODS

To achieve the research purposes, the questionnaires were designed to collect data from conducted of condominiums' residents located in Bangkok. The survey distributed to 210 participants via google form (online survey) and face-to-face interview at the particular condominium in February to April 2018. The survey contains the questions of sociodemographic information, living patterns and self-report of water conservation behaviors including (1) everyday water conservation behaviors and (2) one-time water conservation behaviors. The sociodemographic information involved in age, gender, education level, income, occupation, and ownership to find out characteristics of the participants and conclude the relationship of this information and the self-reported water use and conservation behaviors. Moreover, living patterns in the condominium were surveyed related to cooking day, the practices of clothes washing, and average water bill per month. Next, the self-reported behaviors section includes (1) everyday water conservation behaviors, respondents were questioned "how frequently you perform of these eight everyday water conservation behaviors?" and answered by using a six scale of frequent range from always to never which the list of behaviors is described in Table 1 and (2) one-time water conservation behavior referred to ownership of water saving devices in Table 1. The respondents can select choices, among (1) using each water saving device, (2) non-using this water saving device, (3) not sure that this device is the water saving device or not, and (4) non-using this sanitary ware.

Table 1 Daily water conservation behaviors and Water saving devices

Everyday water conservation behaviors	Water saving devices
I clean food scraps before dish washing.	Dual-flush water closet
I turn off tap during cleaning dishes.	Single-flush water closet: water saving 4.8 liter/flush
I turn off tap during soaping.	Aerated faucet
I turn off tap during brushing teeth.	Aerated shower
I make sure that taps do not drip.	Pressure control shower
I wash full loads of laundry.	Water saving urinal
I check water equipment and make sure that no leakage.	Water saving washing machine
I change sanitary ware immediately when it is out of service.	-

3. RESULTS AND DISCUSSION

3.1 Socio-demographic information

Figure 1 presents the information about socio-demographic from the survey. As can be seen, most of the respondents were female (62.9%), were 31-40 years old (42.2%), had accomplished higher bachelor degree (61.9%). As household projection of Thai population in 2010-2020 study, it found that women tend to be the household leader of Thai family which was consistent with the respondents' data. Furthermore, previous studies [3-4] confirmed that women more prefer to participate on environmental activities than men. Most of them had a personal income per month over 40,000 Thai baht (49.5%) and worked in private company (63.3%). As claimed by National Statistical Office, in 2016 [5], average income per household in Bangkok was approximately 41,897 Baht which is compatible with the collecting data. From the survey, 170 respondents reported that they were the owner of the room unit. With this ownership, decision of behaviors change related to water conservation will be practical effectiveness.

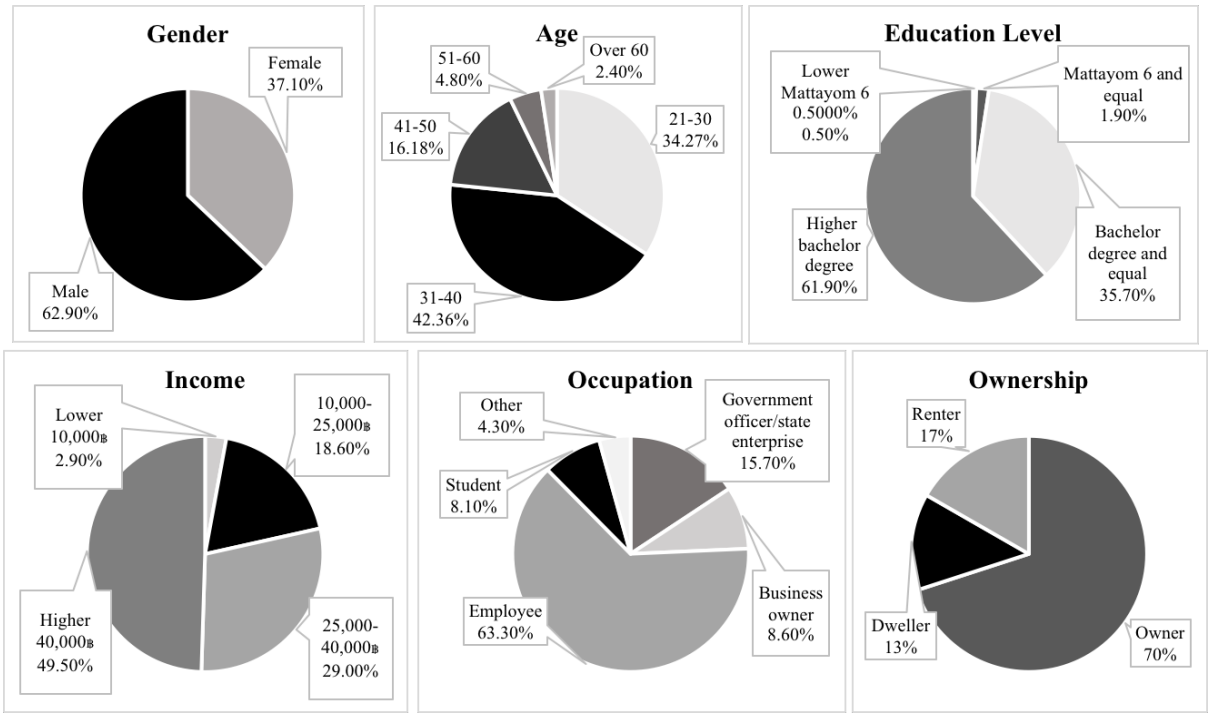

Figure.1: Socio-demographic of respondents

3.2 Water conservation practices

Figure 2 presents the practice rate of 8 water conservation behaviors. Two highest practices rate are for WC5 (making sure that the tap not drip), and WC1 (cleaning food scrapes before dish washing). Most of the respondents always performed these two water conservation behaviors. While 40% of respondents answered always for the behaviors of checking and changing the sanitary equipment. It can be implied that these two main behaviors are involved in habitual factor which relate to repeatable behaviors. On the other hand, checking and changing the sanitary equipment activities are uncommon behavior for some individuals. While consider WC2 (turning off tap during cleaning dishes) and WC3 (turn off tap during soaping), these behaviors had the two lowest of "always" answer. It can be suggested that these two behaviors are concerned about people's convenient, so people tend to ignore these responsibilities.

According to the survey, the respondents were asked about their living pattern related to water use such as cooking activity and how the wash their clothes. The results show that 60% of people cooked in the condominium. Almost of respondent (80%) washed their clothes by themselves which 88% using washing machine, while 22% washing by hand.

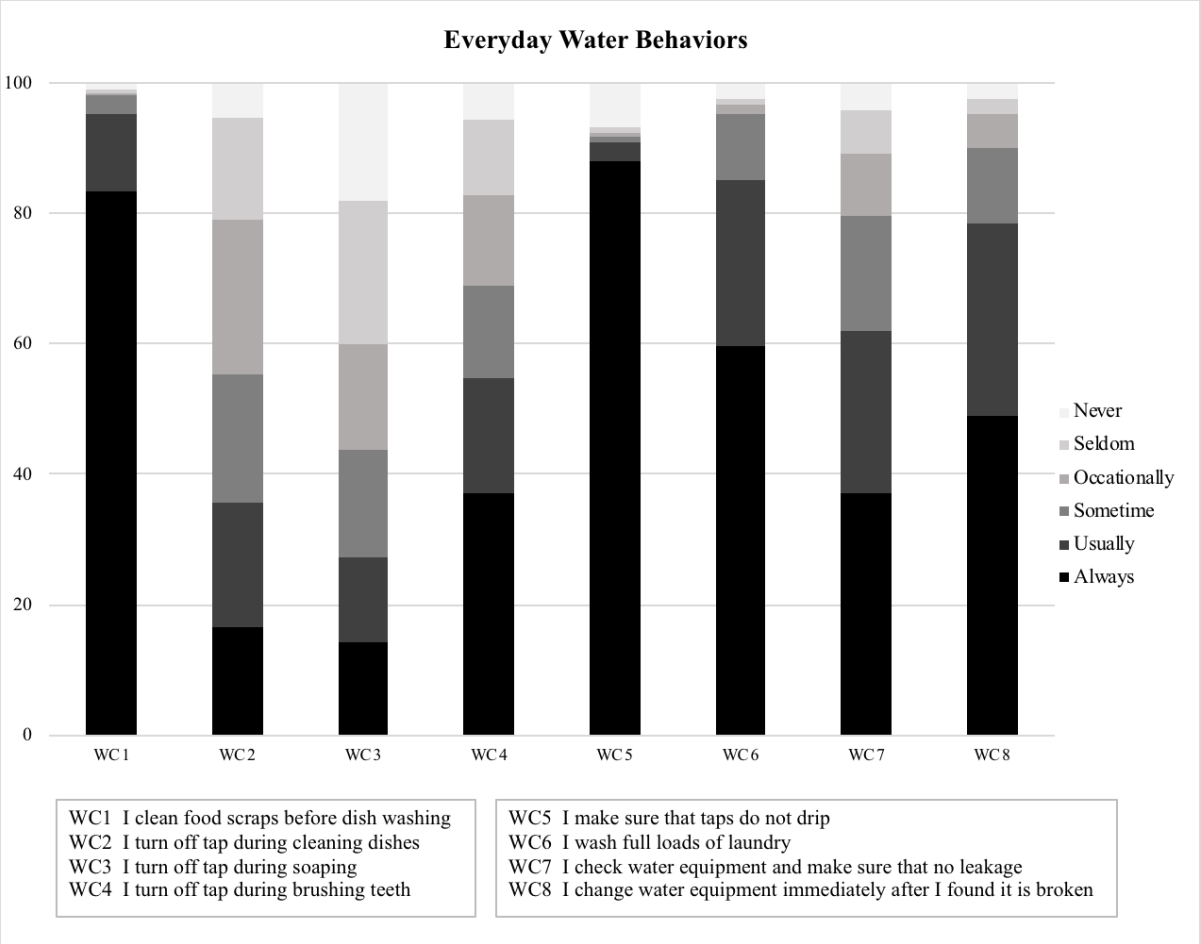

Figure 2: Everyday water conservation behaviors

In Figure 3, it presented one-time water conservation behaviors: installation of water saving devices in household. It can be seen that dual-flush water closet was the most using water saving equipment (over that 60%). Only 20% of the respondents used water saving water closet with single flush. The survey result indicates that the dual-flush toilet has been widely recognized by most people. Moreover, about 80% of respondents had not using the urinal in their condominium, it might be cause of cost saving during construction period. In accordance with the finding about clothes washing, the 38% of respondents who wash clothes by the machine chose to buy a water saving washing machine. However, installation of the sanitary wares had limitation based on the build in fixtures because the condominiums finally finished before moving in. As a consequence, the unit rooms' owners had no choice to change the equipment unless they pay for a renovation.

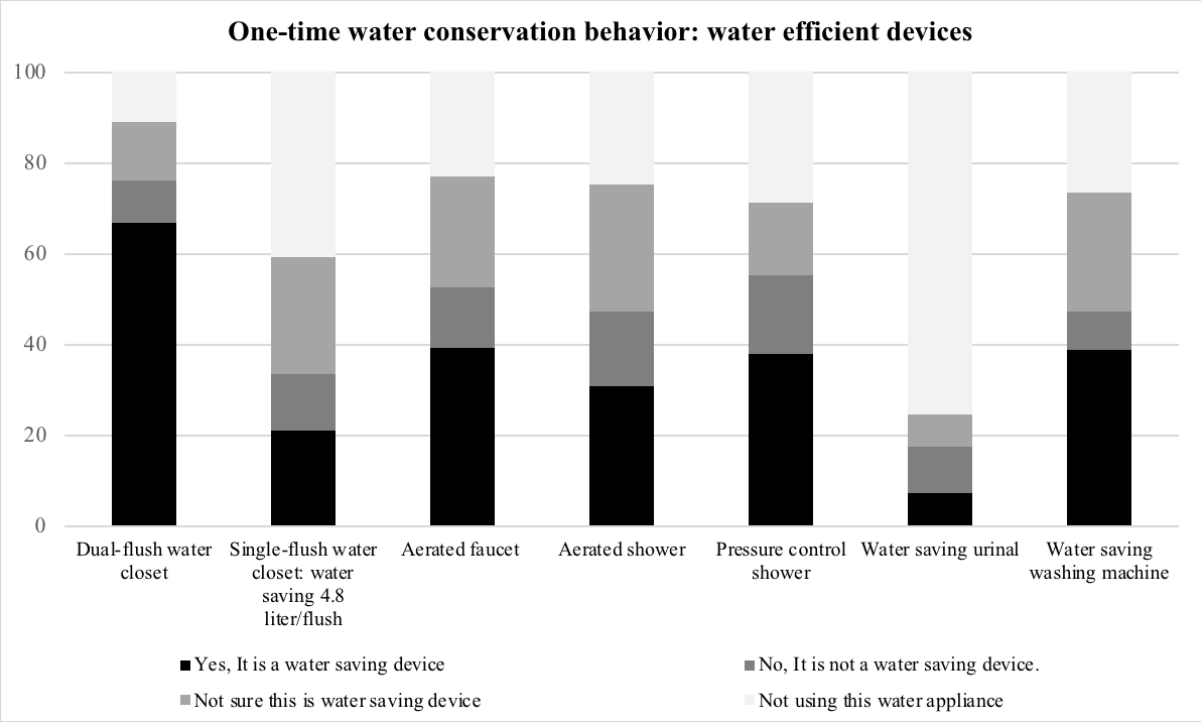

Figure 3: One-time water conservation behaviors

4. CONCLUSION

As increasing water demand in urban area, demand side control at water end user will be essential. This study has addressed water use behaviors of residents in condominium which presents insightful information of the residents on water use and water saving practice. The evidence-base results indicate that the water saving practices in term of turning off taps while doing the activities should be more encourage. Basic knowledge about water conservation should be significantly boost. The water saving promotion can be further enhanced by providing knowledge such as fact and figure of quantities of water loss while dropping or effectiveness knowledge such as beneficial consequences stemming from preforming the water conservation behaviors [6]. Additionally, proposing of water saving devices installation in household should be widely supportive. In case of condominium, selecting of water efficient devices appears to be fixed since the construction process, so that suggestion of these devices' benefits must be offered including technical and economic information to the project owners. However, not only the private owners, but also government agencies should take responsibility to for water conservation practice by developing green procurement policy in order to increase purchasing water saving products. Overall, these results provide primary information in order to design successful policy in conservation action.

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Sustainability Reporting Towards Sustainable Development in Banking Sector: Bangladesh Perspectives

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ABSTRACT

As the key catalyst of growth and development, banking institutions remain at the centre of an economy. Keeping position at the centre of all economic activities and patronizing the industrialization, banks have become accountable for the impact of the industries on the communities and environment. In line with the global development, the commercial banks of Bangladesh and other business bodies have been encouraged to take up the concept of sustainability reporting as a cutting edge technology.

Bangladesh Bank as the regulatory authority for the commercial banks in Bangladesh has already stepped up sustainability reporting following the Global Reporting Initiative (GRI) guidelines. Sustainability reporting is a concrete tool that reinforces transparency of the commercial banks and it builds an enabling environment towards achieving Sustainable Development Goals (SDGs) through sustainable banking. GRI's standard guidelines have been considered in Bangladesh as standard ones and the present study was designed to assess how sustainability reporting impacts sustainable development in banking industry of the country that can also focus to formulate future plan for a sustainability reporting culture for banks in Bangladesh while stepping towards a 'sustainable tomorrow'.

Keywords: Sustainability Reporting (SR), Global Reporting Initiative (GRI), Bangladesh Bank (BB), Sustainable Development Goals (SDGs), Corporate Social Responsibility (CSR).

1 INTRODUCTION

Sustainability is an integral part of value creation. In recent days, sustainability reporting has become an issue of concern for people from different segments including government, business bodies, research entities, development activists and non-government organizations (NGOs) and it has been acknowledged by them as a key component of development mechanism (Tiong and Ananharaman, 2011). In the year 1987, Gro Harlem Brundtland in his 'The Brundtland Report' mentioned the phrase 'sustainable development' and based on the report, 'sustainable development' is defined as "development that meets the needs of the present world without compromising the ability of future generations to meet their own needs".

Sustainability Reporting is the key component through which organizations become enable to formulate their goals, assess the development towards goals and thus ensure sustainability for the organization. Reporting on the organization's sustainability performance will give internal and external stakeholders a clear idea of its impact and can increase the efficiency and thus improve the performance. The latest non-financial reporting tool known as sustainability reporting tends to follow and evaluate the governance practices, environmental impact along with the commitments of a business entity towards the community. It builds an enabling environment towards achieving Sustainable Development Goals (SDGs) as well.

The soundness and the depth of the banking sector is the determinant to accelerate sustainable growth for this sector. Sustainability of banking sector is crucial as it leads towards the path for development of the economy and the nation as a whole. The banking industry of Bangladesh comprises of 59 banks categorized as per their ownership structure as state-owned, private commercial, foreign banks and specialized banks under the regulatory framework of Bangladesh Bank, the central bank of the country. For reporting purposes, banking sector of Bangladesh mainly follows the traditional financial reporting system and exclusive sustainability reporting system is yet to be introduced. In Bangladesh, though there have been a number of researches already done on corporate social responsibility (CSR), regarding the sustainability reporting still there is a lot of scope to work (M. H.U.Z. Khan, 2010). The present study focuses to identify the current status widespread in the sustainability reporting system in banking sector of Bangladesh and also to assess its contribution towards sustainable development of the country.

2 OBJECTIVES

The proposed research is an attempt to identify the current status of sustainability reporting towards sustainable development in banking sector of Bangladesh. Moreover, in the study, efforts were made to identify the benefits of sustainability reporting for the banking sector to achieve Sustainable Development Goals (SDGs).

3 METHODOLOGY

Primary as well as Secondary data have been collected for the study whereas the source of primary data was sample survey. Respondents were involved in a combination of both open and perfect questions in the design of questionnaire (Appendix-1) from different commercial banks. Interview of 20 witnesses of targeted 100 bankers have been interviewed. The study suffered by some limitations such as sample size, and narrow chance.

4 LITERATURE REVIEW

Khan, M. T. (2015) finds that banking sector in Bangladesh responds relatively late in case of sustainability reporting. There is common perception among the bankers that banks are in general relatively environment-friendly entities, in terms of emissions and pollution. But, given the bank's detail analysis of safety of their investors' and depositors' money, the banks are surprisingly slow to analyse the environmental footprint of their clients. It is very important to know the decision making mechanism of a company regarding selection of social indices and environmental parameters which are to be reported in alignment of GRI recommendations. In this regard, the findings of Kobboon Chotruangprasert ('Global Reporting Initiative Indicator Selection Decisions: A Case Study') suggest that economic principles largely impact the sustainability reporting of a company.

Khan, M. H.U.Z, D.M.A. Islam and K. Ahmed (2010) also state that the banking sector of Bangladesh follows the traditional financial reporting system for mostly and not more. The practice of separate sustainability reporting is not present in all banks of Bangladesh in the reporting system. Though a number of works have been executed on the CSR practices, study on the reporting of sustainability is still scarce in Bangladesh.

EY (2015) suggests that concern for global warming added up to the importance of being sustainable in all aspects of business. As a catastrophic country in Bangladesh, the banking as a business is also exposed to the opportunities and threats of global warming. This reason plays a significant role in forming new environment-conscious banking service and product planning.

This is evident from the study of Brammer & Pavelin (2006) that financial soundness of a business entity carries weight towards sustainability revelation since companies having better financial health are supposed to be more capable of meeting the criteria of reporting non-financial indicators and are also anticipated to be discretionary in revealing sustainability disclosures.

Mabrnud (2017) finds that only handful commercial banks of Bangladesh report sustainability related information in their annual report but those are not enough. Moreover, the study finds that, the reported information regarding sustainability reporting does not meet the standard of GR1 or any other guidelines properly. The study indicates problems in the disclosure practice while reporting sustainability disclosures of private commercial banks of Bangladesh. Noteworthy, the banks take a very wide scope for disclosing, as more and more information is inflated into reports. This can lead to a reporting burden for reporting organizations and expose overload for report users. The researchers urge for government regulations to bring in consistency and fruitfulness in these reportings.

5 REPORTING STANDARDS FOR SUSTAINABLE DEVELOPMENT: INTERENATIONAL PERSPECTIVES

The process of sustainability disclosure comprises some basic steps that start with data mining from a reliable source, communicating the same to the stakeholders and comeback with feedback. Sustainability reporting indicates organization's practice of public disclosure on its daily activities that have impact on the financial elements, ecology and to the community as a whole. Internationally accepted sustainability reporting frameworks are as hereunder:

i. Since 1997 Global Reporting Initiative (GRI) has been the pioneer in the field of corporate sustainability reporting as an international independent organization (www.globalreporting.org). It helps sponsors, think-tanks, policy makers and other organizations understand and analyse how key sustainability aspects like carbon banking, civil rights, governance can be affected by the profit generation activities of business concerns.

ii. The OECD as a global key catalyst promotes policy formulation to improve economic and social indicators and also caters to a forum for the governments for their experience sharing and leading way out to global issues related to trade & business, society and ecological reshape. (www.oecd.org).

iii. Enterprises that are committed to ally business activities with universally accepted principles for human rights, labour, environment and anti-corruption have been taken under the umbrella of The United Nations Global Compact (UNGC) which is considered as the biggest policy formulation entity to accelerate business understanding and action towards achieving SDGs by 2030.

iv. In the year 2011, in search of a standards-setting organization, the Sustainability Accounting Standards Board (SASB) was established as an independent body to address the requirement of the sponsors through promoting sustainability reporting including ecological, social and good governance (www.sasb.org). The SASB has developed industry specific standards including commercial banks, and a provisional version of commercial banks sustainability accounting standard has also been issued.

v. To cater social responsibility in business processes ISO 26000 has been formulated by International Organization for Standardization (ISO) (www.iso.org) to standardize organizations for periodic reporting to assess the impact of their activities on community.

vi. With an aim to produce data support for the financials investors in long term globally acknowledged reporting module known as <IR> was published in the year 2014 by The International Integrated Reporting Council ('IIRC') which is an international alliance of key stakeholders. This reporting module is designed to apprehend how different business processes and performance of an entity create value on surroundings at different spans of time from short to medium to long.

vii. Enumeration and management of emanation of Green House Gas ('GHG') is important for a competent, supple, and affluent environment and in this regard 'The Greenhouse Gas Protocol' (GHG Protocol) provides a complete capacity building for the bureaucrats and business bodies as well through formulation of policy framework and knowledge sharing.

viii. Being uniquely mandated by the global community, the Office of the United Nations High Commissioner for Human Rights (OUNHCHR) in entrusted to stand for the universal obligation towards dignifying human ideals (www.ohchr.org).

ix. As an international network of investors working together, the goal of United Nations-supported Principles for Responsible Investment (PRI) initiative is to put some principles for responsible investment into practice (www.unpri.org) while understanding the implications of sustainability for investors and supporting signatories to incorporate these issues into their investment decision making and ownership practices.

x. Institutional investors now-a-days are keen to evaluate probable ecological and community aspects through utilizing non-financial factors. They have already begun reviewing sustainability reporting practices of the corporate bodies and tend to follow the flow of funds based on the sustainable development goals to be implemented by the local governments. Their risk-averse and sustainability-oriented lending/investment priorities are driving businesses to follow responsible practices.

xi. As sustainability reporting tends to address the human civilization issues relevant to financial inequality, social injustice, natural degradation, basic need and rights, good governance in recent years, it has catered enough 'food for thought' to the global think tanks especially in the South Asian aspect it has become in the centre of the interest group.

xii. GRI is expected to formulate further strategy in light of the SDGs launched by the UN General Assembly in 2015 and also based on the already existing standard framework of GRI-G4 in such a way that they are relevant to– and can be implemented by – businesses as well as governments.

6. REGULATORY FRAMEWORK ON SUSTAINABILITY REPORTING BY COMMERCIAL BANKS: BANGLADESH PERSPECTIVES

On February 27, 2011, a policy has been issued entitled 'Guidelines for Green Banking' by Bangladesh Bank to be followed by the scheduled banks. As per the guidelines, the operating commercial banks are required to produce their sustainability reporting for their stakeholders under Independent Annual Sustainability Report (IASR) following Global Reporting Initiative (GRI) principles which is an internationally accepted format. As such, all commercial banks and NBFIs in Bangladesh are required to prepare and publish annual sustainability report (ASR) following GRI or any other international guidelines. To monitor the activities of banks and NBFIs, Sustainable Finance Unit (SFU) has already been formed in Bangladesh Bank.

Bangladesh bank as central bank of the country supports the commercial banks on corporate social responsibility connected activities. A 10% tax exemption facility has been approved by Bangladesh government for the firms with proposition on a part of the corporate income to be allocated for CSR programs. The rising concern for global warming also boosts up the issue of sustainable development activities in all aspects of business. This global warming leads the banking sector of Bangladesh to formulate new strategies towards achieving the Sustainable Development Goals (SDGs). Recent initiatives from the central bank of Bangladesh and other regulatory authorities leads the way to be more sustainable and influence the commercial banks to address the issue of sustainable disclosure.

Therefore, top management of Bangladeshi commercial banks and thorough engagement of key stakeholders are intended to reinforce their effort to undertake more organized social accountability for sustainable development (M. H.-U.-Z. Khan; 2010).

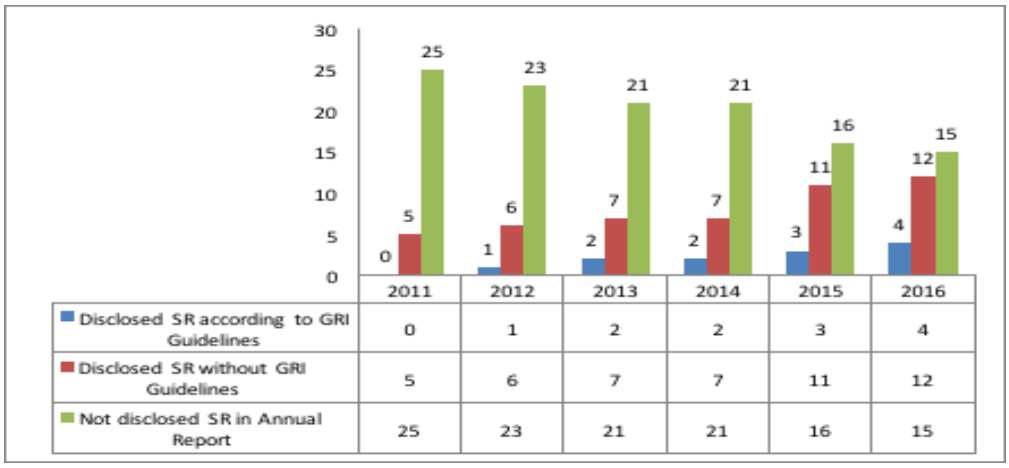
7 SUSTAINABILITY REPORTING TOWARDS SUSTAINABLE DEVELOPMENT: PRACTICES IN BANKING SECTOR OF BANGLADESH

Though small in number, private commercial banks in Bangladesh have been found publishing annual reports encompassing their activities in line with sustainable developments. A recent study on 30 commercial banks out of 59 (Figure-1 & 2) show that only 16.67% banks followed separate sustainability disclosure in their annual report without disclosing GRI sustainability reporting guideline and 83.33% banks did not disclose the separate sustainability report in 2011.

In the year 2012, 3.33% banks disclosed separate sustainability report in the annual report according to GRI reporting guideline, but 20% banks disclosed separate sustainability report in the annual report without following GRI reporting guidelines and 76.67% banks did not disclose sustainability report.

In 2013 and 2014, 6.67% reported separate sustainability disclosure in annual report according to GRI reporting framework, 23.33% disclosed separate sustainability disclosure without following GRI and 70% banks did not disclose the separate sustainability report.

Figure-1: Number of banks disclosed & not disclosed SR in annual report (2011-2016)

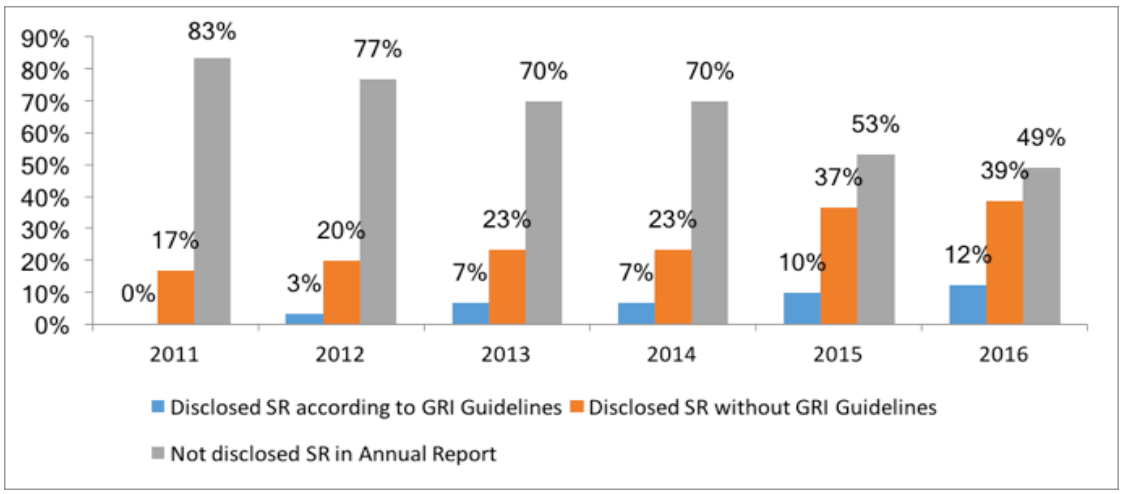


	2011	2012	2013	2014	2015	2016
Disclosed SR according to GRI Guidelines	0	1	2	2	3	4
Disclosed SR without GRI Guidelines	5	6	7	7	11	12
Not disclosed SR in Annual Report	25	23	21	21	16	15

In the year 2015, only 10% banks reported sustainability separately in the annual report according to GRI reporting guideline, but 36.67% banks though disclosed report of sustainability in the annual report separate it was found without following GRI reporting guidelines and 53.33% banks did not disclose the separate sustainability report in annual report.

In the year 2016, among 31 private commercial banks, only 12% banks reported sustainability separately in the annual report according to GRI reporting guideline, but 39% banks though disclosed report of sustainability in the annual report separate it was found without following GRI reporting guidelines and 49% banks did not disclose the separate sustainability report in annual report which signifies the increasing trend in every phases (Md. Shahed Mahmud, Tanmay Biswas and Md. Nazmul Islam, 2017).

Figure-2: Percentage of disclosed SR according to GRI guidelines by the banks (2011-2016)



8 CATEGORIES AND ASPECTS OF SUSTAINABILITY REPORTING GUIDELINES LINKING WITH SDGs

Category	Social			
Sub-categories	**Labour Practices and Direct work**	**Human Rights**	**Society**	**Product Responsibility**
Aspects	• Employment • Labor/Management relations • Occupational health and safety • Training and education • Diversity and equal opportunity • Equal remuneration for women and men • Supplier assessment for labor practices • Labor practices grievance mechanisms	• Investment • Non-discrimination • Freedom of association and collective bargaining • Child labor • Forced or compulsory labor • Security practices • Indigenous rights • Assessment • Supplier human rights assessment • Human rights grievance mechanisms	• Local communities • Anti-corruption • Public policy • Anti-competitive behavior • Compliance • Supplier assessment for impacts on society • Grievance mechanisms for impacts on society	• Customer health and safety • Product and service labeling • Marketing communications • Customer privacy • Compliance • Product portfolio • Audit • Active ownership

Category	Economic	Environmental
Aspects	• Economic performance • Market presence • Indirect economic impacts • Procurement practices	• Materials • Energy • Water • Biodiversity • Emissions • Effluents and waste • Products and services • Compliance • Transport • Overall • Supplier environmental assessment • Environmental grievance mechanisms

9 GRI-G4 FOCUSES ON SDGS INDEX BY FINANCIAL SERVISES SECTOR SUPPLIMENT (FSSS)

G4 stands for the 4th Generation Guidelines which has been introduced by GRI in 2010 that focuses the organizations' capability to enable themselves to be accountable and obvious about their own steps towards SDGs in a supple and incremental way. For the purposes of developing the sector disclosures to facilitate under four categories namely retail banking, commercial and corporate banking, asset management, and insurance, the Financial Services Sector Disclosures document based on the 'GRI Financial Services Sector Supplement (FSSS)' has also been developed to obtain the basic objective of sustainable development goals through financial institutions.

10 SUSTAINABLE BANKING IN BANGLADESH THROUGH SUSTAINABILITY REPORTING

The concept of sustainability in banking has been evolved from the idea of making banking social and environment friendly. By using some broad categories of green banking criteria, CSR activities, role in financial inclusion, Bangladesh Bank has been taking following measures to integrate sustainability reporting into the mainstream banking structure through formulating policies and imposing instruction:

10.1 GREEN BANKING

Green Banking covers a wide area of banking activities that have positive impact on society and environmental protection and finally leads towards sustainable banking. Therefore, all the activities that cover principled banking activities like energy efficient financing & incentives, green credit cards, green loans, green savings accounts, green checking accounts, green money market accounts, green mobile banking accounts, online banking, remote deposit, waste management, roof gardening and green financing come under the umbrella of sustainable banking for overall sustainable development.

10.2 GREEN FINANCE

A total amount of BDT 548.6 billion (USD 6.61 billion) was disbursed during FY 2017 by 50 banks and Non-banking financial institutions (NBFIs) involved in green finance. However, the as per contribution of total green finance signifies that the major contribution by private commercial banks (PCBs) which is 77.64% whereas the contribution of foreign commercial banks (FCBs) is 18.51% follows by NBFIs is 2.54% and state-owned commercial banks is 1.32%. The following Table-1 shows the direct & indirect green finance by banks of Bangladesh and Table-2 signifies the green finance by the banks and financial institutions in different products in the financial year-2017 respectively.

Table-1: Direct and Indirect green finance in FY-2017

BDT in million

Types of bank	Direct green finance	Indirect green finance	Total green finance	Sector-wise contribution (%)
SCBs	2884,40	4336,20	7220,60	1,32%
DFIs	18,90	0	18,90	0,00%
PCBs	30578,50	3953,66	425944,50	77,64%
FCBs	551,30	100973,60	101524,90	18,51%
NBFIs	4632,60	9275,10	13907,70	2,54%
Total in BDT million	**38665,70**	**509950,90**	**548616,60**	**100,00%**
Total in USD million	**465,85**	**6143,99**	**6609,84**	**100,00%**

[Source: Sustainable Finance Department, Bangladesh Bank (Central Bank of Bangladesh)]

SCBs= State owned commercial banks, DFIs= Development Financial Institutions, PCBs= Private Commercial Banks, FCBs= Foreign Commercial Banks, FIs= Financial Institutions

Table-2: Green Finance in different Products by banks in FY-2017

BDT in million

Category of Green Finance	SCBs	DFIs	PCBs	FCBs	FIs	Total
Renewable energy	47,90	4,30	2202,50	330,10	1859,00	4443,80
Energy efficiency	0,00	2,10	3118,80	0,00	277,40	3398,30
Solid waste management	0,00	0,00	7,30	0,00	0,00	7,30
Liquid waste management	101,30	0,00	8678,20	15,30	282,40	9077,20
Alternative energy	0,00	0,00	132,70	0,00	0,00	132,70
Fire burnt brick	441,10	11,90	4646,60	0,00	1085,70	6185,30
Non fire block brick	1,00	0,00	192,60	0,00	0,00	193,60
Recycling & recyclable product	283,20	0,00	5813,00	0,00	180,20	6276,40
Green industry	481,80	0,00	4212,20	152,60	900,20	5746,80
Safety and security of factory	40,00	0,00	1438,00	53,30	46,50	1577,80
Miscellaneous	9,70	0,60	10,30	0,00	0,00	20,60
Others	1478,40	0,00	126,30	0,00	1,20	1605,90
Total in BDT million	**2884,40**	**18,90**	**30578,50**	**551,30**	**4632,60**	**38665,70**
Total in USD million	**46,97**	**0,23**	**369,75**	**6,67**	**56,02**	**467,54**

[Source: Sustainable Finance Department, Bangladesh Bank (Central Bank of Bangladesh)]

10.3 POLICY INITIATIVES

Bangladesh Bank issued its first policy instruction known as 'The Guidelines on Environmental Risk Management' (ERM) for all banks in January 2011. As per guidelines, the banks have been doing compliance in climate risk and are expected to have a minimum five percent in green finance of its total loan portfolio. Banks are also required to make certain of having Effluent Treatment Plan ('ETP') before taking financial decision in applicable cases.

10.4 INVESTMENT UNDER REFINANCE SCHEME IN GREEN PRODUCTS

In Bangladesh, 50 (fifty) banks and NBFIs who have engagement in green banking disbursed BDT 348.80 million (USD 4.12 million) during FY-2017. Bangladesh Bank re-finance to the commercial banks for financing in these green investment in every year. Bangladesh bank selected green products like solar energy, bio-gas plant, effluent treatment plant totalling 51 green products/initiatives are eligible for refinancing facilities under this scheme (Table-3).

Table-3: Disbursement through Refinance Scheme for Green Products (2013-2017)

BDT in million

Green finance products	FY-2013	FY-2014	FY-2015	FY-2016	FY-2017
Bio gas	113,60	212,80	83,30	84,80	46,60
Solar home system	40,20	32,20	87,50	114,70	35,30
Solar irrigation pump	0,00	17,90	26,50	0,60	0,00
Solar assembly plant	122,70	49,60	148,10	16,30	0,00
Solar Mini-grid	0,00	0,00	0,00	10,00	0,00
Effluent treatment plant	57,40	10,00	0,00	58,00	179,60
HHK technology in brick kiln	172,20	59,00	47,00	177,80	10,00
Vermicompost	0,00	0,00	1,10	1,60	1,30
Green industry	0,00	0,00	0,00	400,00	0,00
Safe working environment	0,00	0,00	0,00	35,70	55,30
Organic manure from slurry	0,00	0,00	0,00	0,20	0,10
Paper waste recycling	0,00	0,00	0,00	20,00	20,00
Energy efficient technology	0,00	0,00	0,00	0,00	0,60
Total in BDT million	**506,10**	**381,50**	**393,50**	**919,70**	**348,80**
Total in USD million	**6,12**	**4,61**	**4,76**	**11,12**	**4,12**

[Source: Sustainable Finance Department, Bangladesh Bank (Central Bank of Bangladesh)]

11. SUSTAINABILITY REPORTING: ACHIEVEMENT OF SUSTAINABLE DEVELOPMENT GOALS (SDGS) & ROLE OF BANKS IN BANGLADESH

In continuation of the footstep of Millennium Development Goals (MDGs), to bring an end to poverty, to save the earth and to warrant human development the Sustainable Development Goals (SDGs) have been designed consisting of 17 (seventeen) goals while including new areas such as global warming, financial disparity, modernization, utilization, and good governance. The seventeen sustainable development goals (SDGs) are as under towards transform our world:

Goa1-1 : No Poverty

Goal-2 : Zero Hunger

Goa1-3 : Good Health and Well-being

Goal-4 : Quality Education

Goal-5 : Gender Equality

Goal-6 : Clean Water and Sanitation

Goal-7 : Affordable and Clean Energy

Goal-8 : Decent Work and Economic Growth

Goal-9 : Industry, Innovation and Infrastructure

Goal-10 : Reduced Inequality

Goal-11 : Sustainable Cities and Communities

Goal-12 : Responsible Consumption and Production

Goal-13 : Climate Action

Goal-14 : Life Below Water

Goal-15 : Life on Land

Goal-16 : Peace and Justice Strong Institution

Goal-17 : Partnerships to achieve the Goal

Bangladesh Bank as central bank is playing a vital role to design policy guidelines and programs for stakeholders of financial sector of Bangladesh towards implementing the above sustainable development goals. Bangladesh Bank acts as bridge monitoring communication and coordination among concerned government agencies to implement the terminology and financing approaches of sustainable development. While reviewing the annual reports of different commercial banks of Bangladesh, the following sustainability performances have been found general among them:

11.1 ENERGY CONSERVANCY

This indicates the ecologically responsible activities that include identification and management of process to reduce direct and indirect impact of different activities on the environment, reduce energy consumption and also efficient utilization of energy resources.

11.2 WASTE MANAGEMENT AND RECYCLING

Encouraging work flow automation to minimize use of paper and also use biodegradable papers produced from recycle and also policy formulation towards paperless activities and also encouraging e-mail based communication, web-based activities and less printed documents.

11.3 CONGENIAL WORK ENVIRONMENT

To cater personal development, promote team work and for increasing efficiency, a congenial working environment is developed at the organizations ensuring occupational health and safety arrangement.

11.4 FINANCIAL INCLUSION

The concept of financial inclusion caters more scopes to the wide range of unbanked people to avail tailor made banking facilities at a considering rate which is expected to lead the way towards financial literacy among the people and in long run result into a sustainable financial system. Though banks operate to offer financial services still its CSR activities for financial inclusion increases the efficiency to understand and compare financial products and markets.

11.5 SCHOOL BANKING

In November 2010, Bangladesh Bank instructed to all commercial banks in Bangladesh has to open school banking branches to bring students under the umbrella of banking services which will help the economic activities of the nation and will have contribution towards sustainable development. The primary aim of school banking program is to inspire savings and encourage the savings habit among the students as future citizen. Till December 2017, number of total school banking accounts in Bangladesh raised to 1,46 million having a deposit amount of BDT 13629.60 million (USD 164.81 million).

11.6 OCCUPATIONAL HEALTH

It includes the steps taken by an organization to protect its employees from the occupational health hazards and also take care of the health and safety of its stakeholders through identification of risk factors, ensuring protective measures, capacity building in health safety and also financial cooperation in case of accidents.

11.7 GREEN SUPPLY CHAIN MANAGEMENT

While entering into agreements with suppliers taking into consideration of their respective social and environmental risk is green supply chain management through which business entities become faithful to their suppliers with respect and specially in case of contract and payment terms.

11.8 NETWORKING & RELATIONSHIP

Under this concept organizations tend to work with others to share knowledge and enhance awareness of sustainable development issues while having role in the public debate on the similar issues.

11.9 FREQUENT REPORTING

Presently there is no compulsory obligation to report on CSR activities still different organizations are producing report on their CSR activities. As CSR is considered as a practice of sustainability activities, organization’s motivation towards CSR publication is regarded as their strong commitment towards environment and society.

11.10 EMPOWERMENT AND EFFICIENCY

It is required to enhance the efficiency and empowerment of the persons along with institutions and sector as a whole to be capable of analysing SWOT (strength, weakness, opportunity and threat) in connection with profit generation activities.

11.11 HUMAN RIGHTS

Human Rights and other civil rights violation should be avoided and the adverse issues are to be addressed in proper manner.

11.12 INVESTMENT TO THE COMMUNITY

Organizations need to get concerned with the community from where these are operated to ensure basic needs like rehabilitation, medical care, education, small industries, cultural activities, research, knowledge development, income generation, technological advancement, employment and empowerment of the society.

11.13 EDUCATIONAL DEVELOPMENT

Support for educational development includes providing establishment, patronizing research and knowledge development activities, arrangement for material support, offering donations and scholarships.

11.14 MATERIAL DEVELOPMENT

Arrangement of training, workshop and media programs for the capacity building of the entrepreneurs.

11.15 DISABILITY REHABILITATION

Rehabilitation of the physically and mentally challenged persons through financial support and also through creating employment opportunities.

11.16 ENCOURAGING PHILANTHROPY

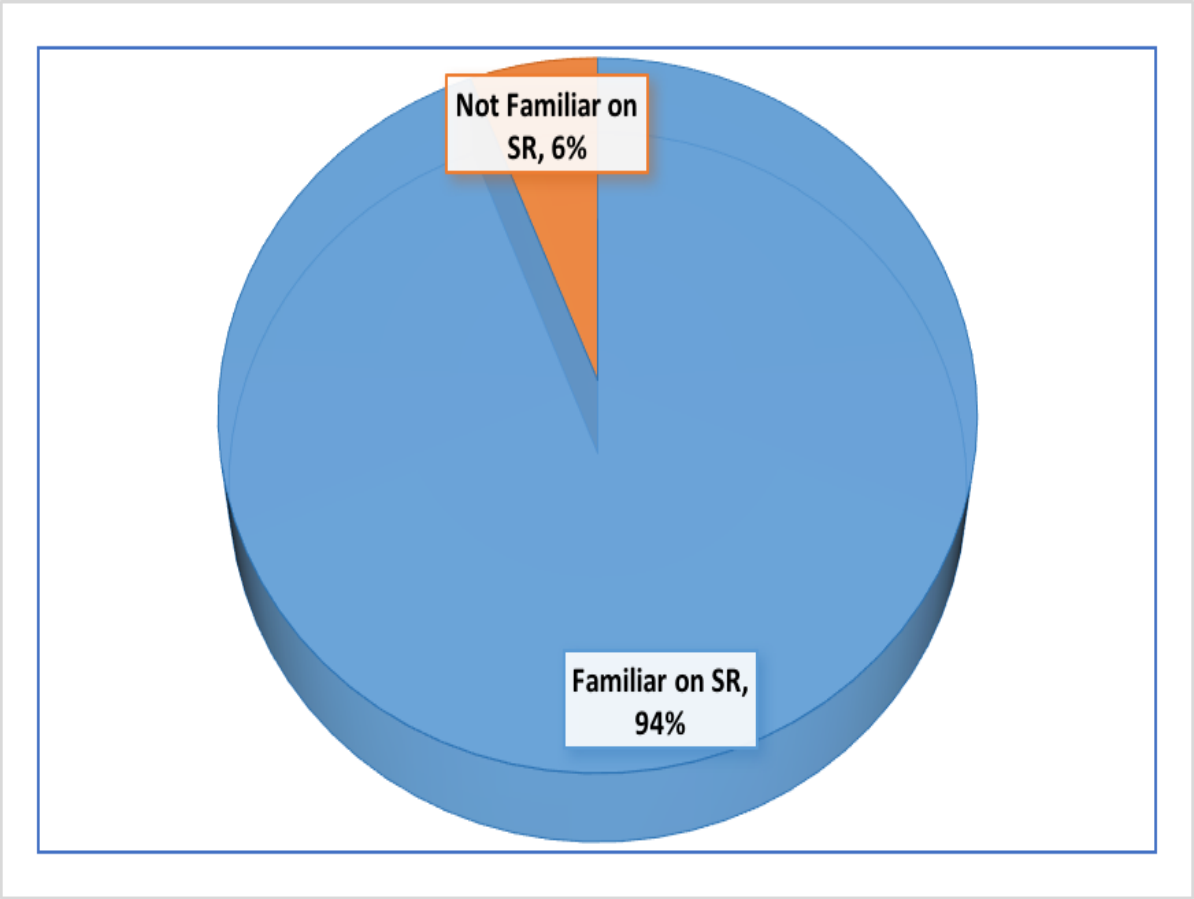
Employees and workers of the organization as part of their civil responsibility can also contribute to the development of the community. Organizations can encourage and inspire the employees to share their extra time, additional resources, special skills and energy to different social service activities for the underprivileged specially those are initiated and patronized by the organization.

12. ANALYSIS AND FINDINGS

With an aim to assess the current status of banking sector in Bangladesh regarding sustainability reporting towards sustainable development the study conducted a primary survey and some important findings are given below.

The study (Figure-3 & 4) tries to identify whether sustainability reporting is familiar to banking officials and sustainability reporting is beneficial for the banking sector. The study finds that 94% banking officials working in the banking sector are familiar with the concept of sustainability reporting and 95% banking officials believe that sustainable reporting is beneficial for banking sector.

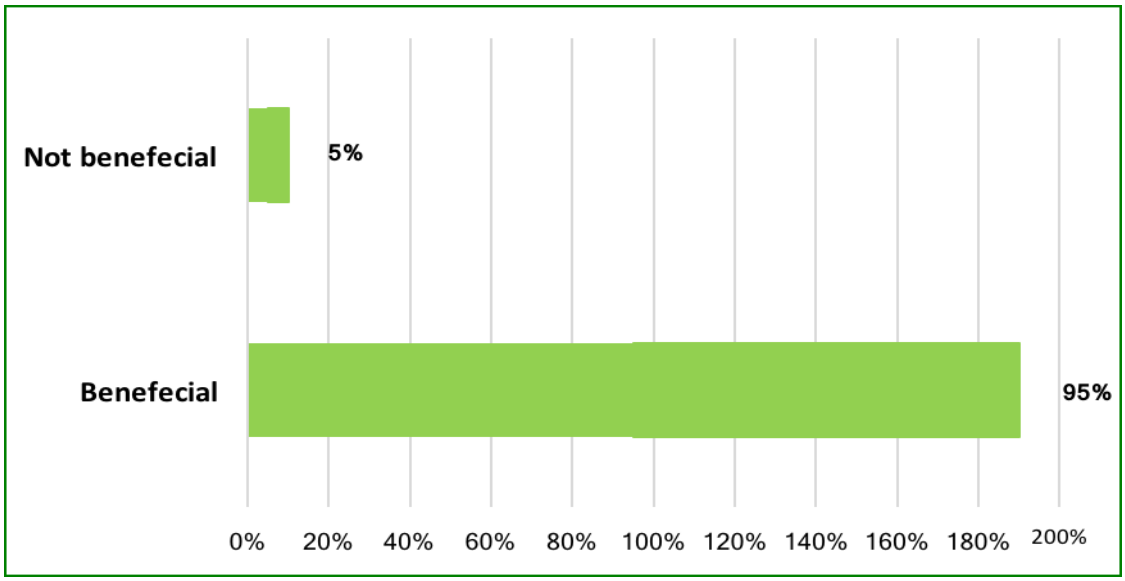
Figure 3: Response of the banking Officials about the Familiarity with Sustainability reporting



Source: Survey Data

Figure 4:

Response of the banking Officials about the Benefits of sustainability reporting

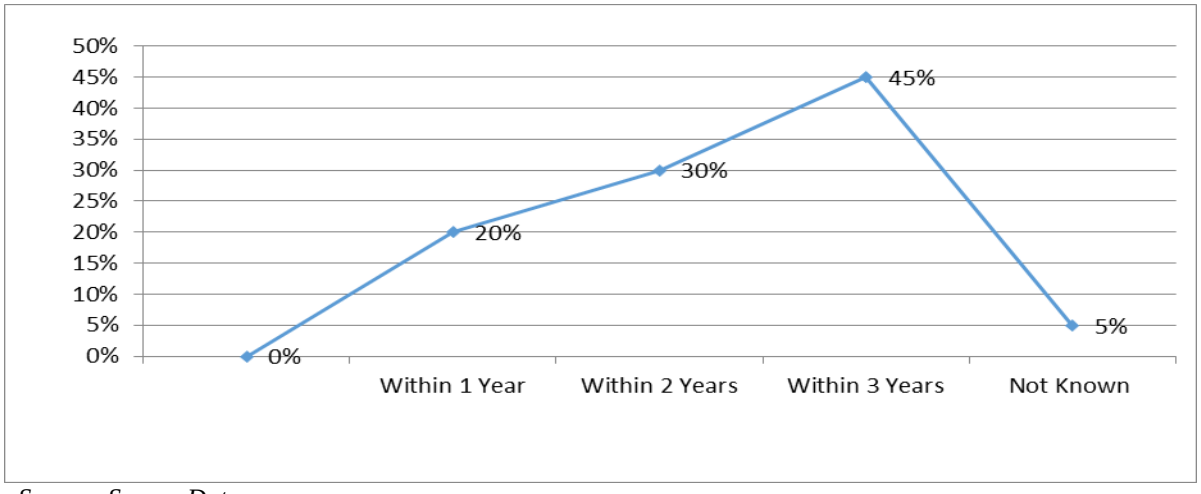


Source: Survey Data

Within how many years sustainability reporting likely to be introduced with your bank? In reply to this question, the study (Figure-5) finds that 20% banker opined in favor of introduced sustainability reporting within 1 year, 30 bankers opined the same within 2 years, 45% opined the same within 3 years and 5% bankers do not know their time frame. Therefore, the study finds that a noteworthy number of banker have plan to introduce sustainable reporting development within few years which is a positive sign for sustainability reporting for the banking sector of Bangladesh.

Figure 5:

Within How Many Years sustainability reporting introduced with bankers



Source: Survey Data

13 CONCLUSION

Sustainability reporting is one of the newest conceptualization of banking policy where investment also focuses on environment. As long as the marketing moving from traditional to digital, the profit-centric business decisions are gradually shifting from exclusive to inclusive, from vertical to horizontal, from individual to social. While getting indulged in the society including its social and natural resources, the responsibility of banking sector towards the society has also been multiplied. Banks are entrusted to offer long term protection for the society which is a greater responsibility in comparison to that of the other businesses which carry fewer responsibilities to the stakeholders.

Accordingly, this environmental concern has become the most important issue for banks and sustainability reporting has been branded as one of the most important parts for banking sector since the banking activities have undeviating effect to the economic factor and local community. Economic growth is strongly relevant with the growth of banking sector and through the sustainable development in banking sector, the local community is going to get contributed. The state is encouraged to promote sustainability reporting more from its political philosophy than profit orientation.

Based on the results of this study, more banks should be reporting economic indicators such as community investments, climate change risks, and climate change financial implications, defined benefit plan liabilities, how the obligations are to be settled regarding defined benefit plan and government funds, compared to environmental indicators.

Sustainability reporting connects to the relationship between the components of SDGs and GRI-G4 guidelines & sector disclosures and the study identifies sustainability reporting as perfect for our economy having focus on socio-economic development. This study recommends that regulators should continuously monitor sustainability reporting and continuous monitoring should make banks' sustainability report in a timely & balanced manner, which is, taking the indicators of sustainable development into consideration.

14 RECOMMENDATION

There should have a strong commitment from the bank authority regarding sustainable disclosure through sustainability reporting towards sustainable development in banking sector in Bangladesh, otherwise it will never be possible to implement this practice. Stakeholders' engagement is also to be ensured. Banks as the key stakeholder are required to render full support to sustainability reporting that also require the focus of top management of the organizations, hence, the central bank is expected to come up with special programs for the top bodies. Investors and customers awareness regarding sustainable disclosure on sustainable development is the key component for sustainable reporting in a standard way.

Awareness to be raised among the entities availing banking facilities to make them understand about the significance of sustainability and encourage them maintaining relationship with the banks with sustainable development practices. Policy analysis is also recommended to combine the green banking reporting and sustainable reporting together to prepare a standard reporting guidelines leaving no distinguishing factors between the two standards to reach the ultimate goal of development of the country in a sustainable way to build a 'sustainable tomorrow' and a bank, as corporate citizen, to be remembered always, "Treat the Earth well. It is not gift from your parents. It is a loan from your children."

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Appendix-1

Sustainability reporting towards sustainable development in banking sector of Bangladesh: Status and Readiness of Bangladeshi Banking sector

Questionnaire

Name of the Respondents:

Name of the Bank:

1. Are you familiar with the term Sustainability Reporting in banking sector?

☐ Yes ☐ No

2. Do you think Sustainability reporting training and development is beneficial for the banking sector?

☐ Yes ☐ No

3. How many years do you know about sustainability reporting?

☐ 1 Year ☐ 2 Years ☐ 3 Years ☐ Others

SUSTAINABLE DEVELOPMENT EDUCATION FOR HOLISTIC URBAN PLANNING IN INDIA: CURRENT PRACTICES AND CHALLENGES

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Abstract

Education for sustainable development is a crucial prerequisite for holistic infrastructure strengthening in developing countries. It helps in the formulation of an effective mechanism for comprehensive sustainable growth of communities, which leads to development from the grass-root level to the apex. India has been successful in realizing the importance of education for sustainable development (ESD) and climate change education (CCE) and, as a result, has launched various schemes and programs in the last ten years. Most notable among these is the Smart Cities Mission which has been launched by the Government of India in 2015. This mission aims at promoting cities that provide core infrastructure and a decent quality of life to its citizens, while maintaining and encouraging the concept of sustainable development. However, education for sustainable development in India requires a pan-sectoral approach with different actors playing key roles in relevant sectors. It is quintessential to integrate education and awareness related to sustainable development into the existing curriculum of middle and higher mainstream education in India. The United Nations Decade of Education for Sustainable Development (2004-2015) has brought about a paradigm shift in the realm of community education and awareness across the globe, although its validity is still being questioned by certain sectors. This paper aims to compare the features of this intervention with the programs and schemes launched in India after the turn of the century, enabling the reader to gather a comprehensive picture of the global standards and the status of education for sustainable development in developing and climate-change-vulnerable countries like India. Additionally, the paper would also analyse the challenges and roadblocks faced by such measures across the country.

Key Words: Sustainable Development, Climate Change, Urban Planning, Community Education, Resilience, Sustainability

Introduction: Evolution, Institutional Framework and meaning of ESD

The Brundtland Commission, formed in 1983, and formerly known as the World Commission on Environment and Development, defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The objective was to create an organization other than the UN which could form a global agenda by bringing both the developed and developing nations on a common platform. This would facilitate enhanced interaction, cooperation and a multi-disciplinary course of action amongst people and resources for the overall development of the planet. Initially, this commission had 21 nations as its members and was chaired by Gro Harlem Brundtland, Norway's former Prime Minister. Public hearings were conducted in 15 countries and subsequently in 1987 a report was published entitled "Our Common Future". This report illustrated how political contribution and public participation at a large scale could bring about an efficient management of environmental resources and motivational sustainable progress of communities and societies. Following the publication of this report, an international conference was called upon with an aim of reviewing the work being done by different countries with respect to sustainable development, which resulted in the occurrence of the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil in 1992, also known as the "Earth Summit". It was at this conference in Rio that a global plan of action titled the "Agenda 21" was formulated which focused on, among other aspects, biodiversity conservation, climate change, forest management, and roles and responsibilities of nations towards spearheading sustainable development. Chapter 36 of the Agenda 21 developed the structural framework for Education for Sustainable Development (ESD) and stated that "Education, including formal education, public awareness and training should be recognised as a process by which human beings and societies can reach their fullest potential. Education is critical for achieving environmental and ethical awareness, values and attitudes, skills and behaviour consistent with sustainable development and for effective public participation in decision-making. Both formal and on-formal educations are indispensable to changing people's attitudes so that they have the capacity to assess and address their sustainable development concerns." The countries were motivated by Agenda 21 to form and push forward a structure aiding education for sustainable development. However, ESD was not prioritized within policy making in most countries and therefore, only a small number of countries drafted a framework which focused on working for this process in the true sense.

The World Summit on Sustainable Development was held in Johannesburg in 2002, and it was at this summit that the United Nations General Assembly proposed a plan of action wherein a Decade of ESD would be considered. Consequently, at the 57th Session of the UN General Assembly in December 2002, Resolution 57/254 was adopted which declared 2005 to 2014 as the "Decade of Education for Sustainable Development (UNDESD) and appointed UNESCO as the nodal agency for its propagation and promotion.

At this juncture in the paper, it is crucial to understand in clear terms, the real meaning and scope of ESD. It would be safe to mention that ESD is a vision and a school of thought to help policy makers, experts and both private and government actors to create educational policies and framework with the aim of environmental and societal protection, while taking into account different challenges and hurdles, making it a sub-field of core education. According to UNESCO, it is based on different levels and types of learning – learning to know, learning to be, learning to live together, learning to do, and learning to transform oneself and society. Also, ESD could enable the creation and propagation of a "learning society" wherein the community learns with and from its members about growing more

resilient and withstanding sustainability-induced hindrances and risks. Therefore, ESD is, in essence, a consciousness of true learning and education, engaging and aligning people towards the issues of sustainable development, channelling their combined resourcefulness and capabilities, utilizing their diversities, and including the oppressed and marginalized – all with the aim of giving meaning and credibility to sustainable development as a whole and generating innovative solutions to meet crises and challenges. Interestingly and alarmingly, the 2010 State of the World Report published an article elaborating the Ecological Footprint Indicator which analyses the impact of human actions on Earth with respect to available natural resources. According to this indicator, at this moment humankind is already using the resources and services worth 1.3 Earths which goes on to show that the Earth is not capable of servicing and sustaining the human population at present and this trend is disastrous and catastrophic. It has been estimated that by 2050 the human population will be 9.07 billion out of which 62 per cent of the population will be residing in Africa and South-East Asia. This surge in the number of consumers and their aspirations will have a tremendous impact on the global resource base which is already under immense pressure and depleting at a faster rate than ever before. This present and predicted environmental state paints a glaring picture of the levels of damage, destruction and exploitation humans can inflict on nature, which by itself is in perfect harmony with the components and gives selflessly and continuously. However, as a silver lining to this bleak picture, it probably is an opportune moment for us to realize that now is the time to reverse this process of environmental degradation and strive for a future structured on foundations of sustainability, justice, humanity and equity.

ESD at the Global Level and UNESCO

Education for sustainable development (ESD) has sparked numerous debates all over the world during the last ten years of its inception and inclusion in various sectors of the society, illustrating a neo-liberal approach towards all things sustainable. Unfortunately, it has transformed itself into a vague and foggy concept in many realms of education; many environmental educators perceive it as just an extension and sophistication of environmental education at the elementary level. It is still unclear whether this has brought about more coherence and solidity at the environmental level including social, political and economic equity. In many case, the very concept of sustainable development is unclear which leads to a grey zone of proposals related to education for sustainable development which is very difficult for actors to grasp. If we consider UNESCO's take on education for sustainable development, we would notice that 10 emerging areas of multidisciplinary and multifaceted fields have been considered which portray the current problems being faced by the modern world:

1. reduction of poverty,
2. gender equality,
3. promotion of health,
4. environmental conservation and preservation,
5. rural transformation,
6. human rights,
7. intercultural understanding and peace,
8. sustainable production and consumption,
9. cultural diversity,
10. information and communication technologies.

It can be clearly seen that even at the global level, the true purpose, strength and capabilities of education for sustainable development is being masked by integrating into it other major

issues of burning global attention. Although these issues grab the attention of international media and major players and bring a certain emotional appeal to the concept of ESD, its true intention of promoting awareness and information about sustainable development at the global level is over-shadowed and bogged down.

One major problem that ESD faces at a global scale is that only the environmental educators seem to be associated with this concept at various levels of its implementation. Educators belonging to other fields are either very superficially involved in this concept in their capacity, or do not comprehend the meaning and criticality of this concept themselves. At this point, it must be considered that environmental education as a subject in the educational curriculum of schools is not new and has been around for about more than 30 years now. On intellectual and educated platforms, environmental education is the latest buzz-word and is the cause of numerous international summits, conferences and treaties. However, at the classroom level, this subject has played little to no role in reducing and reversing global environmental damage and loss, and is still being considered an emerging field of education and awareness especially in developing countries such as India. On the contrary, it has become sensitive and debatable at the political level in various countries as its true essence and efforts challenge existing social norms, practices and unfair social ranks. For instance, the International Implementation Plan accepted at the Johannesburg Summit in 2002 did not lay any impetus on education as a whole, and surprisingly, these plans were approved at the Fourth Preparatory Meeting in Bali, Indonesia in the same year. This clearly highlighted that no definite goals or tasks were developed, except those which has already been formulated at the "Education for All Initiative" in Dakar. Also, hardly any voluntary contributions and monetary aid comes from private players for the under-developed countries, signifying that poverty is one of the major factors for environmental degradation and such countries have to fend for themselves.

At this juncture, it is imperative to mention that not everything is bleak in the realm of environmental awareness and ESD. In several communities, environmental and sustainable management policies have gained importance and have attracted the attention of various experts. Also, a positive impact has been made by UNESCO towards bringing the ESD cause to the forefront at the Rio Summit (1992) and the Thessaloniki Conference (1997). This has been possible despite several hindrances and tragedies such as the 9/11 attacks, lack of financial support for the Global Environment Facility, and governance crises in the United Nations environmental branches.

Education for Sustainable Development (ESD) as an Ethical and Cost-effective Means of Addressing Climate Change

The economic and social costs associated with climate change are substantial, with about 5 million deaths and 10 million illnesses each year globally. In this regard, it will be safe to say that propagating and mainstreaming ESD makes economic as well as ethical sense. The multiplier effect of ESD means that the community as a whole can benefit from what one individual has learnt. Knowledge about local capacity and mitigation measures can be passed on from one individual to the future generations, enabling citizens to participate in the decision-making process especially at the local levels. Members of the public usually have an incomplete and hazy understanding of the word 'climate change' which hinders their comprehension of its severity. Greenhouse gases can even have severe impacts far away from their source of emission which illustrates that people living far away from the source are impacted in a similar manner as compared to the people living near the source. These

complex systems make it hard for communities to connect the dots which in turn undermine their motivation to act. Therefore, increasing peoples' understanding and awareness is the first step towards motivating and empowering them and to help them realize the causal relationship between their simple daily actions and the climate-induced damages that communities will experience globally. Enhancing and propagating the cause of ESD is, therefore, one of the key elements through which national and international governments can demonstrate their commitment towards a sustainable future. Additionally, this would aid governments in fulfilling their promises towards Education for All (EFA) and the Millennium Development Goals (MDGs) (Bangay & Blum, 2010). Reducing individual emissions is obviously part of the solution to the climate change crises, but it should not be the only measure adopted in this regard (Kawall, 2011). Promoting and ensuring sustainability will also need huge changes in the governance at the regional, national and international levels (Gowdy, 2008). The ESD framework is woven with the personal, institutional, and socio-political levels and is, therefore, primarily connected with both the individual as well as the collective. At the individual level, actions include reduction of one's own energy consumption, while at the collective level, a dialogue needs to be established between companies and organizations to reduce their global carbon footprint.

Researchers and scholars worldwide seem to have reached a common consensus that human behaviour and habits need to change to ensure sustainable development and a sustainable future. The free society has been built on the concept of individual choices and decisions, but extreme damage to the environment and climate has forced us to think otherwise. The problem with the education of today is that the educational goals are measured on the basis of how easily they can be measured. Teachers start focusing on what the students have learnt, because of which the process, and not the result becomes important. After the announcement of the United Nations Decade of Education for Sustainable Development, the focus has shifted from education *about* sustainable development to education *for* sustainable development. This implies that there is a need to focus more on changing the pedagogy and vision of learning, instead of focusing on the content of the education. The base for the formation of an inter-disciplinary approach should be inculcated during the primary years of schooling. ESD in essence requires integrative courses which modifies the role of the teacher or the instructor. It is clear that cooperation and coordination between different disciplines is required to overcome the problems facing the environment, and for this education must advocate a form of learning that raises awareness at individual, economic, social and environmental levels (Angelotti, Perazzone, Tonon, Bertolino, & Barbiero, 2009)

ESD and its Role in Models of Quality Education Globally

The World Education Forum on Education for All (EFA) has addressed quality education in its EFA framework and goals. Goal 6 of this framework calls for: 'Improving every aspect of the quality of education, and ensuring…excellence so that recognized and measurable learning outcomes are achieved by all, especially in literacy, numeracy and essential life skills' (UNESCO, 2000). However, ensuring quality education is a complicated process as the definition of quality is itself always evolving (Barrett, Chawla-Duggan, Lowe, Nikel, & Ukpo, 2006). Despite conflicts in definition, UNESCO (UNESCO, 2000)has put forth the basic principles of quality education.

Two principles characterize most attempts to define quality in education: the first identifies learners' cognitive development as the major explicit objective of all education systems. Accordingly, the success with which systems achieve this is one indicator of their quality. The

second emphasizes education's role in promoting values and attitudes of responsible citizenship and in nurturing creative and emotional development.

Three models of quality education are predominant in the international education literature:
1. The economic view of education quantitatively measures the level of quality; for instance, rates of enrolment and retention, and also, performance of students in national or international tests, supporting the theory that education is important for the economic development of any nation (Barrett, Chawla-Duggan, Lowe, Nikel, & Ukpo, 2006) (Kumar & Sarangapani, 2004)

2. The second model of education focuses on the humanist aspect with the student at the centre of the process. Here, the goals include wider social goals such as human rights and social justice, and democracy. This model of education aims to develop the complete personality of the student with problem-solving abilities (Barrett, Chawla-Duggan, Lowe, Nikel, & Ukpo, 2006).

3. The third model of education is the "learning as connection' which explains how existing knowledge of local context can be linked with the learning of new foreign concepts. Embedding local knowledge with abstract foreign concepts is very important for sustainable development education as it enables both to grow (Lotz-Sisitka, 2013).

ESD in India and its Contribution towards Modern Urban Development

In India, Education for Sustainable Development and Environmental Education are deeply connected to each other, with similar impetus and pedagogy over the last few decades. The importance of ESD in India grew after the 42nd amendment in 1976 and with the formation of a dedicated Ministry of Environment and Forests in the 1980s. This led to various activities such as green press, green bank, eco-labs, eco-policies, eco-farming, eco-harvesting, etc. It is common perception that environmental problems are escalating because of population growth, mismanagement of resources, and industrialization globally, and ESD has been identified as a means to encourage public awareness and participation, especially in India. ESD and Environmental Education in India got a breakthrough when the apex judiciary of India, the Honourable Supreme Court gave a ruling in 1991 that this subject should permeate all levels of education, ranging from primary education up to undergraduate and graduate schools as well. Additionally, the Supreme Court gave orders to the University Grants Commission (UGC) for providing grants in order to ensure smooth implementation and execution of this subject at the university level. During the academic year 2004-05, environmental education got implemented in almost all undergraduate institutions, which consists of 85 per cent of students pursuing higher education (India, 2009). However, it would not be wrong to say that environmental education still focuses on the theoretical understanding of the environment and hardly focuses on sustainability and measures for the future. It is important to align environmental education in India with the objectives of Agenda 21 for sustainable development. Education emphasizing on sustainable development and adopting a multi-disciplinary approach, making people conscious about the environment, has the maximum chances of success (Fien & Tilbury, 2002). In India, there is a need to connect environmental needs and human morality to ensure the progress of ESD in the right direction. ESD in India aims to teach students not only 'what to think' but also 'how to think', enabling them to make informed decisions, effectively analyse information and participate in social life. In this regard, the ESD model in India could look at the Sustainable Development Liaison Group in Scotland which works for the implementation of ESD in primary and

middle school curricula. This group has actively mobilized students, parents, teachers and communities, who regularly meet in the school and outside as well, to discuss this theme and to formulate eco-political-pedagogical projects. This has led to the construction of various eco-schools all over Scotland.

It is clear that the ultimate goal of ESD is to ensure positive citizen behaviour and active citizen participation. The figure depicted below shows the environment-citizen behaviour flowchart highlighting the placement and importance of environmental sensitivity, knowledge of the issue, knowledge of procedure, incentives, and citizen empowerment for sustainable development. Citizens have become more aware towards various kinds of pollution but the effect is not significant (Marcinkowski, 1989), and therefore, there is a need to re-orientate the existing educational programme to boost competence, knowledge, abilities, values and attitudes towards sustainable development.

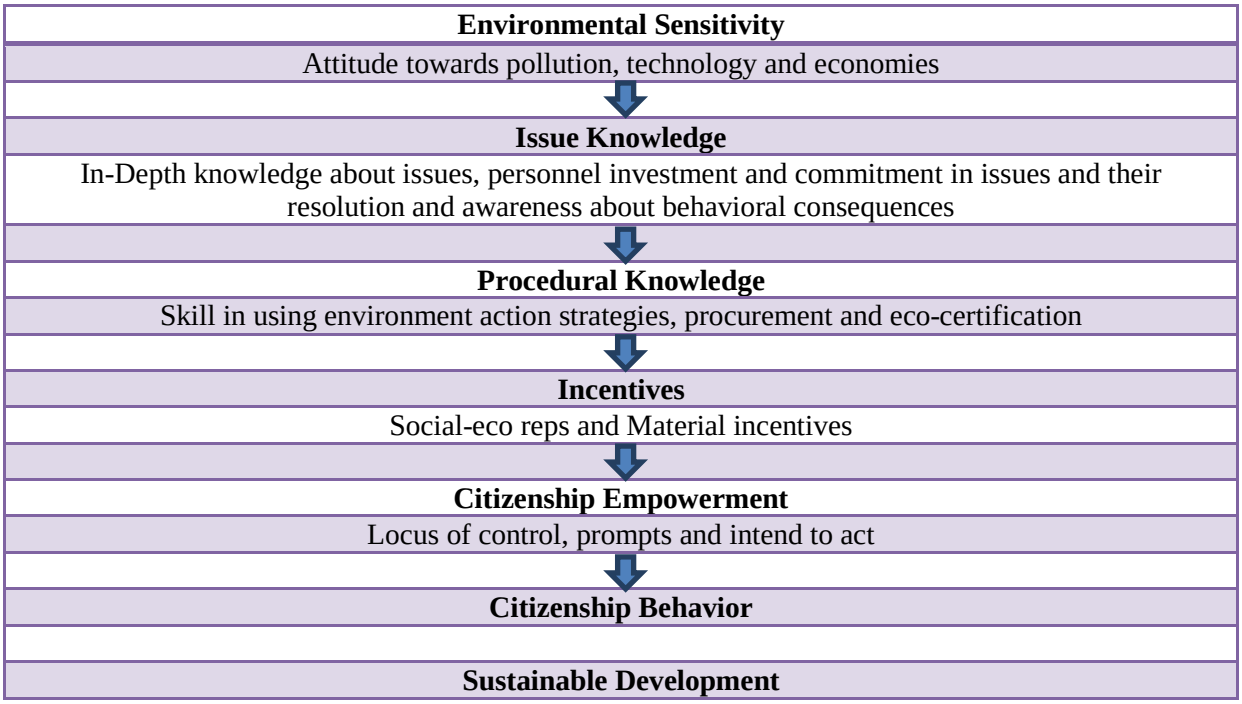

Figure 1: Environment Citizenship Behavioral Flowchart. Source: Adapted from Hungerford and Volk (1989) and Levy and Marans (2012)

Having a deep understanding of the problems plaguing our environment has a lasting influence on an individual's behavior (Hines, Hungerford, & Tomera, 1987). Over the past few decades of incorporating ESD in the curricula in India, it has been noticed that individuals make more responsible decisions when they have the knowledge and confidence about to undertake such actions successfully. Empowerment of citizens has a crucial role in motivating responsible sustainable behavior among the community. The participation of youth in ESD programs encourages the level of understanding regarding human-environment interactions and has the ability to increase a sense of stewardship for the environment. Over the course of the last 10 years in the urban politics of India, various urban development schemes have been launched such as the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Jawaharlal Nehru National Urban Renewal Mission (JNNURM) and the Smart City Scheme among others. It is encouraging to see that these revolutionary urban development schemes have considered the aspect of sustainable development in their plans for the creation of a new and modern India.

Conclusions

India has played a crucial role in the development of the Sustainable Development Goals (SDGs) and the country's national development goals are deeply aligned with the concept of sustainable development. The expression "Sabka Saath Sabka Vikas", which translates as "Collective Effort, Inclusive Growth", has been proclaimed by the Prime Minister of India, Narendra Modi and forms the cornerstone of India's sustainable development and national progress agenda. It can be safe to say that various initiatives for promoting ESD, both at the national and global levels, have led to the inclusion of this subject into the Indian curricula at various levels of education. Students are becoming adept to information related to the welfare of their surroundings.

A major shortcoming that ESD faces in the Indian context is that it provides comprehensive theoretical information about the issues plaguing the environment and hindering sustainable development, while ignoring the ways in which the recipient of this information can participate actively towards achieving the same. This often leads to bewildered students who, after having studied a lot about the problems, feel overwhelmed and fail to take effective measures towards propagating environmental awareness and sensibility. ESD needs to find tangible solutions for environmental protection and climate-change awareness, providing a wide platform of participation for teachers and students. ESD should also shed light on the inter-relationship between social, political, economic and ecological environments, which differentiates from country and country. Any imbalance in this precarious relationship, especially in a country like India, can have international repercussions. For this reason, ESD should have an extremely strong position in the Indian educational curricula in order to develop a sense of responsibility, solidarity, pride and belongingness amongst the national and global communities. As mentioned in the beginning of this paper, a pan-sectoral approach is required for the effective implementation and understanding of Education for Sustainable Development and Climate Change. Quintessential participation of youth is required in propagating ESD and spreading it outside the confines of educational institutions to boost human-environment interactions and formulate a sense of stewardship for sustainable development. Furthermore, ESD needs to branch out in the form of excursions, seminars, conferences and workshops at the local, regional, and national levels to capture the participation of a wide section of key actors, students and teachers.

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Sustainable Production of Gracilaria (Rodophyta) thru Science & Technology Community-Based Approach

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ABSTRACT

Gracilaria farming using net module method was adopted by three coastal communities of Rosario, La Union, Philippines thru the Science and Technology Community Based Farm Project of the University. Gracilaria, an agar bearing macroalgae, is one of the three commercial species of seaweeds in the Philippines. Gracilaria has been used as an important source of agar, a phycocolloid with important uses as food and numerous industrial applications. Cooperators selected were capacitated with knowledge and skills on Gracilaria biology, mariculture, proper harvesting, drying technology using helio-house solar dryer, storage, and value addition. Farming showed luxuriant growth of vegetative cuttings inserted and outgrowths from net modules were pruned after 5-6 months leaving the propagules to undergo vegetative reproduction. Using the technology, production of Gracilaria increased from 6,000 kg/ha/yr to 28,480 kg/ha/yr. Coastal communities have actively participated in promoting Gracilaria farming technology in the province of La Union. Overall, with S and T intervention, farming of Gracilaria thru the community-based approach is technically feasible, low cost, profitable, environment-friendly technology that empowered the coastal communities to engage in Gracilaria farming as a supplemental livelihood. Thru the project, the coastal communities developed value awareness on Gracilaria leading to the sustainability of this valuable endemic resource.

Keywords: community-based, farm management, Gracilaria, phycocolloids, value added products

Sustainable strategy and value creation in the corrugated cardboard sector: the SADA group experience

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Abstract

In recent decades, the business world has demonstrated a strong commitment to preventing and reducing the environmental impact of its production activities as well as improving its ethical and social performance. In particular, the paper industry, like other basic industries, has made considerable efforts to innovate processes and reorganise its activities in order to improve the use of resources, social and environmental aspects and achieve increasingly high economic performance. In addition, some organizations in the sector have established relations with their stakeholders in order to implement and ensure a strategic corporate approach aimed at creating social value for the territory.
The purpose of this paper is to highlight how the involvement of organizations is necessary to "build" lasting sustainability as it is able to integrate growth into competitiveness, environmental protection and social development. This is due to the extraordinary synergies that can result from the structured adoption of paths marked by sustainability and the promotion of local dynamics oriented to development. We then analysed the systems, management tools and sustainability standards adopted by the Sada Group. The company has always been oriented towards pursuing management models capable of generating social value (together with economic value) at a systemic level (the so-called shared value). This was done in order to explore the opportunities and the main critical elements that derive from a strategic drive towards improving one's performance in a holistic approach.

Key words: sustainability, value creation, socio-environmental tools, LCA

1. Introduction

The current context in which Italian paper companies operate is characterised by high levels of complexity. The latter can be summarised as the contemporary economic situation, the well-known phenomena of market globalisation and events and problems that call for the need to follow growth paths that are not only sustainable from a strictly economic point of view, but above all, functional to improving technological and environmental performance. In the light of this scenario, therefore, new challenges are emerging for paper companies in Italy which, having in the past paid little attention to aspects related to environmental management, have found themselves, in recent decades, having to search for appropriate strategies for the dissemination of environmentally friendly processes, organized as a "closed system" of material and energy flows, in order to optimize the use.

A first line of action undertaken by the most virtuous companies in the sector has been oriented towards the search for technological solutions aimed at an efficient use of material and energy resources.

It is sufficient to consider, for example, the production of electricity, which is carried out using cogeneration systems that improve its efficiency, as well as the treatment, recovery and reuse of waste water, up to the more efficient management of the waste produced.

The analysis of energy consumption and technological innovations implemented in recent years in the Italian paper industry has shown that the path taken, aimed at optimizing the use of energy resources in production processes, has led to a significant improvement in energy efficiency.

These results, however, which attest to the considerable commitment of the Italian paper industry to achieving higher technological, energy and environmental standards, represent only a starting point for tackling the competitive challenges arising from the complex reference context in which these companies currently operate.

The processes of globalisation of the economy, but also of regionalisation and integration of the European paper industry, as well as the stringent environmental constraints defined at Community and international level, require further and more substantial improvements in the energy and environmental efficiency of production processes.

In addition, new demands have emerged that are broadly related to the sphere of ethical and social needs.

The world of production has been called upon to contribute to the achievement of wider sustainability, whose objectives have gone beyond those that had characterized previous decades.

The "sustainability" is the assumption by companies of precise moral responsibilities based on socially shared ethical principles and by consumers of more responsible lifestyles (Proto and Supino, 2009).

The progressive widening of the concept of "corporate social responsibility" is defining a more demanding role for the business world, and for the organisations of the paper sector in particular, from which a rethinking of the same aims that the companies are called to pursue derives. In fact, alongside the traditional function of production, which is still the constitutive element of their being and operating, they are asked to give greater impetus to sustainability, with a view to enhancing at the same time the economic capital, human capital and natural capital.

The possible paths to be taken to improve their performance, not only economic but also environmental and social, are based not only on the recycling of paper waste and the more widespread use of high-efficiency cogeneration and renewable sources, but will necessarily involve an increase in investments in research and development, also carried out within districts and/or production areas, for the realization of process and product innovations that will allow companies in the sector to improve not only their efficiency, but also that of the entire national economy.

Similarly, a broad involvement of all stakeholders is necessary in order to achieve sustainability as a fair, equitable and transparent form of value creation for all stakeholders.

In this context, the study analyses the main initiatives adopted by an organization that operates in the paper industry the Sada Group, in order to explore the opportunities that derive from a strategic drive towards sustainable to improve business performance. The company was founded in 1870 as a sawmill and carpenter, then the owners decided to transform the core business into corrugated

cardboard by buying the first case-makers and die-cutting machines. Through a series of acquisitions and participations today the company is part of the holding company “Sada Participazioni” and controls the companies Sabox and Sifim. Currently, the company Antonio Sada & figli is among the top 10 players in the corrugated cardboard sector at national level.
Therefore, the work has been divided into four sections. The first section summarizes the role that the paper industry plays in Italy, with particular attention to the corrugated cardboard sector. This was done in order to outline the main characteristics of this type of paper, which is widely used in the packaging sector in Italy. The work continues with the presentation of the Sada Group, a company in the Italian corrugated cardboard manufacturing system that stands out for its numerous initiatives aimed at building the sustainability of the organisation in its triple dimension: economic, environmental and social. A study was then presented, carried out within the group, which revealed the considerable advantages and critical issues associated with corrugated packaging.
The last section outlines some concluding considerations that highlight the main opportunities that can arise from a strategic orientation towards sustainability in terms of improving company performance.

2. The market positioning of the Italian corrugated cardboard sector

The Italian paper and board industry occupies a relevant role in the national economic scenario (Malandrino et al. 2014). One of the main productive realities of the manufacturing industries both in terms of turnover, number of firms and workers, not to mention the significant flow of products exported, the sector comprises various areas specialized in the production of different types of paper and board. Currently, the sector is composed of 113 firms employing 19300 workers and achieves a turnover of more than 24 billion euros, equal to 1.4% of GDP (ASSOCARTA, 2017).
In the context of the different types of paper and cardboard, corrugated cardboard, invented and patented in the mid-1800s, plays an absolutely important role to the point of becoming an irreplaceable material in the logic of the modern economy. In 2017 the total national production - in surface - has nearly reached the 6,8 billion of square meters (in weight 3,8 million tons), with an increasing trend in comparison to the last years (Cecchini, 2018).
The turnover of the companies that make it up is about 3.8 billion euros, providing employment to about 15 thousand employees.
The production growth highlights the fundamental role of the corrugated cardboard sector in the enhancement of exports and in the competitiveness of Made in Italy products.
Italy remains the largest producer of corrugated board in Europe after Germany (FEFCO, 2017). Almost half of the national corrugated cardboard production is concentrated in Lombardy (23.6%), Emilia-Romagna and Marche (which together account for 23.5% of national production). The production areas that follow are Triveneto (17.1%), Tuscany (13.5%), South and Islands (9.2%), Lazio-Umbria-Abruzzo (7.1%) and Piedmont-Liguria-Valle d'Aosta (5.8%) (Cecchini, 2018).
The current spread and use of corrugated cardboard has led to a constant qualitative evolution both in the techonology and in the services offered. In fact, it is a dynamic product of great topicality, always in step with the renewed needs of the market. Corrugated board, in its simplest structure, consists of two paper surfaces (covers) that enclose a corrugated paper (flute). The various elements are coupled together by means of a glue of vegetable origin.
There are two types:
Single flute cardboard, also known as plain cardboard, consisting of two flat covers and an inner one;
Double flutes cardboard, consisting of three flat covers and two flutes (GIFCO, 2017).
The function of the flutes is fundamental: they are true load-bearing pillars that confer resistance and robustness, while at the same time cushioning external shocks. Transformed into packaging, corrugated cardboard becomes a robust container, ideal for grouping, transporting and protecting. Corrugated cardboard is, therefore, ductile, resistant and extremely versatile; characteristics that make it the ideal packaging for the protection and transport of products.

Corrugated cardboard packaging is, in fact, among the most widespread in Europe, such packaging is chosen for the packaging of 75% of European goods and more than 40% of such packaging is used for food products (FEFCO, 2017).
In Italy, corrugated cardboard packaging is mainly used in the food sector (fruit and vegetables, fresh and processed products, beverages, fish, meat and chickens), with a growing market share of 60.3%. The remaining 39.7% of the boxes in circulation are used by the non-food sectors, from household appliances to construction, from the metalworking industry to the pharmaceutical industry, from furniture to hygiene, cosmetics and household cleaning. Recently, it has also played an important role in online sales. E-commerce is, in fact, a fundamental sector for the development of the corrugated cardboard supply chain, as it is the packaging par excellence for the shipping of goods purchased online (GIFCO, 2017).
According to scientific research, corrugated cardboard trays keep fruit and vegetables fresher and safer than traditional plastic crates and can significantly reduce the contamination of moulds and bacteria. (FEFCO, 2017)
Corrugated cardboard is the natural and eco-sustainable packaging material par excellence (Pira, 2017). It is also often chosen for its recyclability and biodegradability characteristics.
Over the years, the diffusion of managerial schemes oriented towards the promotion of development models based on sustainability has oriented sector organisations towards the creation of production processes based on the efficient use of resources and the reduction of the use of raw materials. The average weight of corrugated board is currently 566 grams per square metre, compared to 605 grams in 2000. In addition, more than 80% of the cardboard put on the market is made from recycled material. (FEFCO, 2017).
In turn, end-of-life packaging is recyclable in its entirety: thanks to the work of Comieco, the national consortium for the recovery and recycling of cellulosic-based packaging, 89% of paper and cardboard packaging in Italy each year is sent for recovery and 80% for recycling.

3. Sustainable management in Sada group

Sustainability building is an integral part of the Sada Group's vision and values, a constant commitment to supporting sustainable business growth, that is, to promote employment and social and territorial cohesion, and intelligent growth through the development of knowledge and innovation.
All the organization commits itself to a process of continuous improvement to face the complex challenges that the market presents every day and to respond with great operational and production flexibility to the increasingly demanding demands of customers.
In recent years, the Sada group has undertaken various initiatives and adopted new approaches and tools aimed at reconciling the environmental and ethical-social dimensions in the managerial dynamics that govern its group (Fig.1).
This has implied a broadening of responsibilities and horizons, through the adoption of ethical principles in the governance of management activities. Collaborative and transparent approaches have been adopted, putting in place new communication strategies with its stakeholders, strategies that represent the expression of the acquired awareness of the importance of the heritage of intangible assets, such as image, trust and reputation, in the realisation of profit and in the ability to compete.
The Group is equipped with a modern Quality Laboratory to carry out tests on corrugated cardboard and cardboard. The staff is continuously trained at the best accredited laboratories and prepared on all the latest quality innovations, analyzes the adequacy of the characteristics of all incoming raw materials, performs tests on the semi-finished product and completes the verifications through a series of tests on the finished product.

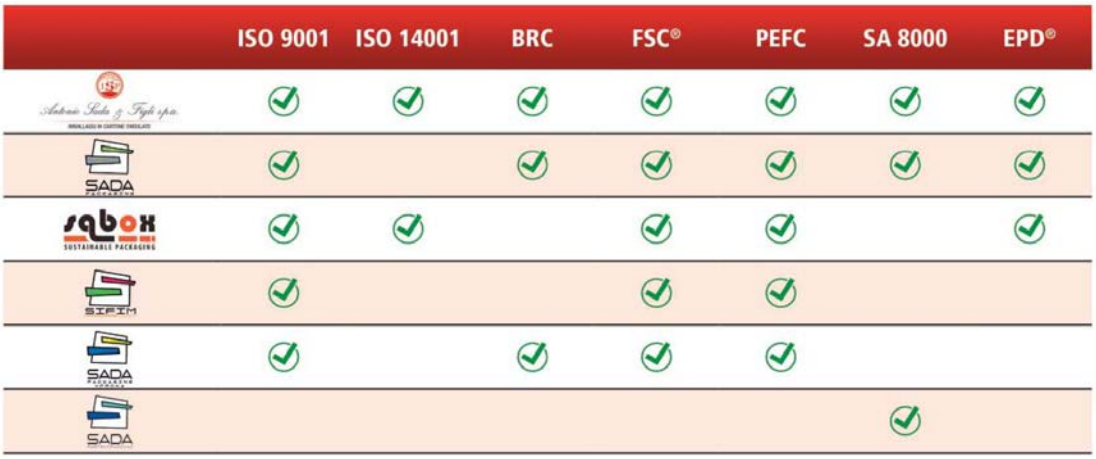

Figure 1 - Systems and tools for socially responsible management in the Sada Group

The group has, first and foremost, identified the "key" stakeholders, i.e. those categories of stakeholders vital for the survival of the organisation, who are the recipients not of simple information but of a structured and continuous communication channel. Subsequently, it established a permanent dialogue with these stakeholders, through the activation of an adequate range of communication tools; it identified indicators, intended as summary information on the performance achieved in the field of social responsibility (Key Performance Indicators - KPI). They are significant for the stakeholders, quantifiable, to allow a comparison in time and space and measurable, or rather, the result of a suitable and periodic survey system. Finally, the performance and conformity of the organisation's operations with the declared values are constantly monitored. The need also arose to improve information flows on the organisation's social and environmental performance, in awareness of the limits inherent in traditional economic and financial accounting documents. This is how a process aimed at broadening company information has begun, which has gone beyond the now narrow and strongly structured scope of aspects linked to the economic-financial-equity balances to also involve those linked to communication in terms of the social value of business activities. By the end of 2018, in fact, the first CSR (Corporate Sustainability Report) will be published, drawn up according to the GRI - G4 guidelines.
The firm respects Global Compact ethical principles and values: human rights and working environment.
The group expresses its social commitment both in relation to the internal dimension - primarily in the management of human resources, in terms of education and continuing training, flexibility of working hours, equal opportunities and in environmental management, in terms of energy saving, dematerialization, emission reduction, use of recycled materials - and in relation to the external dimension of the company, through better relations with the local community, with business partners, suppliers, etc.

3.1 Enviromental management

The Sada Group was one of the first in Italy to obtain FSC multi-plan FSC certification in 2009, ensuring product traceability of recycled cardboard from pulp to product stage.

Currently, more than 95% of the paper used by the Sada Group is FSC® certified, guaranteeing that it comes from responsibly managed forests (virgin fibre paper) or that it has been made using only post-consumer fibres (recycled paper). The FSC® brand is appreciated and recognized by customers and consumers as a synonym of respect and conservation of forests and the rights of the people who live and work in them.

Sada group was also one of the first firm in the sector to put in place eco-compatible – in particular lean thinking models – production processes, reducing waste, improving energy efficiency, limiting consumption and losses and recovering and recycling production waste.

The group is also very attentive to optimising the use of resources, particularly energy and water.

It has built a 2.7 MW photovoltaic system that saves 0.6 g of CO_2 per kW.

Water destined for productive processes is obtained from an artesian well. To limit water consumption, same color orders are put together and cleaning machinery is reduced to a minimum. To avoid toxic waste, the use of water-based ink is privileged together with natural glues not containing plasticized composites. The distilling plant recycles most of the water for subsequent uses. Cardboard scraps are compacted into bales, tied up and sent to the Group's paper mills which are also a platform for recycling and subsequent reuse. The outcome is a virtuous chain whereby paper is produced, discarded and recycled locally.

The group is carrying on the Gross Reduction Project. Its objective is to reduce the gross amount of die-cutting expected in the orthogonal direction to the die-cutting direction (the direction in which the corrugator travels). This allows, independently from the corrugator trim and the reel heights used, to obtain a semi-finished product saving of 4mm per sheet.

This first step involved the plane die-cutting cycle and the B and T flutes, then it will be extended to the rotary die-cutting and to other flutes.

With reference to the data for 2017, the expected saving for 2018 on flat die-cutting is 52,000m^2 year, for a value of about 23,000.00 € per year.

For the rotary die-cutting you would obtain a saving of about 37,000 m^2 year for a value of about 17.000,00€.

The Sada Group is firmly convinced that doing business does not mean producing mere wealth for the individual but is an expression of the creation of social value, opportunities for growth and development that generate a significant impact on the territory.

This is the spirit with which the companies of the Sada Group have joined the formation of the 100% Campania Network, the first network of companies for sustainable packaging operating in the recycling and processing chain of second raw materials from separate waste collection in the area. Companies from Campania that operate along the paper supply chain that have joined together for the first time in order to develop a shared project and encourage the development and growth of the territory to which they belong.

In Campania, in fact, 150,000 tons of paper waste are collected every year: not all this paper waste is used and processed in the region, most of it goes abroad and less on the domestic market, depriving the territory of the related value. The cycle of transformation of proximity creates value from the territory and for the territory. The network is an accelerator for the exchange of best practices and knowledge, both internally and externally, with innovative and sustainable proposals and solutions.

The Network encourages and enhances the use of Campania waste according to a local value chain, in an integrated and sustainable way, favouring and promoting the circular economy and local recycling through the production of sustainable packaging.

Thanks to the 100% Campania Network, today the Group can supply a special packaging (greenBoxX®) obtained by recycling only local waste, FSC® certified and equipped with EPD® (Environmental Product Declaration) produced and distributed according to a closed sustainable cycle that maintains the entire value chain in the territory.

Closed loop supply chain projects were carried out with industrial customers and large retailers, recovering the waste from their plants, transforming it into reels and then back into packaging, within a circular economy system. The entire system is traced and certified with a view to reducing the exploitation of natural resources, emissions and waste generation.

The Sada Group, one of the first in Europe, has conducted an LCA study on the main corrugated cardboard compositions produced in its plants.

The LCA study makes it possible to identify and quantify environmental impacts throughout the life cycle of a product, from raw materials to disposal: it is a fundamental step in the development of the sustainability policies of the Sada Group and its customers. The validation of the results and the achievement of the relative EPD® allow the Group to transfer data along the supply chain and to develop projects to reduce the impact with customers and suppliers.

4. The sustainability of corrugated packaging through the LCA study

The growing awareness that the recent environmental challenge imposed by technologies aimed at the diffusion of green energy lies in the correct understanding and measurement of the economic,

environmental and social impacts associated with their entire life cycle, makes it necessary to implement approaches based on Life Cycle Management (LCM), from a Life Cycle Thinking (LCT) perspective. This was done in order to provide policy makers and economic operators, as well as the communities concerned and the community in general, with elements for assessing the various energy options, which are characterized by consistency, completeness, transparency and clarity.
The operational tool to carry out such assessments is represented by the Life Cycle Assessment (LCA), a standardized methodology (ISO 14040), based on the systemic assessment of the environmental criticality of a product (but also of a process or an activity), through the identification and quantification of the consumption of raw materials and energy as well as the polluting impacts associated with all phases of the life cycle (extraction of raw materials, from cradle to grave, or from cradle to cradle in the event of recycling or reuse of the product, or even in the event of recycling some of its components only, to achieve a virtuous “closing of loop”.
On the basis of these considerations, the Sada group carried out an LCA study on corrugated cardboard boxes produced to understand the critical impacts of its supply chain and to improve its processes with a view to sustainability.
The LCA study is, in fact, important for the development of the company's sustainability policies because, in addition to being able to provide certified data on packaging, it allows the complete and organic collection of data relating to the manufacture of the product. It identifies weak points in the production process, keeping emissions, resource consumption and related effects under control. It allows to evaluate the environmental performance, identifying the process or activity on which it is possible to intervene, through concrete actions to reduce emissions.
In addition, this activity provides the opportunity to communicate what has been achieved, to improve the image of its products by deepening the commitment on issues of economic and environmental sustainability, related to the product category.
The boundaries of the system include all phases of the life cycle of the products considered from the cradle to the gate (LCA cradle-to-gate). This includes the phases of production of raw materials, their transport to production, as well as the use of energy sources in all stages and the management of products, by-products and waste. On the other hand, downstream processes are excluded from the analysis.
The process of collection and sorting of recycled material was considered in the upstream phase, while no impact was considered for the final waste sent for recovery other than transport to the company that deals with its disposal/recovery.
In particular, product life cycle stages can be grouped into upstream, core and downstream processes, as illustrated in Figure 2.
In this LCA study, the environmental impacts of the creation of 8 different types of packaging were analysed, made using different combinations of recycled paper, listed below:
TMT/363/C, LUSBK/362/C, XPMTB/442/B, TMT/363/B, CGSCMCGS/343/B, CGSCCFCFCGS/31113/EB, LML/363/B, LUSL/343/B.
These products have been chosen because they represent a variety of boxes produced.
The study has limitations related to the data quality of the upstream phase as it was not possible to recover primary data for all the paper compositions that make up the cardboard.

4.1 Analysis of the production process

Figure 3 shows the company process flow used to analyze the entire life cycle of some of the types of corrugated packaging produced, paying particular attention in the analysis to quantify the weight per square meter of the products, which characterizes them in the eyes of the customer and distinguishes in terms of physical quality, strength, etc..

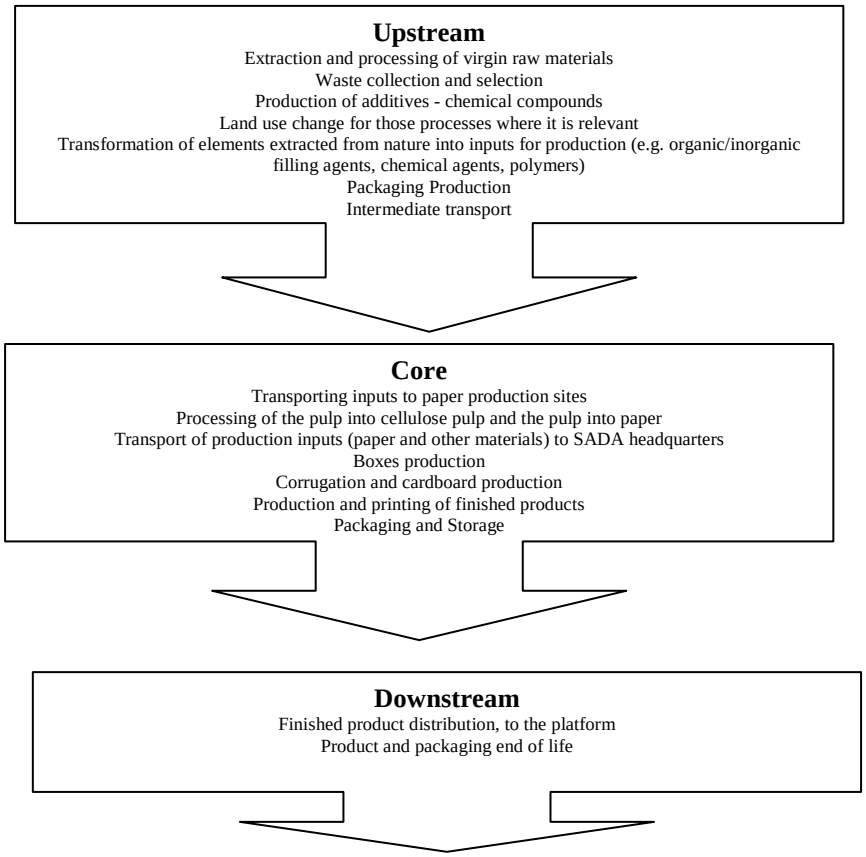

Figure 2 - Upstream, core and downstream processes

Life cycle stages of corrugated cardboard involves from the production of raw materials: various types of paper, from Italian and foreign suppliers and other material resources used by SADA for the production of packaging (e.g. glues, inks, etc.).
It also includes the production of corrugated cardboard, by processing paper and laminating and the process in which the cardboard produced is die-cut and printed according to production needs, and then subjected to folding and packaging.
The main raw material is reels of virgin or recycled paper. The reels are stored, subdivided by type in a special covered warehouse and labelled in order to ensure identification and traceability.
The storage of the paper reels is organized by vertical stacking and handling is carried out by forklifts equipped with special devices for handling the reels.
The reels are transported to the corrugating machine where the cardboard sheets are made, which can be composed of two or three layers of smooth paper with the interposition of one or two corrugated sheets; the bond is made by means of adhesive based on wheat starch. The adhesion between two sheets, one smooth and one wavy, is achieved through a process of gelatinisation of the starch-based glue at about 60 °C, in which case the starch is able to penetrate into the papers forming a stable bond. The continuous web generated by this process is cut into appropriately sized sheets using a cutter system. The process ends with the sheets being stacked and the semi-finished product being sent to the warehouse.
The production line is composed of two corrugating units, a double gluing machine, a battery of tops, an auxiliary cutter, a cord cutter, a transversal cutter and a collector-stacker.
The semi-finished material consists of stacks of corrugated sheets. These stacks are transferred by means of transfer trolleys and a series of motorized roller tracks that constitute the storage and handling system for this product.

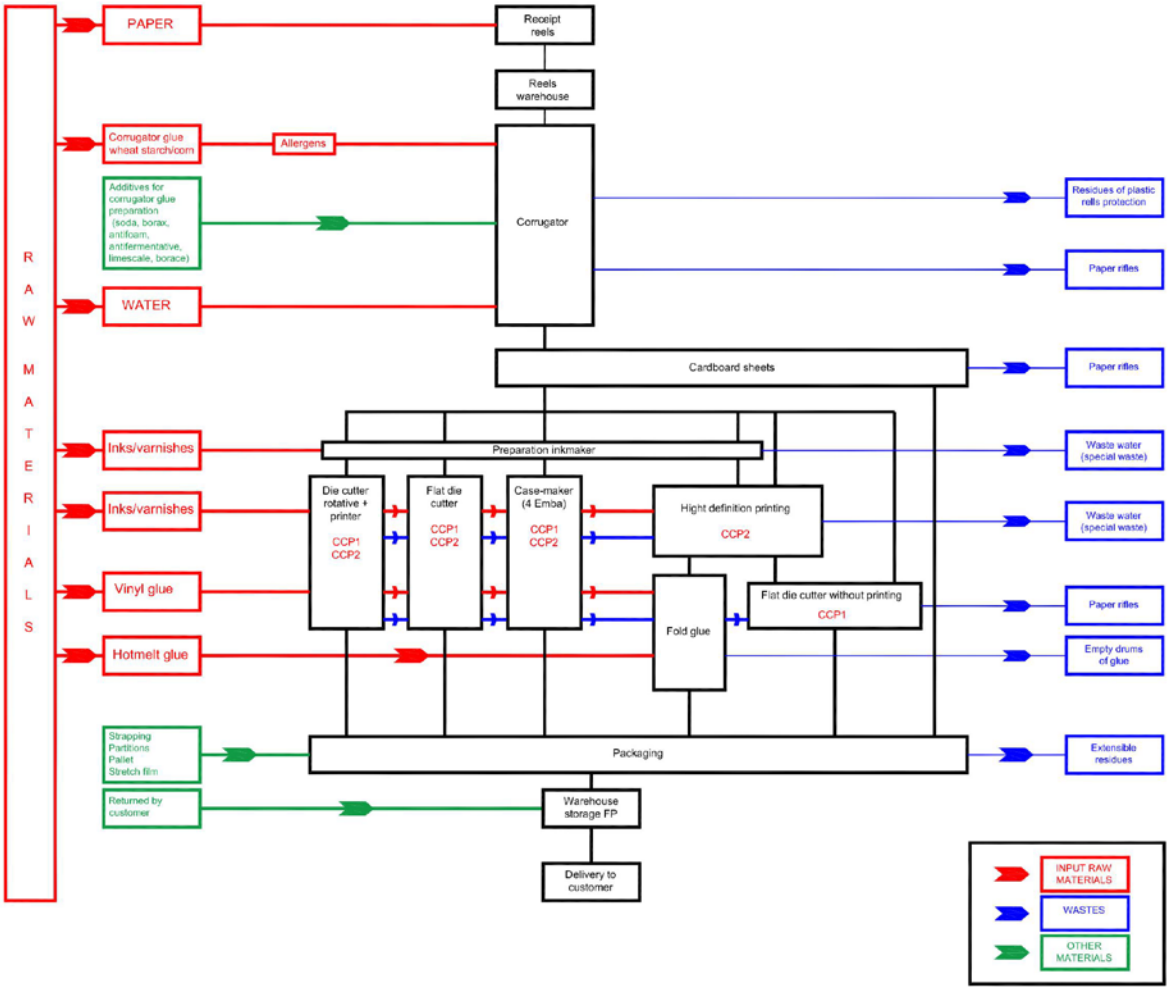

Figure 3 – Company process flow

From these rollers, the cardboard stacks can be transferred, via other conveyors, to the feeding lines of the department's converting machines.
Depending on the specific requirements, the semi-finished material can be stored "on the ground" using forklift trucks or sent to the strapping line.
In this phase, the corrugated sheet is converted into packaging by carrying out special operations such as printing and die-cutting.
The activity is carried out with the help of special transformation machines. Each transformation machine is nothing more than an appropriate sequence of "modules", each of which is used to carry out a specific operation.
By combining these modules in sequence, it is possible to configure the different processing machines to obtain products corresponding to the different customer requirements.

4.2 *Life Cycle Inventory* – LCI

Through the inventory of inputs (consumption) and outputs (emissions) associated with each phase of the life cycle, the consumption of raw materials, energy, water, etc. has been identified and quantified, as well as the different polluting emissions.
At the inventory stage, it was particularly important to assess the "quality" of the data, i.e. their validity, reliability, transparency and consistency. Primary data provided by both paper suppliers and the SADA Group were used. Databases had to be used for some raw materials (Ecoinvent 3.1).

The primary energy data of the suppliers and of SADA have been associated with Ecoinvent processes related in part to the Italian energy mix and in part to the photovoltaic production for the corrugated cardboard making activity. For the paper mills that provided primary data, both being Italian, reference was made to the Italian mix while the European mix was used for the others, as required by the Ecoinvent profiles used.
The environmental impacts related to transport have been included and calculated for paper suppliers through Ecoinvent processes, knowing the distance from the production site and the real transport modes.
Primary data was measured at the plant level, which required the use of allocation criteria.
The inventory was concluded with the identification of a multitude of items - related to the consumption of raw materials and pollutant emissions to air, water and soil. An impact assessment phase was then carried out, which made it possible to sort and structure the information provided by the inventory in order to provide understandable and comparable results to support the decision-making process.

4.3 *Impact Assessment* (IA)

At this stage, the potential environmental impacts associated with the identified inputs and outputs were assessed and their effects on human health and the environment analysed. It is the most critical phase as it has required classification, characterisation and aggregation of impacts.
The assessment of the different environmental impacts under analysis was carried out for the 8 different types of packaging made from different combinations of recycled paper over the defined life cycle and gave the detailed results in Figure 4 for each of the types of boxes considered in the study with an indication of the contributions relating to the upstream and core phases.

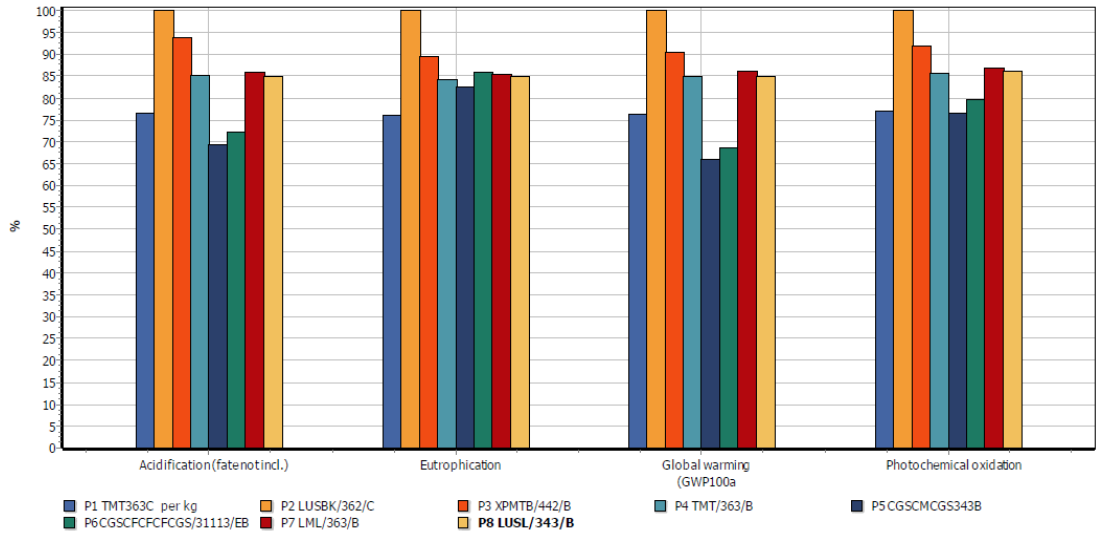

Figure 4 – Results of IA

The EPD 1.01 method (2013) was used to assess the environmental impact of Simapro in accordance with the objective of the study it requires to calculate:

- Climate changing gas emissions, as sum of GWPs, 100 years, in CO_2 equivalent.
- Emissions of acidifying gases, as the sum of the acidification potentials expressed as (SO_2) equivalents.
- Emissions of gases which contribute to the creation of ozone levels in ambient air as the sum of ozone-creation potentials C_2H_4 equivalent.
- Emissions of substances to water that contribute to the reduction of aquatic oxygen such as PO43-equivalents.

The most significant aspects of the study concern the production of raw materials that still have significant environmental impacts that cannot be eliminated and partly the energy consumption linked to the production phase of the boxes.
The use of raw materials of vegetable origin and deriving from recycling, on the other hand, makes it possible to reduce some impacts because non-renewable resources are not consumed and because in the growth phase of the plants and subsequently with recycling one of the main greenhouse gases (i.e. CO_2) is absorbed and stored. However, the impact of this storage has not been included in the calculation of the results, since for plants converted into paper and not recycled the re-issuing and short cycle is not included, for recycled paper and any by-products there are no unambiguous data on storage time.
It should be noted, however, that the accumulation of biogenic carbon in the product has been estimated by deriving, as a European average, from the study "Carbon Footprint of Cartons in Europe - Carbon Footprint methodology and biogenic carbon sequestration", IVL Swedish Environmental Research and Institut and is equal to 730 kg CO_2 equivalent per ton of product (Pro Carton, 2017).

4.4 *Interpretation Analysis*

The Interpretation Analysis was the last phase of the LCA study and was a systematic process for identifying, qualifying, verifying, and evaluating the information contained in the LCI and/or LCIA results and presenting it in a manner that meets the application requirements described in the study's objective and scope.
The adequacy of the model, based on completeness, sensitivity and consistency checks, conclusions, limitations and recommendations were also considered.
The aim is to provide an instrument to support the decision-making process, in order to make the necessary choices.
The study certainly confirmed the well-known advantages of using waste paper, in terms of sustainability, of which the main ones are outlined below:

- less waste to be incinerated or stored in landfills, which are costly methods to bear. The reuse of paper, even if not infinitely recyclable, allows to prolong the life of the raw material, using it for more products, and to delay in time the phase in which it becomes waste;
- less tree felling (deforestation) to produce paper. Waste paper is the production factor that enters the paper system as an input to replace wood pulp. However, this factor is less relevant if the paper comes from timber produced in Europe, where most forests are cultivated;
- there is a reduction in the impacts due to the extraction/obtainment of the raw material which could be linked to changes in land use, fuels and chemical agents used in the methods of cultivation or to the transport of the raw material from the countries of production (North Europe, America, Asia, on the other hand, recycling is mainly local.

However, the study shows that even more than the use of waste paper to reduce process emissions seems important:

- the reduction of processing waste given the significant impacts of materials from the upstream phase;
- energy generation technologies.

Given the significant amounts of heat and electricity consumed by the process, cogeneration is a technology that has proven to be beneficial, in particular when using efficient and low emission fuels.
The main limitations of the study are that the data are not uniform. It is therefore recommended to improve data collection by involving several providers. Furthermore, even if SADA were to be able to have data disaggregated by process and by product (e.g. quantity of paper used/waste by

product), a more detailed analysis and possible product-specific recommendations could be obtained.

5. Sustainability in R&D

The R&D and Marketing Department was created to respond to the innovation strategy desired by the management of the Sada Group.

A team of people has been created combining transversal skills in the fields of paper technology, corrugated cardboard, chemistry and marketing, with the aim of uniting the know-how of all the companies in a single group, to provide support to customers and transform requests and requirements into functional and innovative solutions.

It offers outsourcing for the realization of projects from the idea generation up to the implementation on the market working in collaboration with the customers also in the search for new materials, optimizations and new processes. Particular attention is paid to sustainability. The Department offers its customers its experience for all research, development and innovation activities. Develops new functional packaging design solutions that respond to customer needs, promotions and market trends.

In a highly competitive environment such as packaging, it is increasingly difficult to stand out from the competition. Corrugated cardboard packaging is evolving into an increasingly optimized packaging of shapes, also to meet the needs of versatility. The R&D Department of the Sada Group has understood these requests and has created Cornerless®, a patented and innovative packaging designed for the world of fruit and vegetables that fully exploits the surface, gaining in versatility and possibility of use. Excellent example of eco-design, compared to traditional trays is more competitive and sustainable.

Thanks to the original and simple forming system, it allows you to take advantage of countless advantages that are not found in similar types of packaging.

It is sustainable and competitive because there is less use of material than traditional trays thanks to its structure that allows you to use high-performance raw materials with light weights.

It is robust and offers exceptional performance. Thanks to its shape, it guarantees stability and resistance in terms of BCT.

It is versatile and contains more products inside. Since the entire surface area, including the corner spaces, can be used, even plastic trays with the most varied shapes can be used.

Allows "user friendly" stacking and great stability. The tooth that is created consists of two layers of cardboard that give great strength, ease of stacking and great stability during handling and storage.

It allows to have advantages both from an exhibition point of view and from an air circulation point of view thanks to its large opening.

In addition, thanks to the possibility of containing more workpieces, there is more production per pallet and therefore less handling in the warehouse.

The Sada Group, with its cutting-edge technologies and the latest generation in the sector, can print Cornerless® up to 7 colours. It is also possible to apply special finishes, barrier treatments and anti-wet varnishes. The project was managed in collaboration with manufacturers of assembly machines and assembly centres. Thanks to these collaborations, the prototype has been perfected and the technical skills have been increased with a better knowledge of processes and systems. Cornerless® also won 3rd place at the Best Practices Award for Innovation held in Salerno on 1 and 2 December 2016, and was awarded as best example of eco-design at the 2017 Packaging Oscar.

6. Discussion and conclusion

This paper, through the presentation of a case study, illustrates how a strategic approach oriented towards sustainability can create, in the long term, virtuous circuits in terms of productivity, competitiveness and image.

Indeed, there is now a widespread conviction that companies that achieve positive environmental and social results can only achieve better economic results

In particular, the results show how the affirmation of socially responsible behaviour opens new perspectives for organizations and, in particular, for companies that are increasingly called to take a leading role in a new economic scenario in which the realization of a widespread and lasting development is increasingly hoped for. A development based on wider sustainability, as it also extends to the environmental and social spheres. In fact, from a One Bottom Line approach to another of the Triple Bottom Line type (Elkington, 1997), we have moved on to highlight the transition from a purely economic reporting to another, which also takes into account the other two perspectives of sustainability, pursuing a joint maximization.

From this perspective, sustainability represents an approach aimed at creating value over the long term and extended to all stakeholders (not only shareholders, but also employees, customers, suppliers, lenders, communities, institutions, etc..), and based, above all, on the ability to seize all opportunities, but, at the same time, to manage the risks arising from the evolutionary dynamics that characterize the current scenarios.

The Group has succeeded in promoting corporate behaviour capable of effectively combining responsibility and competitiveness. First of all, they envisage an information and awareness campaign, able to highlight the potential and effects on competitive performance. This creates a stable, systematic and planned link between social and environmental commitment, stakeholder involvement and communicational enhancement of what has been achieved.

Its model of lean thinking to reduce waste during production, rationalize energy, limit consumption, recycle waste and improve corporate efficiency epitomizes Sada Group’s innovation process.

In its application dimension, a process aimed at sustainability has been implemented in the Group through a number of qualifying factors, such as:

- the sharing of values, mission and its own policy oriented towards sustainable development;
- the adoption of a training-intervention process, capable of implementing improvement actions through inter-functional projects involving employees through specific training and organisational communication paths;
- the development of an internal control system capable of monitoring both the achievement of the predefined objectives and any ethical risks, as well as verifying the implementation of commitments towards the stakeholders that the organisation has undertaken;
- the definition of key indicators capable of monitoring economic, social and environmental performance.

In conclusion, the process of responsible management enriches the process of improving the corporate culture, with the contribution of internal collaborators and the various external stakeholders:

- internally, through the virtuous process of strategic sharing and responsible co-planning, using communication and training to "contaminate" the organisation vertically and transversally and stimulate feedback flows;
- externally, through the creation of partnerships with stakeholders and therefore, as far as possible, with all stakeholders, whatever the title of the negotiating relationship with the organisation, in order to demonstrate the ability to understand and try to satisfy their needs, harmonising them, where possible, with those of the company.

Value creation is the product of dynamic inter-systemic interaction supported by values that determine responsible action and governance ability to create relationships with stakeholders based on projects and vision oriented to CS and values. Value creation is therefore linked to the ability to collect and share critical resources and create stable and reliable mutual benefits.

The implications for further research of our findings suggest that a culture of integrating economic, social and environmental objectives into business strategies and processes creates sustainable value, as our case study shows. Such sustainable management of the supply chain could inspire other companies to develop innovative ecological models of sustainable development.

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The value of the Multi-functional value of water in Taiwan

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Abstract

With continuous climatic change, droughts have begun to occur more frequently. In order for industrial sectors to secure a stable supply of water during the time of droughts, or to maintain the normal functions of industrial production lines, transfer of agricultural water has often been utilized. This will happen more frequently as the climates continue to change. There is a high possibility that continuous climatic change will affect the current water management operations. This study uses the Contingent Valuation Method (CVM) to evaluate the value of water including: 1)the willingness to accept of the Agricultural sectors to transfer water .2)the willingness to pay by the industrial sectors under climatic change to avoid the risk of water shortage. 3)The value of the Multi-functional value of agriculture water. Furthermore, if we transferring Agricultural water to industrial users, the multi-functionality function of the paddy may have lost, it is the loss of the entire society. In this study, we compare the Agricultural sector willingness to accept, the industry sector willingness to pay and the society willingness to accept by Contingent Valuation Method (CVM), to realize the inner value of Agriculture water by the Agricultural sector, the industry sector and the entire society. However, When the water transfer, the third party has very little protection due to the multiple functions of the environment being compromised by the regulations. This study could provide a basis for the proposition of a reasonable water transferring system, such that the transaction cost could be lowered, the interests of all water users could be promoted, and the efficiency of water utilization could be increased.

Keyword: Agricultural Water, the value of Water , willingness to accept, Water price, willingness to pay

Wastewater treatment using micro-algal consortium for sustainable water usage in rubber latex coagulation: In accordance with SDG 6.3

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Abstract

In a country like India, where the population is recorded at 1.3 billion and going through a phase of rapid urbanization, the number of people migrating to the urban areas is immeasurable and the amount of wastewater that is generated from various industrial activities is enormous. India is the 5th largest rubber producing country in the world. The states of Kerala and Tripura, accounts for maximum production of rubber in the country. Tripura, one of the north-eastern states of India has advantageous agro-climatic conditions for the cultivation of Hevea brasiliensis (rubber tree). The state's tropical monsoon type of climate and fertile soil properties makes it the second largest producer of rubber in the country after Kerala.

In the fiscal year 2015, the state of Tripura was accountable for the production of 37,277 million tons of rubber. (ENVIS Centre: Tripura State Pollution Control Board) An enormous amount of effluent is generated in the production of rubber from its latex. Due to the use of acidic additives in the latex coagulation, preservation and creaming process, the nature of the effluent generated is highly acidic. And because of the acidic nature of effluent, it also has the potential to cause harm to the aquatic flora and fauna. The extremely polluting nature of the effluent that is released into nature without any prior treatment has the potential to disbalance the environmental dynamics of the surrounding area.

This study incorporates the technique of using micro algae consortium in lowering down the pollutant's concentration in the wastewater. Results of this study has shown us that there is **54.8%** reduction in TDS, **23.7%** reduction in nitrite concentration, **34.7%** reduction in nitrate concentration, **19.91%** reduction in phosphate concentration and **33.4%** & **40.8%** reduction in COD & BOD load respectively.

1. Introduction

Tripura, one of the north-eastern states of India has advantageous agro-climatic conditions for the cultivation of *Hevea brasiliensis* (rubber tree). The state's tropical monsoon type of climate and fertile soil properties makes it the second largest producer of rubber in the country, after Kerala. In the fiscal year 2015, the state of Tripura was accountable for the production of 37,277 million tons of rubber (ENVIS Centre: Tripura State Pollution Control Board, 2016). An assessment report made by the Rubber Board and the National Bureau of Soil Survey and Land Use Planning, 2015 suggested that Tripura has the potential of cultivating rubber in an area approximately around 100,000 hectares. Henceforth, in the recent times; Tripura has seen a rapid growth of the Rubber Processing Societies (RPS) and Rubber Parks (RP), which as a result has brought in derived economic benefits to the state.

Rubber industry is economically one of the key industries as it feeds other industries with its output, mainly construction and automobile industries (Gowda and Mayya., 2016). Because of the rapid increase in the number of rubber industries in Tripura, the state has seen a significant growth in its economy. However, despite the economic benefits, the rubber processing industries generate ample amount of effluent with high concentration of nitrogen and phosphate that may lead to undesirable eutrophication. (Mohammadi *et al*., 2010)

Due to the use of acidic additives in the latex coagulation, preservation and creaming process, the nature of the effluent generated is highly acidic. And because of the acidic nature of effluent, it also has the potential to cause harm to the aquatic flora and fauna. The untreated wastewater that is discharged from the rubber industries usually contains a very high concentration of Chemical Oxygen Demand (COD), Biochemical Oxygen Demand (BOD), total dissolved solids (TDS) and total suspended solids(TSS) that change the chemistry of the aquatic ecosystems and has detrimental effects on the surrounding water bodies. Higher level of BOD and COD can lead to fish kills and anaerobiosis because it depletes the dissolved oxygen. Thus, the release of rubber wastewater to the environment without prior treatment has the potential to cause serious and protracted consequences.

The study incorporates Sustainable Development Goal (SDG) 6.3[1] laid down by the United Nations. An enormous volume of water is required as a raw material in the production of

[1] SDG 6.3: By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing the release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.

commercial rubber from latex. Therefore algal bioremediation treatment gives us a potential solution to lower down the concentration of COD, BOD, TSS and TDS to the safe disposal standards lodged down by the Central Pollution Control Board (CPCB) and can also reuse the same water for sustainable usage in rubber latex coagulation (Asia and Akporhonor., 2007).

Algae cultures give us a riveting step in wastewater treatment, as the process of bioremediation exploits the metabolic potential of algae in cleaning up the environment. In this study, a microalgal consortium has been used to treat the effluents from the rubber processing industries with an objective to contribute in achieving SDG 6.3. Algae due to their ability to use inorganic nitrogen and phosphorus for their growth remain a potential solution in treating wastewater with high nitrogen and phosphorus concentration. It also has the property of removing heavy metals and toxic organic compounds hence do not contribute to secondary pollution. Algae being a phototroph can grow in the wastewater without a carbon source and its photosynthetic activities release oxygen in the wastewater thus lowering down the COD and BOD load. Consequently, microalgae cultures can be used as a potential solution for treatment of wastewater to reduce pollution in the surrounding water bodies.

2. Research objectives

The purpose of the present study is to characterize all the parameters in initial wastewater and algae treated wastewater and to compare the concentration of the possible pollutants (pH, TSS, TDS, ammoniacal nitrogen, nitrite, nitrate, dissolved phosphate, COD and BOD) with the CPCB standard for sustainable water usage in rubber latex coagulation.

3. Research methodology

3.1 Sample collection

The rubber wastewater sample was collected from the effluent disposal site of the rubber processing unit at the rubber processing society in Jalabasa, Tripura.

The wastewater sample that was collected was generated from the coagulation tray in the rubber processing unit.

3.2 Sample preparation

Previously isolated and acclimatized microalgal consortium was used for the wastewater treatment (i.e. 20% inoculum in 60% rubber wastewater). Similarly, a negative control of 60% rubber wastewater was incubated along with the algal culture in Thermo Scientific

shaker. Incubation conditions: 100ml sample in a 250ml conical flask at 28°C for two weeks with 100 rpm rotational speed and 3000 lux intensity of white fluorescent light. All the parameters were checked for the negative control and the algae treated wastewater after an incubation period of two weeks.

To ensure growth of the algal strain, cell count, optical density (OD) and pH were measured on the 1st day of incubation and after two weeks of incubation. Cell counts were taken using haemocytometer, OD was measured using the spectrophotometer and pH was measured using pH meter (WTW inolab).OD at 680 nm was measured for intensity of chlorophyll and OD at 750 nm was measured for turbidity.

3.3 Characterization of parameters

All the protocols used to quantify the parameters in the rubber wastewater samples are in accordance with the American Public Health Association (APHA) norms. All the chemicals used for preparation of reagents and carrying out the experiments are manufactured by HI MEDIA, India.

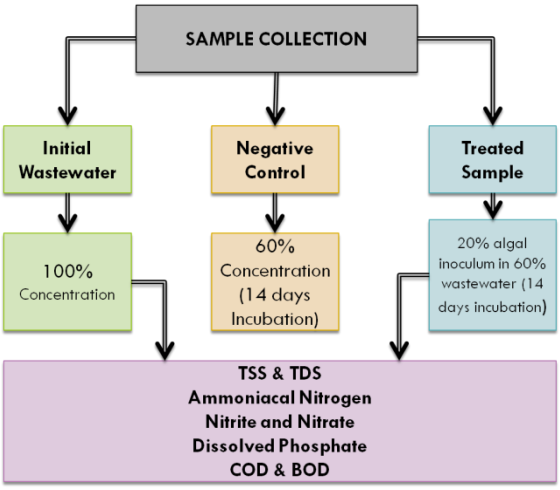

Figure 1 Schematic diagram of the research approach

4. Results and discussion

The dynamics of cell count, OD and pH of the algal culture are presented in Table 1. Characterization of several parameters was done and the results obtained after characterizing all the parameters for raw wastewater, negative control and algae treated wastewater are presented in Table 2.

The study aims at carrying out a comparative analysis of the untreated and treated wastewater with the standards laid down by CPCB.

Table 1: Dynamics of algal cell count, OD and pH at first day and after two weeks of incubation.

Day	Cell count	Optical density @ 680nm	Optical density @ 750nm	pH
1st	**80*10^4 cells/ml**	**2.872**	**2.114**	**7**
14th	**184*10^4 cells/ml**	**3.286**	**2.590**	**10.05**

Table 2: Physiochemical and organic characteristics of the effluent before and after algae treatment (after 14 days of incubation)

Parameter	Initial concentration in 100% wastewater	Concentration in negative control	Concentration in algae treated wastewater	CPCB standard
pH	4.71	7.09	**10.05**	6-9
Ammoniacal Nitrogen (mg/L)	7.80	10.90	**11.50**	50
Nitrite (mg/L)	27.30	23.63	**18.05**	1
Nitrate(mg/L)	1.09	0.98	**0.64**	10
Dissolved phosphate (mg/L)	16.46	10.30	**8.25**	5
COD (mg/L)	11,600	7200	**4800**	250
BOD (mg/L)	161	93.6	**55.5**	50
TDS (mg/L)	15260	6280	**2840**	2100
TSS (mg/L)	1030	890	**2970**	100
Dissolved oxygen (mg/L)	6.20	4.77	**9.16**	-

Highly polluted wastewater that is generated in the production of commercial rubber is an inevitable by-product of rubber processing units and is extremely harmful to the environment if released without being treated. Thus, wastewater treatment is a necessary measure to

safeguard the surrounding environment. We have seen that after an incubation period of 14 days, the microalgal consortia in rubber wastewater has the potential to lower down the pollutant's concentration. (Table2)

4.1 TSS and TDS

In comparison to the negative sample, the TDS concentration in the algae treated wastewater has decreased and the TSS concentration, however, has increased (Figure 2). After an incubation period of two weeks, the TDS concentration in the sample has decreased by 3440mg/L. Thus the microalgal consortium remediates the TDS at an average 245.7mg/L/day. However, the TSS concentration has increased because of the growth of the algal biomass. The difference between the concentration of TSS in the negative control and in the algae treated wastewater is attributed to the algal biomass production i.e. 2.08g/L. The reduced concentration of TDS after microalgal treatment also reduces the pollution level and with further incubation time, it would be possible to bring down the concentration of TDS to the safe disposal limit.

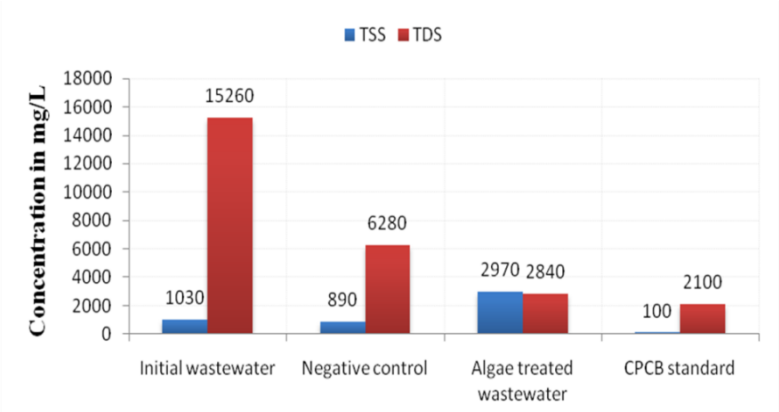

Figure 2. Graph showing comparison in TSS and TDS concentration with incubation time.

4.2 Ammoniacal nitrogen, nitrite and nitrate

Significantly unique and a particular relation in case of ammoniacal nitrogen, nitrite and ammonia was observed (Figure 3). In the initial wastewater, ammonia concentration is quite low as compared to the nitrite concentration. The reason is that the initial pH of the wastewater was very acidic around 4.71 and at such a low level of pH, free ammoniacal nitrogen gets dissolved into ammonium ion. In initial wastewater, nitrite concentration is higher than the ammoniacal nitrogen and nitrate concentration which may be attributed to the presence of nitrifying bacterias. However, in the algae treated wastewater, the ammoniacal nitrogen concentration has increased due to algal growth which raises the pH (Table 2).

Despite increasing ammoniacal nitrogen concentration; it is still well under the specified limit.

In comparison to the negative control, the nitrite and nitrate concentration has been seen to decrease in the algae treated wastewater. Algal growth suppresses the activity of the nitrifying bacteria; hence the ammonia present could not get oxidized to nitrite. Algae rather than spending energy in converting ammonia to nitrite, utilizes the available nitrite and nitrate for their growth, accounting for their low concentration in the algae treated wastewater. Ammonia and nitrate concentration are seen to be well under the specified limit, whereas the nitrite concentration showed declining trend. With further incubation time, it would be possible to bring down the nitrite concentration to the permissible level for safe disposal.

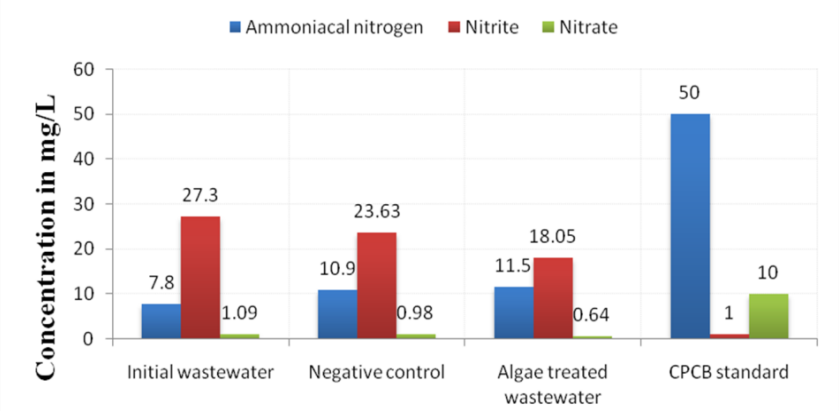

Figure 3. Graph showing comparison in ammoniacal nitrogen, nitrate and nitrite concentration with incubation time.

4.3 Dissolved Phosphate

The phosphate concentration has decreased in the algae treated wastewater as compared to the negative control. A reduction in 2.05 mg/L of dissolved phosphate can be observed (Figure 4). Reduction in the phosphate level indicates that the algal strain has degraded inorganic constituents present in the wastewater. Phosphorus is a necessary element in the algae growth system especially in nucleic acid component and hence the concentration is seen to be decreasing, as the algal strain utilizes it for their growth.

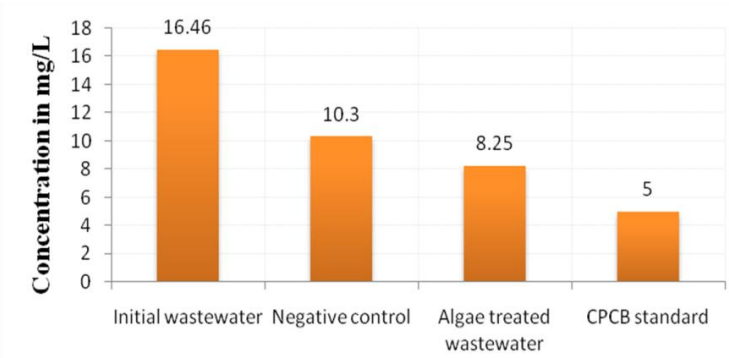

Figure 4. Graph showing comparison in dissolved phosphate concentration with incubation time.

4.4 COD and BOD

In comparison to the initial COD and BOD concentration, the concentration of the algae treated wastewater has significantly declined (Figure 5 and 6). In an incubation period of two weeks, the COD concentration has come down from 7200 mg/L to 4800 mg/L i.e. 2400 mg/L or 33.33% reduction. Therefore, it may be inferred that the algal consortia degraded 171.42 mg/L/day of organic matter through chemical oxidation. It was also observed that the BOD concentration has decreased significantly. Hence, the algal consortia used for wastewater treatment releases enough oxygen for bacteria to break down 38.1 mg of organic matter in 14 days. The decrease in the concentration of COD and BOD is the reflection of reduction of pollutants in the treated effluent that may be reused after additional treatment or can safely dispose off for sustainable environmental management.

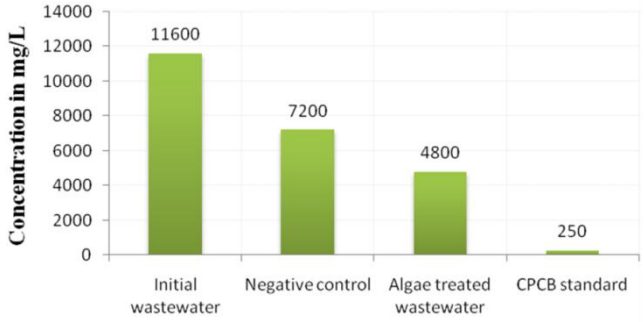

Figure 5. Graph showing comparison in COD with incubation time.

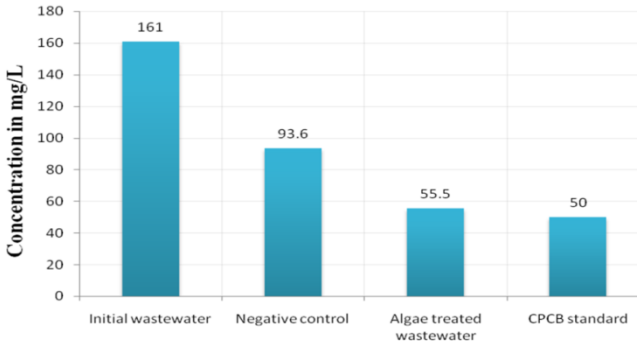

Figure 6. Graph showing comparison in BOD with incubation time.

4.5 pH and dissolved oxygen (DO)

The pH of the effluent changed from 4.71 to 10.05 i.e. from acidic to alkaline (Figure 7).Algae through photosynthesis utilize the CO_2 present in the environment and hence make

the pH basic in nature. When CO_2 breaks down in water, it forms carbonic acid. Carbonic acidity has the ability to lose two H^+ ions and hence can make the water acidic. Removal of CO_2 from wastewater by algae thus changes the pH to alkaline.

As observed, the DO concentration has increased in the algae treated wastewater as compared to the negative control (Figure 8). Algae take up carbon dioxide and release oxygen as a by-product of photosynthesis. As a result, the dissolved oxygen in treated wastewater has increased indicating an improved aquatic chemistry.

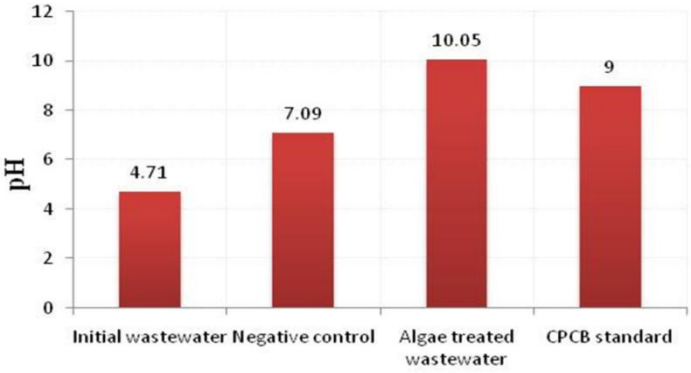

Figure 6. Graph showing comparison in pH with incubation time.

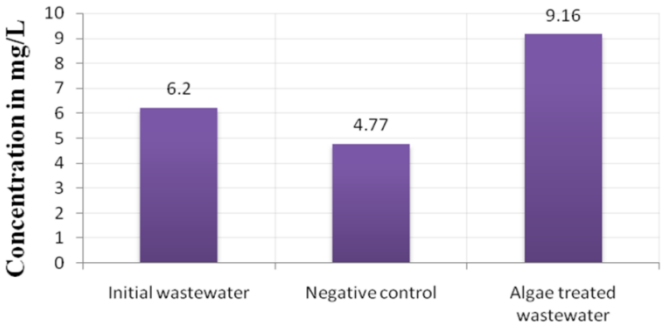

Figure 7. Graph showing comparison in DO with incubation time.

5. Conclusion

In this study, it has been observed that a huge quantity of water is needed as a raw material for the processing of commercial rubber and the enormous amount of untreated effluent that is generated thereafter shows detrimental effects towards the environment. As a consequence of which, the ground water table in the surrounding areas has started to show deteriorating trends. The release of the effluents from rubber processing units into public water bodies can bring about the depletion of DO and therefore ends up in disturbing the ecological balance. Due to the rising concern of minimalizing waste to prevent the possible harm to human health and environment, treatment of waste in all forms is of utmost importance. Thus, this study incorporated the scientific knowledge and technique to use micro algae consortium for the treatment of rubber wastewater by bringing down the concentration of the pollutants to the safe specified limit for either its disposal or its reuse. Bioremediation thus is the most environment-friendly and effective treatment to lower down the concentration of pollutants in wastewater. In this study, we analyzed the effluent quality data before and after the treatment with algae. The result that is obtained can also be used in reference to the baseline data to

assess the undeniable pollution load in the neighboring areas. Through this study, we tried to assess 10 parameters that are responsible for causing water pollution. The result obtained shows us that the concentration of 4 out of the 10 parameters after algae treatment has lowered down to the safe disposal limit given by CPCB. As mentioned earlier, the rest 6 parameters have shown decreasing trends in their concentration and with a longer incubation time for the algal strain, the concentration of these parameters will presumably come down to the specified limit.

It is noteworthy to mention that, from the results of the present study we can hypothesize that once the algal consortia that is used in the present study is identified, it can effectively be used for the treatment of effluents from rubber processing industries at the pilot scale. However, it is a known fact that the growth cycle and activity of algae is a complex process and understanding its mechanism is exceedingly important.

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An Assessment of Community-Based Tourism in Sagada, Mt. Province

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Abstract

The study was conducted to examine the capabilities of Sagada in the development of its destinations and the assessment of Community-Based Tourism through practices of sustainability development. Mixed method approach was used determine the locals' level of agreement on the positive and negative implications of Ecotourism in Sagada in terms of economic, environmental, and socio-cultural indicators. As well as determine the community's involvement and awareness in their tourism industry. The results show the sustainability of the community based tourism in Sagada utilizing the three parameters of sustainability namely, economic, environmental and socio-cultural. For the economic aspect, community-based tourism generates income for the locals through small establishments and enterprises. For the environmental aspect, ecotourism helps in the preservation and protection of their environment as well as it raise awareness of its importance. Lastly for the socio-cultural aspect, community-based tourism helped locals maintain and preserve their accustomed traditions and practices despite of the annual increase of tourist arrivals.

Introduction

Tourism can be a commitment to the sustainable development of an area. It adds to the economic status of the area as a result of the wide variety of services it can give to people, for example, work in the lodgings, travel agencies, and different offices around the traveler spot. The tourism business gives openings for work to the general population. As indicated by United Nations, the tourism industry that advances environment protection is a huge supporter to the socio-economic profile of the country or the area. Tourism additionally has been capable in maintaining the quality of environment and to guarantee the arrangement of satisfying experiences for visiting tourists. Ecotourism is the protection of the environment and the preservation of the natural resources. It is

likewise respecting the way of life of the place and not exploiting its resources. Ecotourism is a wonder wherein it will extraordinarily influence the sustainable development of the area in view of the indicators it can achieve, which are the economic, socio-cultural, and environmental indicators.[3]

According to Goodwill & Santilli, community-based tourism is a type of tourism wherein the locals of the community are the ones who manage and own the tourism services and products they offer to the general public.[4] Sagada was the chosen locale of the study since Sagada obtained nationwide popularity through the film entitled "That thing called tadhana" that hit theaters last 2014, now faces severe tourism problems because of the sudden influx of tourists in the area. In which according to Tracey Santiago, head of secretariat of the International Council on Monuments and Sites (ICOMOS) Philippines, the locals are trying to formulate a sustainability master plan that will help them determine the availability of accommodation and balance the carrying capacity in order for the municipality to accommodate the tourist arrivals without deteriorating Sagada.[2]

To be able to let future generations experience and see the beauty of a destination, sustainability is needed. The study was conducted to assess the community- based tourism of Sagada. The researchers determined the locals' level of agreement on the positive and negative implications of Ecotourism in Sagada in terms of economic, socio-cultural, and environmental indicators which is the basis for sustainability.

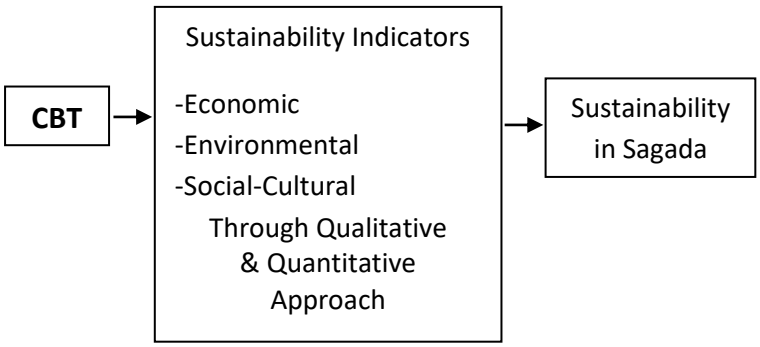
Theoretical Framework

Social Exchange Theory was used as the theoretical framework of this study. The theory outlines how relationships must be beneficial and reciprocal in order to work and be sustainable.[1] This theory will be a way to help broadly explain and predict how individuals and social groups interact with one another when exchanging goods or services. Furthermore, there is a formula for predicting one's behavior for a certain situation which is:

Behavior (profits) = Benefits of interaction – Costs of interaction

It means that the behavior of a person is determined by the benefits a person could get from another. If the cost of interaction between two people outweighs the benefits, the relationship will most likely to end.

Conceptual Framework



This research is tied in with investigating the tourism business of Sagada, Mt. Province, concentrating on the industry's present status. The conceptual framework determines the sustainability of the community based tourism in Sagada using the three sustainable parameters which are economic, environmental and socio-cultural. It is done through both quantitative and qualitative approach.

Methods

Mixed method approach is comprised of both qualitative and quantitative research. The process of data gathering is done through conducting surveys and interviews. It is done through collecting, analyzing and evaluating the data gathered from the target respondents. The survey questionnaires are composed of 52 questions in total. It is divided into 2 categories which is the positive and negative impacts of Ecotourism. Under the following categories are the indicators used in this study which are economic, environmental, and socio cultural. Data was obtained in the municipality of Sagada. The researchers made use of simple random sampling wherein every member of the municipality has an equal probability of being chosen. Weighted mean and percentage distribution was used for the statistical treatment of data.

Sample and Sampling Technique

The chosen respondents for the study are the local community of Sagada and their executive secretary. They were the chosen respondents as they are the ones involved in the community-based tourism in Sagada. Simple random sampling technique was used for the collection of data through quantitative data. In which it is defined as in a statistical population, one has an equal chance of being chosen.

Research Instrument

The study used survey questionnaire as research instrument. The first part of the questionnaire is all about the demographic profile of the respondents which are the locals of Sagada. This includes the gender, age, civil status, occupation and their place of occupation. The second and third part of the questionnaire was about the positive and negative impacts of Ecotourism in the municipality. The respondents checked the box based on a 4 point Likert Scale. It is both divided into four categories which are the parameters of sustainability namely, economic, socio-cultural and environmental aspects.

The researchers also conducted a pilot testing survey to the persons who have already visited Tagaytay through survey sheets which had questions in English and were translated into Filipino. The pilot survey used the four-point Likert scale where the choices were four, three, two, and one, corresponding to strongly agree, agree, disagree, and strongly disagree respectively.

Data Collection

The researchers utilized a validated survey questionnaire that was distributed among the local people of Sagada who takes an interest in the community-based tourism ventures with respect to their degree of their participation in various tourism and environmental exercises, and their contribution in community-based projects. The survey questionnaire was translated into Filipino for the local people in Sagada to

easily comprehend and answer. The Executive Officer of Sagada helped the researchers upon gathering information and as well as to lead the survey conduction.

Statistical Treatment of Data

Mode, percentage and frequency were the statistical tools that were used. Mode was the first tool used and was the value that frequently appeared on the set of data. The second tool is percentage which was the alternative way of having proportion. Percentage was a hundred times of the proportion. Multiplying the proportion to 100 will equal to percentage. Frequency was the last tool used; it was used to describe the different types of variables.

Furthermore, to achieve reliable and valid results, the following statistical tools were used:

1. Mode. It shows and interpreted the result on to what level does the local community agrees regarding the sustainable community-based tourism in Sagada, Mountain Province.

RANGE	VERBAL INTERPRETATION
3.25 - 4.00	Strongly Agreed
2.50 - 3.24	Agreed
1.75 - 2.49	Disagree
1.00 – 1.74	Strongly Disagree

2. Frequency. This method was used when different variables have many values in the study. It was used to create a frequency table to produce the statistics of continuous and huge variables summary which also includes the categorical variables.

3. Percentage. This showed the rate of each variable.

The statistician also provided the formula to determine the number of respondents needed for the study.

For unknown proportion use p= .5

$$\frac{n \geq (Z_{\alpha/2})^2}{4E}$$

$(Z_{\alpha/2})^2 \longrightarrow$ reliability factor

$4E \longrightarrow$ margin of error

$\alpha = .05$

$E = .05$

$$\frac{n \geq (Z_{.05/2})^2}{4\,(.05)^2} = \frac{(1.96)^2}{4\,(.0025)} = 385 \text{ respondents}$$

Results

ECONOMIC ASPECT

3.14 - mean of the positive economic impacts

- Generates income for the locals through small establishments and enterprises
- It increased various handicrafts and souvenirs that are sold for the tourists inside Sagada.

2.98 - mean of the negative economic impacts

- It increased the number of vehicles inside the municipality and their cost of living.
- It makes house rentals, price of locally produced goods and commodities sold in local shops expensive.

There is a significant difference on the locals' level of agreement on the positive and negative implications of Ecotourism in Sagada in terms of economic indicator. The mean of the positive economic impact is 3.14 and the negative economic impact is 2.98. It indicates that the mean for positive economic impact is higher than the negative economic impact of Ecotourism in Sagada. The local community agreed that Ecotourism has more positive economic impact than the negative. It has greatly affected the increase of income and livelihood of the locals through small establishments and enterprises. It also increased various handicrafts and souvenirs being sold for the tourists in the destination. Furthermore, the practice of community-based tourism in Sagada brought a great number of tourists and provided job opportunities for the locals that cater to the tourism industry for of Sagada. Moreover, it also improved the locals' income in order to sustain their needs despite of being a 5th class municipality.

ENVIRONMENTAL ASPECT

3.12 – mean of the positive environmental impacts

- Helps the Municipality to be aware of the importance of their natural environment.
- Helps the Municipality to preserve and protect their natural environment.
- Raises the awareness of people about Sagada's carrying capacity.
- Raises the awareness of people on the proper disposal of solid waste.

3.04 – mean of the negative environmental impacts

- Increased air pollution.
- Increased noise inside the municipality.
- Makes the municipality surrounding dirty.
- Destroys the natural environment.

The results of the environmental impacts show that the mean of the positive impacts is a bit higher than that of the negative impacts. Even so, it is still in the range of three. The numbers show that there is no significant difference between positive and negative impacts. No significant difference means that the weight or effect of both negative and positive impacts balance each other out. The reason as to why that is, is because as negative impacts are inevitable in the environmental aspect of tourism, locals find ways to counter these effects.

SOCIO-CULTURAL ASPECT

3.08 – mean of the positive socio-cultural impacts

- It opens employment and livelihood for women.
- It provides part-time job for students
- It helps the Municipality to have a sense of pride of their culture.
- It increased the settlement of people in the municipality.
- It decreased urbanization.
- It helps the municipality to have a better health service.

2.55 – mean of the negative socio-cultural impacts

- It increased crime rate.
- It destroys the local custom and culture.
- It adapts based on the tourists demands.
- The culture clash between the tourists and locals is evident.
- Ecotourism as an avenue for local cultures to be perceived as commodities.
- The number of child labour rises.
- Changes in cultural products and festivals.

There is a significant difference on the locals' level of agreement on the positive and negative implications of ecotourism in Sagada in terms of socio-cultural indicator. The mean of the positive socio-cultural impacts which is 3.08 is very much higher to the mean of the negative socio-cultural impacts that is 2.55. Based on the locals of Sagada's answers, they agree that there are more positive socio-cultural impacts of ecotourism than of its negative socio-cultural impacts. Some of these positive impacts are it opens employment and livelihood for women, it provides part-time job for students, it helps the Municipality to have a sense of pride of their culture, it increased the settlement of people in the municipality, it decreased urbanization, and It helps the municipality to have a better health service.

Discussion

The results of the survey have shown that the locals of Sagada agreed in all three (3) aspects of sustainability parameters both positive and negative effects. Moreover, economic and socio-cultural aspects both have significance difference while the environmental aspect has no significant difference.

For economic aspect, the community-based tourism in Sagada brought an influx of tourist and provided job opportunities that are related in the tourism industry for the local community. It also increased the locals' income in order to sustain their needs despite of being a 5th class municipality. For the socio-cultural aspect, the community-based tourism in Sagada helped locals maintain and preserve their accustomed traditions and practices despite of the annual increase of tourist arrivals. Sagada even implemented an ordinance with regard to the filming of their sacred rituals in which the tourists should ask permission and secure a permit first to the municipal office. For the environmental aspect, the community-based tourism in Sagada both has positive and negative impacts. It means that although they have environmental related programs to protect the biodiversity of Sagada, degradation of the environment is still inevitable because most of the tourist

destinations that can be in the municipality are all in a natural setting.

Therefore, the practice of sustainability of community based tourism in Sagada has a significant factor in the perception of the locals. The three main indicators used in this study which are economic, environmental, and socio cultural determined the perception of the locals when it comes to the sustainable development of CBT in the destination. Furthermore, the assessment of the locals' perception on CBT resulted from analyzing that there has been a huge impact in the increase of tourist arrivals, preservation on cultural and ritual activities and conserving the biodiversity. Moreover, focusing on the sustainability of CBT will lead into achieving the well-being of the destination as it plays a major contributor in benefiting the local community and the local government as well.

In line with the data gathered, the researchers suggests for a creation of project initiated by the local government of Sagada to conduct monthly gatherings that require the presence of locals to address their concerns regarding their tourism industry and for the local government to raise the awareness of tourism in their community and come up with a tourism action plan that will further help the sustainability of Sagada, Mountain Province.

The researchers have concluded that among the three indicators that determine the implications of ecotourism in Sagada, economic and socio-cultural both yielded a significant difference. Locals agreed that there are more positive effects of ecotourism than negative based on the economic and socio-cultural aspect. While the environmental indicator on the other hand yielded no significant difference as locals agreed that both negative and positive effects of ecotourism are balanced.

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