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Editorial

The OPA being the apex body of 52 professional member Associations catering to 34 disciplines with a total membership of more than 60,000 professionals could & should make a huge & immense contribution towards recovery & stability of our motherland out of current worst crisis since its independence in 1948.

The OPA Journal provides a creative platform for professionals in OPA & member associations to engage in scientific communication based on their expertise and professional experience. This year we are privileged to present articles covering a wide range of areas such as Supply Chains, Medical, Education, Economic, Science, Health, Cyber Security, Geology, Textile Technology, Human Resource Management, Energy, Geo-Politics etc. OPA Journal thus provides ideal platform for all readers to widen their spectrum of knowledge.

I must acknowledge the commitment & dedication of all members in OPA Publication Committee with sincere gratitude & appreciation, who extended their contribution to formulate the "OPA Publication Policy" & subsequent process for timely publication of OPA Journal during this year. We will encourage all authors to work to the standards & guidelines stipulated in OPA Publication Policy & such emphasis on methodological rigor is vital to ensure that conclusions reached from publications contained in the journal are valid and reliable.

Blind review process remains a vital component of our assessment of submitted articles. There is strong consensus that accepted articles are often improved by blind reviews and criticisms are dealt with; this explicit appraisal process also helps to engender trust of the reader. On behalf of OPA, I would like to convey our sincere thanks & appreciation to all professional reviewers who extended an enormous service to accomplish the review process within the stipulated timelines. The paper journal remains popular amongst readers, and it will remain the core output. However, the use of electronic media is now a vital component of dissemination, providing a vehicle for wider international access to download selected publications, encouraging debate etc.

I will fail in my duty, if I do not mention about the excellent & cordial guidance & assistance extended by President OPA, President Elect OPA, Immediate Past President, General Secretary, all Office Bearers & also Center Director with all staff for their cooperation extended to the Publication Committee.

The OPA Journal with the online availability & higher dissemination will create an ideal platform to provide evidence-based solutions & discuss on innovative approaches to find sustainable solutions for national issues.

Maj Gen Renaka Udawatta (Rtd)
Editor-in Chief
OPA Journal

Cultivating Prosperity in Sri Lanka: Tracing the Impact of the Fruit Supply Chain on Rural Development

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Abstract

Sri Lanka's fruit supply chain holds immense potential for driving rural development, yet it faces various challenges that hinder its full realization. This study examines the current state of the fruit supply chain in Sri Lanka, analysing its structure, key actors, and the challenges and opportunities it presents for rural communities. The research utilizes a mixed-methods approach, combining quantitative data analysis with qualitative insights from secondary data sources. Key findings reveal that post-harvest losses, limited access to technology and markets, and inadequate infrastructure pose significant challenges to the efficiency and sustainability of the fruit value chain. Smallholder farmers, who dominate the sector, often lack the resources and knowledge to adopt improved practices and access profitable markets. However, the study also identifies several opportunities for enhancing the value chain, including investing in post-harvest infrastructure, promoting value addition and processing, strengthening market linkages, and empowering farmers through training and support services. The study concludes that a holistic approach is required to unlock the full potential of the fruit supply chain for rural development in Sri Lanka. This involves addressing the identified bottlenecks, promoting sustainable agricultural practices, and fostering a conducive policy environment that supports the growth of the sector. The findings of this research offer valuable insights for policymakers, development practitioners, and other stakeholders to design and implement effective interventions that can enhance the livelihoods of rural communities and contribute to the overall economic development of the country.

Keywords: *Fruit supply chain, rural development, post-harvest losses, market access, smallholder farmers, value addition, sustainable agriculture.*

Introduction

Sri Lanka, an island nation renowned for its agricultural heritage, boasts a thriving fruit sector that plays a crucial role in both domestic consumption and export markets (EDB Sri Lanka, n.d.). The country's diverse climatic conditions and fertile soils enable the cultivation of a wide variety of fruits, including bananas, pineapples, mangoes, and other tropical delights. However, the fruit supply chain in Sri Lanka, encompassing everything from cultivation and harvesting to processing, distribution, and consumption, faces unique challenges and opportunities that significantly impact rural development. The complexity of the fruit supply chain is evident in the multiple stages involved, each with its own set of hurdles. Post-harvest losses due to inadequate handling and storage practices, limited access to modern technology and infrastructure, and the need to comply with stringent quality standards for domestic and export markets pose significant challenges (Wanninayake et al., 2018). Moreover, the dominance of small-scale farmers in Sri Lanka's fruit production sector adds further complexities, as they often lack the resources and bargaining power to navigate the market effectively.

Despite these challenges, the fruit supply chain also holds immense potential for driving rural development in Sri Lanka. It serves as a vital source of income and employment for rural communities, contributing to poverty reduction and economic growth (Perera & Jayawardena,

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2016). Additionally, the development of infrastructure and logistics networks associated with the fruit supply chain can improve connectivity and access to markets for rural areas, thereby fostering broader socioeconomic development.

The complexity of the fruit supply chain is evident in the multiple stages involved, each with its own set of hurdles. Post-harvest losses due to inadequate handling and storage practices, limited access to modern technology and infrastructure, and the need to comply with stringent quality standards for domestic and export markets pose significant challenges (Wanninayake et al., 2018). Moreover, the dominance of small-scale farmers in Sri Lanka's fruit production sector adds further complexities, as they often lack the resources and bargaining power to navigate the market effectively.

Despite these challenges, the fruit supply chain also holds immense potential for driving rural development in Sri Lanka. It serves as a vital source of income and employment for rural communities, contributing to poverty reduction and economic growth (Perera & Jayawardena, 2016). Additionally, the development of infrastructure and logistics networks associated with the fruit supply chain can improve connectivity and access to markets for rural areas, thereby fostering broader socioeconomic development.

Understanding the intricacies of the fruit supply chain and its impact on rural development is essential for designing effective policies and interventions. This research aims to investigate into the various aspects of the fruit supply chain in Sri Lanka, examining its strengths, weaknesses, and potential areas for improvement. By identifying the key challenges and opportunities, this study will provide valuable insights for stakeholders to enhance the efficiency, sustainability, and inclusiveness of the fruit value chain, ultimately contributing to the overall development of rural communities in Sri Lanka.

The research adopts a mixed-method approach, combining quantitative data analysis with qualitative insights from of secondary data sources to investigate the fruit supply chain in Sri Lanka and its implications for rural development. The study will draw upon existing literature, reports, and publications from government agencies, research institutions, and international organizations, as well as relevant media articles and online resources. Through thematic analysis of this data, the research will identify key trends, challenges, and opportunities within the fruit value chain, with a particular focus on its impact on rural livelihoods, employment generation, and economic growth.

Research Problem, Question, and Objectives

Research problem: Sri Lanka's fruit supply chain, while brimming with potential due to the country's diverse fruit cultivation and growing global demand, is hindered by several significant challenges. These include high post-harvest losses due to inadequate infrastructure and handling practices, limited access to technology and markets for smallholder farmers, quality issues, and fragmentation throughout the value chain. These issues not only constrain the sector's ability to contribute to rural development and economic growth but also pose a threat to food security and nutritional intake within the country. Additionally, the lack of a comprehensive national fruit policy and weak coordination among stakeholders further exacerbate these challenges, necessitating a thorough investigation and innovative solutions to unlock the full potential of this vital sector.

Research question: How can Sri Lanka's fruit supply chain be optimized to enhance rural development, considering challenges such as post-harvest losses, limited market access, and inadequate infrastructure, while capitalizing on opportunities like value addition and diverse fruit cultivation?Research objectives: This study aims to analyse the current state of the fruit supply chain in Sri Lanka.identifying key bottlenecks and opportunities for enhancing

its contribution to rural development. It seeks to understand the structure and actors within the value chain, assess the impact of post-harvest losses, limited market access, and inadequate infrastructure on rural livelihoods, and explore potential interventions such as promoting value addition, strengthening market linkages, and empowering smallholder farmers while promoting medium and large-scale glowers. By examining both challenges and opportunities, this research aims to provide evidence-based recommendations for policymakers and stakeholders to optimize the fruit supply chain for sustainable and inclusive rural development in Sri Lanka.

Global Evidence on How Fruit Supply Chains Transform Rural Lives

China dominates global fruit production, accounting for nearly half of the world's total output, with a wide variety of fruits like citrus, grapes, apples, and bananas thriving in its diverse climates (FAOSTAT, 2020). India follows as the second-largest producer, boasting a rich assortment of fruits like mangoes, bananas, grapes, and citrus fruits due to its varied soil and weather conditions (FAOSTAT, 2020). While Ecuador may not be the largest producer, it stands out as the world's leading exporter of bananas, contributing significantly to the global fruit trade (Trade Map, 2022). Spain, renowned for its citrus fruits, particularly oranges and mandarins, secures a strong position as a major exporter (Trade Map, 2022). Though not a major producer itself, the Netherlands serves as a crucial hub for re-exporting fruits from various countries, ensuring a wider distribution of diverse produce (CBI, 2023). Finally, Mexico has emerged as a leading exporter of avocados, berries, and mangoes, meeting the growing demand for these popular fruits worldwide (USDA, 2023).

Several countries have strategically leveraged their fruit sectors to drive rural development, thereby improving livelihoods and fostering economic growth in rural areas. India's diverse fruit production, particularly mangoes, bananas, grapes, and citrus fruits, provides substantial employment and income opportunities for millions of rural farmers, with government support for infrastructure and market access enhancing this impact (FAO, 2017). Ecuador's banana industry, as the world's leading exporter, serves as a cornerstone of its rural economy, generating employment and export revenues that contribute significantly to national development (UNCTAD, 2021). In Costa Rica, the pineapple industry's focus on sustainability and social responsibility has resulted in job creation, infrastructure improvements, and support for education and healthcare in rural communities (IICA, 2019). Chile's thriving export of fruits like grapes, apples, and blueberries has transformed rural areas through investments in technology, irrigation, and post-harvest handling, leading to increased productivity, skilled jobs, and improved living standards (OECD, 2022). Similarly, South Africa's citrus industry, supported by government initiatives in research, marketing, and infrastructure, plays a crucial role in providing employment and income for rural families (Citrus Growers' Association of Southern Africa, 2023).

Global evidence consistently highlights the pivotal role of fruit supply chains in driving rural development, particularly in developing countries. Research by the Food and Agriculture Organization (FAO, 2014) demonstrates that well-functioning fruit value chains enhance farmers' incomes, create employment opportunities, especially for women and youth (Michelson, 2021), and improve rural livelihoods. For instance, Gulati et al. (2005) found a 30% income increase for Indian smallholder farmers participating in mango value chains.

The positive impact extends beyond economic sphere. Fruit value chains contribute to social and environmental development by fostering community cohesion, empowering women, and promoting sustainable practices (World Bank, 2018). In Kenya, the mango value chain empowered women through increased

participation in production, processing, and marketing (Maertens & Swinnen, 2015). Recent research also underscores the role of fruit value chains in enhancing food security and nutrition in rural areas (HLPE, 2021).

However, optimizing this impact faces challenges. High post-harvest losses, limited access to finance and technology, and inequitable benefit distribution remain key issues (FAO, 2014). Climate change further exacerbates these challenges, affecting fruit production and quality (Bokusheva & Hockmann, 2022). Inadequate infrastructure, market volatility, and weak institutional frameworks also hinder fruit value chain development (Rehman et al., 2016).

Addressing these challenges requires a multifaceted approach. Investment in cold storage and transportation infrastructure is crucial to reduce post-harvest losses (Kitinoja & Kader, 2021). Digital technologies, such as mobile apps for market information and traceability systems, can empower farmers and improve transparency (Wossen et al., 2023). Financial inclusion programs are also needed to provide farmers with access to credit and insurance.

Policymakers and practitioners can learn from successful interventions. Farmer cooperatives and producer organizations empower farmers, improve market access, and enhance value addition (Hellin et al., 2009). Public-private partnerships mobilize resources, share knowledge, and scale up successful initiatives (Minten et al., 2019). Recent studies emphasize the importance of inclusive business models that engage smallholder farmers and ensure equitable benefit-sharing (Michelson, 2021).

Furthermore, integrating sustainability principles into fruit value chains is crucial. This includes promoting climate-smart agriculture practices, reducing environmental footprints, and ensuring fair labour conditions (FAO, 2022). Certification schemes and standards can also play a role in promoting sustainable practices and accessing premium markets.

The COVID-19 pandemic has disrupted fruit value chains, exposing their vulnerabilities (Kerr, 2020). However, it has also accelerated the adoption of digital technologies and e-commerce platforms, offering new opportunities for market access and resilience (Wossen et al., 2023).

Looking ahead, research should focus on understanding the specific needs and constraints of different actors in fruit value chains, particularly women and youth (Michelson, 2021). Analysing the impact of climate change on fruit production and identifying adaptation strategies is also crucial.

By drawing upon global evidence and best practices, countries can design and implement policies and programs that maximize the positive impact of fruit value chains on rural development. This will contribute to sustainable and inclusive economic growth while addressing food security and environmental challenges.

Supply Chain Realities vs. Value Chain Aspirations in Sri Lanka

While both terms are interconnected in the context of Sri Lanka's fruit industry, they represent distinct yet complementary concepts. The fruit supply chain refers to the linear sequence of activities involved in bringing fruits from the farm to the consumer's table. This encompasses cultivation, harvesting, post-harvest handling, processing, packaging, transportation, and distribution (Wanninayake et al., 2018). It focuses on the physical flow of goods and the logistical processes required to ensure the timely and efficient delivery of fruits to consumers.

The fruit value chain, on the other hand, expands upon the supply chain by considering the value added at each stage. It encompasses not only the physical flow of goods but also the economic and social interactions among various actors in the chain, including farmers, traders,

processors, exporters, and consumers (Perera & Jayawardena, 2016). The value chain approach emphasizes the importance of understanding how value is created, captured, and distributed among these actors, and how this value creation can contribute to rural development.

In Sri Lanka, both the fruit supply chain and value chain face unique challenges and opportunities. Inefficient post-harvest practices, limited access to technology and markets, and fragmented value chains hinder the full potential of the sector (Wanninayake et al., 2018). However, the country's diverse fruit production, growing consumer demand, and potential for value addition present significant opportunities for growth and development.

Efforts to enhance the fruit value chain in Sri Lanka often focus on improving infrastructure, promoting sustainable farming practices, strengthening market linkages, and empowering smallholder farmers (Jayasekara & Jayawardena, 2016). By addressing these challenges and capitalizing on the opportunities, Sri Lanka can unlock the full potential of its fruit sector, contributing to rural development, economic growth, and food security.

A Theoretical Exploration of Fruit Supply Chains and Rural Development

The fruit value chain, a complex network of interconnected activities from production to consumption, has emerged as a significant driver of rural development in many parts of the world (Gulati et al., 2005). Theoretical frameworks like the Global Value Chain (GVC) theory emphasize the importance of understanding the entire value chain, from input suppliers to final consumers, to identify opportunities for upgrading and enhancing value creation at different stages (Gereffi et al., 2005). In the context of Sri Lanka, the fruit supply chain holds immense potential for generating income, creating employment, and improving livelihoods in rural communities (Perera & Jayawardena, 2016).

The Sustainable Livelihoods Framework (SLF) provides a comprehensive lens to analyse the impact of fruit value chains on rural livelihoods. This framework considers five key assets – human, social, natural, physical, and financial – that individuals and households utilize to achieve their livelihood goals (Scoones, 1998). The fruit supply chain can influence these assets in various ways, such as providing employment opportunities (human capital), strengthening social networks (social capital), utilizing natural resources (natural capital), investing in infrastructure (physical capital), and generating income (financial capital).

Another relevant theory is the Value Chain Governance (VCG) framework, which examines how power relations and coordination mechanisms influence the distribution of benefits and risks among actors in the supply chain (Gereffi et al., 2005). In the Sri Lankan fruit sector, understanding the dynamics of VCG is crucial for ensuring equitable participation and benefit-sharing among smallholder farmers, traders, processors, and exporters. By analysing the power dynamics and governance structures within the value chain, policymakers can design interventions to empower marginalized actors and promote more inclusive development outcomes.

Furthermore, the concept of Territorial Rural Development (TRD) emphasizes the importance of place-based approaches to rural development, recognizing the unique characteristics and assets of specific territories (Ray, 2000). In the context of fruit value chains, TRD highlights the need to consider the local context, cultural practices, and environmental conditions when designing interventions to enhance the value chain's contribution to rural development. This approach can lead to more effective and sustainable outcomes by tailoring solutions to the specific needs and opportunities of each region.

Uncovering Sri Lanka's Rich Fruit Cultivation Heritage

Sri Lanka's tropical climate and fertile soils make it ideal for cultivating a wide variety of fruits, contributing to both domestic consumption and export markets. Bananas, pineapples, and papayas are the dominant commercially grown fruits, often destined for export.

However, the country also boasts a rich diversity of other fruits, including mangoes, watermelons, rambutans, mangosteens, wood apples, guavas, pomegranates, and jackfruits, among others. These fruits not only enrich the local diet with their diverse flavours and nutritional benefits but also contribute to the cultural identity and culinary traditions of Sri Lanka.

The country's fertile soils and favourable weather conditions allow for the cultivation of a wide variety of fruits, ranging from staple crops like bananas and pineapples to exotic varieties such as mangoes, mangosteens, and rambutans (Dahanayake, 2015). Smallholder farmers and plantations play a crucial role in this sector, with their produce catering to both domestic consumption and export markets (Sri Lanka Export Development Board, n.d.).

Bananas, pineapples, and papayas are the dominant commercially grown fruits in Sri Lanka, with a significant portion of the harvest destined for export, particularly to the Middle East and Maldives (Sri Lanka Export Development Board, n.d.). These fruits, known for their sweet flavour and nutritional value, are cultivated in large-scale plantations, utilizing modern agricultural practices and technologies to ensure high yields and quality standards.

In addition to the major commercial crops, a wide range of other fruits are cultivated in home gardens and small-scale farms across the island. These include mangoes, watermelons, rambutans, mangosteens, wood apples, guavas, pomegranates, and jackfruits, among others (Dahanayake, 2015).

Table 1: Major Fruit and Cultivating Districts of Fruits in 2006 (Share of National Production)

District	Mango (%)	Banana (%)	Papaya (%)	Pineapple (%)
Kurunegala	20.9	19.7	7.3	42.3
Monaragala	5.4	7.2	4.8	3.8
Badulla	5.0	3.4	5.3	2.8
Rathnapura	5.4	13.2	5.7	0.6
Hambantota	6.0	8.2	10.1	1.1
Gampaha	8.5	7.2	4.2	40.8
Kalutara	2.3	3.1	11	1.4

Source: Export Development Board

These fruits not only enrich the local diet with their diverse flavors and nutritional benefits but also contribute to the cultural identity and culinary traditions of Sri Lanka.

Despite the abundance and diversity of fruits grown in Sri Lanka, the sector faces several challenges. Post-harvest losses due to inadequate handling and storage practices, limited access to modern technology and infrastructure, and competition from other fruit-producing countries are some of the key constraints hindering the full potential of the industry (Wanninayake et al., 2018). However, with ongoing efforts to improve agricultural practices, enhance infrastructure, and expand market access, Sri Lanka's fruit cultivation sector has the potential to continue its growth and contribute significantly to the nation's economic development and food security.

Sri Lanka's fruit export sector, though relatively small compared to other agricultural exports, demonstrates significant potential for growth and contribution to rural development. Bananas, pineapples, and mangoes are the key fruit exports, primarily destined for the Middle East, Europe, and Asia (EDB Sri Lanka, 2023). Despite challenges like limited infrastructure and high production costs, the government is actively supporting the sector through financial assistance, training programs, and promotion

of sustainable farming practices (Hector Kobbekaduwa Agrarian Research and Training Institute, 2023). This support, coupled with rising global demand for exotic fruits, indicates a promising future for Sri Lanka's fruit export sector, potentially leading to increased foreign exchange earnings, employment opportunities, and improved livelihoods in rural communities (Dissanayake & Udari, 2023).

Sri Lanka's fruit production supply chain, though pivotal for rural development, grapples with complex challenges. While offering vital income and employment opportunities, particularly for women, and contributing to a diversified rural economy (Department of Agriculture, Sri Lanka, 2023), the sector faces substantial post-harvest losses due to inadequate infrastructure and limited market access for smallholder farmers (Hector Kobbekaduwa Agrarian Research and Training Institute, 2018). These issues are compounded by a lack of value addition and the prevalence of unsustainable farming practices (Advocata Institute, 2023).

However, potential solutions include investing in storage and processing facilities, facilitating market linkages, promoting sustainable practices, and providing capacity building for farmers, as suggested by the World Bank (2023). By addressing these challenges, Sri Lanka can unlock the full potential of its fruit sector for both economic growth and sustainable rural development.

Navigating the Supply Chain from Orchard to Market

Sri Lanka's fruit supply chain is a complex network of interconnected activities, beginning with cultivation and extending through harvesting, post-harvest handling, processing, distribution, and ultimately, consumption (Department of Census and Statistics, 2016). The chain involves a diverse range of stakeholders, including smallholder farmers, large-scale plantations, traders, processors, exporters, retailers, and consumers. Each stage of this chain presents unique challenges and opportunities, impacting not only the livelihoods of those involved but also the overall economic development of the country.

The cultivation stage is characterized by a mix of traditional and modern practices, with smallholder farmers often relying on traditional knowledge and techniques, while larger plantations may employ more advanced technologies (Dahanayake, 2015). However, both types of producers face challenges such as pests and diseases, climate variability, and limited access to quality inputs. The post-harvest stage is critical for maintaining fruit quality and reducing losses, but it often suffers from inadequate infrastructure and inefficient handling practices (Wanninayake et al., 2018).

Processing and value addition present opportunities for increasing the value of Sri Lankan fruits, but the sector is still underdeveloped, with limited processing capacity and a lack of diversified products. The distribution and marketing of fruits are also fragmented, with multiple intermediaries involved, leading to price fluctuations and inefficiencies (Perera & Jayawardena, 2016). Additionally, the export market, although promising, faces challenges due to stringent quality standards, competition from other countries, and logistical constraints.

Sri Lanka's role in the global fruit supply chain is still developing, with significant potential for growth. While not a major global player, the country produces a variety of tropical fruits like bananas, pineapples, and mangoes, primarily exporting to the Middle East, Europe, and Asia (EDB Sri Lanka, 2023). This contributes to the global supply of these fruits, albeit on a smaller scale compared to major producers like Ecuador or India. However, Sri Lanka faces challenges in maximizing its contribution, including high post-harvest losses, limited market access for smallholder farmers, and a lack of value addition (Hector Kobbekaduwa Agrarian Research and Training Institute, 2018; Advocata Institute, 2023).

Despite these hurdles, the government's support for the sector, combined with increasing global demand for exotic fruits, suggests a promising future for Sri Lanka's fruit exports, potentially enhancing its position in the global fruit supply chain (Dissanayake & Udari, 2023).

Sri Lanka's sour banana export sector has witnessed significant growth in recent years, driven by government initiatives and increasing international demand. The Ministry of Agriculture has established dedicated export processing zones and processing centers in regions like Jaffna and Rajanganaya, enabling the successful export of high-quality sour bananas to markets like Dubai (Ministry of Agriculture, 2023).

The government's Agriculture Sector Modernization Project (ASMP) has played a crucial role in providing technical and financial support to farmers, leading to the expansion of cultivation areas and increased production (The Morning, 2023). While challenges like ensuring consistent quality and meeting international standards persist, the sector's expansion plans, including new cultivation zones in Embilipitiya, Hambantota, and Sevanagala, indicate a promising future for Sri Lanka's sour banana exports (Ministry of Agriculture, 2023).

Recent data indicates a shift in Sri Lanka's fruit export destinations, with a growing focus on the European Union and Middle Eastern markets. While the United States remains a significant importer, its share of Sri Lankan fruit exports decreased in 2023 (Sri Lanka Export Development Board, 2023). Within the EU, Germany, Italy, the Netherlands, Belgium, and France are the top five destinations, with Italy and France showing positive growth in 2023 (Sri Lanka Export Development Board, 2023).

The Middle East, particularly Qatar, Maldives, and the United Arab Emirates, has also emerged as a key market for Sri Lankan fruits, with notable growth observed in exports to France and Kuwait (Observatory of Economic Complexity, n.d.). These trends suggest a diversification of export markets for Sri Lankan fruits, potentially reducing reliance on a single destination and opening new opportunities for growth in the sector.

Sri Lanka's potential for diversifying its fruit export basket is significant, with several underutilized fruit varieties holding promise in international markets. These include indigenous fruits like wood apple (divul and beli), lovi, veralu (leech lime), and namal, known for their unique flavours, nutritional value, and potential applications in the food, pharmaceutical, and cosmetic industries (Jayaweera, 1982; Pushpakumara et al., 2014; Ayurvedic Medical Council of Sri Lanka, 2016). Additionally, exotic fruits like uguressa, himbutu, durian, and rambutan, already popular locally, could find niche markets abroad due to their unique taste and potential health benefits. With targeted investments in research, cultivation, processing, and marketing, these untapped fruit varieties could not only diversify Sri Lanka's export portfolio but also contribute significantly to rural livelihoods and economic growth.

The Lucrative Allure of Fruit Farming in Sri Lanka

Fruit cultivation in Sri Lanka presents a compelling case for farmers seeking higher economic returns compared to traditional crops. While staple crops like rice and tea have long dominated Sri Lankan agriculture, the fruit sector has emerged as a lucrative alternative, offering greater profitability and resilience to market fluctuations.

According to a study by Jayasekara and Jayawardena (2016), banana cultivation, a major fruit crop in Sri Lanka, demonstrates higher profitability compared to paddy cultivation, with a gross margin that is nearly double. This is attributed to factors such as higher market prices for fruits, increasing domestic and international demand, and the potential for value addition through processing.

Moreover, fruit cultivation offers farmers greater flexibility and diversification options. Unlike traditional crops that often require specific climatic and soil conditions, a wide variety of fruits can be grown in different regions of Sri Lanka, allowing farmers to adapt to local conditions and diversify their income sources. This reduces their vulnerability to crop failures and market fluctuations, ensuring a more stable and sustainable livelihood.

The potential for value addition in the fruit sector further enhances its attractiveness for farmers. By processing fruits into juices, jams, dried fruits, and other products, farmers can capture a larger share of the value chain and increase their income (Wanninayake et al., 2018). This also creates opportunities for rural employment and contributes to the overall development of the local economy.

However, it is important to note that fruit cultivation also comes with its own set of challenges. It requires greater investment in inputs, technology, and post-harvest handling compared to traditional crops. Moreover, market access and price volatility remain critical issues for smallholder farmers, necessitating government support and effective market linkages (Perera & Jayawardena, 2016). Despite these challenges, the potential for higher returns and greater resilience makes fruit cultivation an increasingly attractive option for farmers seeking to improve their livelihoods and contribute to the economic development of rural Sri Lanka.

See Table 02

Unpacking the Evolution of Rural Development Strategies in Sri Lanka

Since gaining independence in 1948, Sri Lanka has embarked on a series of rural development policies aimed at improving the livelihoods of its rural population and reducing poverty (Lakshman, 1997). Initial efforts focused on agricultural modernization through land reforms, irrigation projects, and the introduction of high-yielding crop varieties. The government also invested in rural infrastructure, such as roads, schools, and healthcare facilities, to improve access to basic services (Moore, 1985). These early policies achieved significant success in increasing agricultural productivity and reducing poverty rates in the 1950s and 1960s.

However, by the 1970s and 1980s, new challenges emerged, including rising population growth, land fragmentation, and environmental degradation. The government responded with a shift towards integrated rural development programs, focusing on poverty alleviation, livelihood diversification, and environmental sustainability (World Bank, 2018). These programs emphasized community participation, decentralized decision-making, and the integration of various sectors, such as agriculture, education, and health.

In recent years, Sri Lanka's rural development policies have increasingly focused on sustainable agriculture, supply chain development, and the promotion of rural non-farm activities (IFAD, 2020). The government has also recognized the importanceof digital connectivity and technological innovation in empowering rural communities and bridging the urban-rural divide (UNDP, 2021). While progress has been made, persistent challenges such as poverty, inequality, and climate change vulnerability require continued attention and innovative solutions to ensure sustainable and inclusive rural development in Sri Lanka.

Triumphs and Transformations in Sri Lanka's Rural Landscape

Since gaining independence in 1948, Sri Lanka has made significant strides in rural development, achieving notable improvements in various socioeconomic indicators. One of the most significant achievements has been the reduction of rural poverty. Through targeted interventions such as land reforms, agricultural modernization, and social welfare programs, Sri Lanka has successfully lifted millions out of poverty

Table 2: Performance of the Most Common Fruits in Sri Lanka

Fruit	Production Performance (2019)			Export Performance (2019)		Total Score	Ranking
	Extent (ha)	Production ('000 fruits)	Production (t)	Quantity(t)	Export value(LKR/kg)		
Banana	44,671	56,139	673,668	17,926	142.36	39	2
Score	9	5	9	9	7		
Lime	10,238	334,546	16,727	-	-	17	7
Score	7	7	3	-	-		
Mango	27,460	444,136	155,448	528	516.27		1
Score	8	8	8	4	9	40	
Orange	6,742	59,213	8,882	-	-	14	8
Score	6	6	2	-	-		
Papaw	6,178	52,562	78,843	10011	102.80	30	3
Score	5	4	7	8	6		
Passion fruit	508	8,846	885	-	-	3	9
Score	1	1	1	-	-		
Pineapple	4,665	35,834	44,793	592	438.98	26	4
Score	3	2	6	7	8		
Rambutan	6,929	709,468	24,831	-	-	21	5
Score	7	9	5	-	-		
Avocado	3,453	49,881	16,461	108	409.47	21	5
Score	2	3	4	5	7		

(Lakshman, 1997). The country's poverty rate, which stood at 26.1% in 2002, declined to 4.1% by 2016, with rural areas experiencing a more substantial decrease (Department of Census and Statistics, 2016).

Another notable achievement is the improvement in rural infrastructure and access to basic services. Investments in roads, electricity, irrigation, education, and healthcare have significantly enhanced the quality of life in rural communities (World Bank, 2018). For instance, the percentage of households with access to electricity in rural areas increased from 55% in 1990 to 98% in 2016 (Department of Census and Statistics, 2016).

Sri Lanka has also made commendable progress in education and health outcomes in rural areas. Literacy rates have consistently improved, and infant and maternal mortality rates have significantly declined (World Bank, 2018). These achievements highlight the positive impact of government investments in education and healthcare infrastructure and services in rural communities.

While these achievements are noteworthy, challenges persist, particularly in addressing regional disparities and ensuring sustainable and inclusive development (UNDP, 2021). Continued efforts are needed to promote sustainable agriculture, diversify rural livelihoods, enhance access to finance and technology, and empower marginalized groups to ensure that the benefits of development reach all segments of the rural population.

How Sri Lanka's Fruit Supply Chain Nurtures Rural Prosperity

The fruit supply chain in Sri Lanka, encompassing cultivation, harvesting, processing, distribution, and consumption, plays a pivotal role in rural development. This intricate network connects smallholder farmers, who often cultivate diverse fruit varieties in their home gardens, to local and international markets, creating opportunities for income generation, employment, and economic growth (Perera & Jayawardena, 2016). The sector's contribution to rural development extends beyond economic benefits, as it also fosters social cohesion, empowers local communities, and promotes sustainable agricultural practices.

However, the fruit supply chain in Sri Lanka faces several challenges that hinder its full potential. These include post-harvest losses due to inadequate infrastructure and handling practices, limited access to finance and technology for smallholder farmers, and market volatility (Wanninayake et al., 2018). Addressing these challenges requires a multi-faceted approach that involves investing in infrastructure, improving post-harvest management, strengthening market linkages, and promoting sustainable production practices.

Despite the challenges, the fruit supply chain offers significant opportunities for rural development in Sri Lanka. By enhancing the value chain's efficiency, inclusivity, and sustainability, the country can unlock its full potential to create a more prosperous and resilient rural economy.

This can be achieved through initiatives such as promoting farmer organizations and cooperatives, investing in value addition and processing, and expanding market access for smallholder farmers (Jayasekara & Jayawardena, 2016). Additionally, government policies and support play a crucial role in creating an enabling environment for the growth and development of the fruit sector.

The fruit supply chain in Sri Lanka is a critical driver of rural development, offering both challenges and opportunities. By addressing the existing constraints and capitalizing on the potential for growth, the country can create a more vibrant and sustainable fruit sector that contributes significantly to the livelihoods and well-being of its rural communities. This requires a collaborative effort from all stakeholders, including farmers, traders, processors, policymakers, and development agencies, to ensure a thriving and equitable fruit supply chain for a prosperous Sri Lanka.

Cultivating Rural Development through Sri Lanka's Fruit Supply Chain

Sri Lanka's fruit supply chain holds immense untapped potential for driving rural development, offering a promising avenue for socioeconomic growth and poverty reduction. While the country boasts a rich diversity of fruits, the sector has not yet fully realized its potential due to various constraints. However, recent studies have identified several opportunities for enhancing the fruit supply chain and maximizing its impact on rural communities.

One of the key areas with untapped potential is post-harvest management. Inefficient handling and storage practices lead to significant post-harvest losses, estimated to be around 30-40% for some fruits (Wanninayake et al., 2018). Investing in infrastructure such as cold storage facilities, collection centres, and improved packaging techniques can significantly reduce these losses, ensuring that more fruits reach consumers and generate income for farmers.

Another area with significant potential is value addition and processing. Sri Lanka currently exports most of its fruits in raw form, missing out on the opportunity to capture higher value through processing. By developing local processing industries for products like fruit juices, jams, and dried fruits, the country can not only increase the value of its exports but also create employment opportunities in rural areas (Jayasekara & Jayawardena, 2016).

Furthermore, strengthening market linkages and promoting niche markets can enhance the competitiveness of Sri Lankan fruits in both domestic and international markets. This involves improving access to information, facilitating market linkages between farmers and buyers, and promoting the unique qualities and flavours of Sri Lankan fruits to discerning consumers (Perera & Jayawardena, 2016). By tapping into these untapped potentials, Sri Lanka's fruit supply chain can play a pivotal role in transforming rural livelihoods, boosting the economy, and promoting sustainable agricultural practices.

Obstacles Facing Sri Lanka's Fruit Supply Chain in Fostering Rural Development

Despite the immense potential of the fruit supply chain in driving rural development in Sri Lanka, several bottlenecks hinder its full realization. One of the most significant challenges is the fragmented nature of the sector, characterized by a large number of smallholder farmers with limited resources and bargaining power (Perera & Jayawardena, 2016). This fragmentation makes it difficult for farmers to access credit, technology, and market information, limiting their ability to invest in productivity-enhancing measures and negotiate fair prices for their produce.

Furthermore, inadequate post-harvest infrastructure and inefficient handling practices result in significant post-harvest losses, estimated to be around 30-40% for some fruits (Wanninayake et al., 2018). This not only reduces farmers' incomes but also hampers the country's ability to meet domestic demand and capitalize on export opportunities. The lack of adequate cold storage facilities, processing units, and efficient transportation networks further exacerbates these losses, hindering the development of a robust and competitive fruit value chain.

Market access remains a major bottleneck for Sri Lankan fruit producers, particularly smallholder farmers. The lack of reliable market information, limited bargaining power, and dependence on intermediaries often result in low prices for farmers and high margins for traders (ITC, 2023). Moreover, stringent quality standards and phytosanitary regulations imposed by international markets pose challenges for small-scale producers who lack the resources and technical knowledge to comply with these requirements.

Additionally, the lack of coordination and collaboration among stakeholders in the fruit supply chain creates inefficiencies and hinders the sector's overall growth. The absence of strong farmer organizations and cooperatives, limited coordination between government agencies and private sector actors, and the lack of a comprehensive national fruit policy all contribute to this fragmented landscape (Stamm et al., 2011). Addressing these bottlenecks requires a concerted effort from all stakeholders to strengthen coordination, invest in infrastructure, promote sustainable practices, and empower farmers through access to information, technology, and markets.

A Roadmap for Strengthening Sri Lanka's Fruit Supply Chain and Empowering Rural Communities

To unleash the untapped potential of the fruit supply chain for rural development in Sri Lanka, a multi-pronged approach is required, addressing key bottlenecks and fostering a conducive environment for growth. Firstly, empowering smallholder farmers is crucial. This can be achieved through initiatives such as farmer organizations and cooperatives, which provide collective bargaining power, access to resources and technology, and training on good agricultural practices (Jayasekara & Jayawardena, 2016). Additionally, providing financial support, such as microcredit schemes and crop insurance, can enable farmers to invest in productivity-enhancing measures and mitigate risks.

Secondly, investing in post-harvest infrastructure and technology is essential to reduce losses and ensure the quality and safety of fruits. This includes establishing collection centers,

cold storage facilities, packing houses, and improving transportation networks (Wanninayake et al., 2018). Adopting innovative technologies such as solar-powered drying systems and mobile processing units can further enhance value addition and reduce post-harvest losses, particularly in remote areas.

Thirdly, strengthening market linkages and promoting value addition can significantly increase the income of farmers and create new employment opportunities in rural areas. This involves facilitating direct linkages between farmers and buyers, both domestically and internationally, through platforms such as farmers' markets, e-commerce platforms, and contract farming arrangements (Perera & Jayawardena, 2016). Additionally, promoting value addition through processing fruits into juices, jams, dried fruits, and other products can create a diversified product portfolio and capture higher value in the market.

Finally, creating a supportive policy environment is crucial for the sustainable development of the fruit value chain. This includes formulating a comprehensive national fruit policy that addresses issues such as land tenure, access to finance, research and development, and market regulations. Moreover, streamlining bureaucratic procedures, providing technical assistance, and promoting sustainable agricultural practices can further enhance the competitiveness and resilience of the fruit sector, ultimately contributing to rural development and poverty reduction in Sri Lanka.

Discussion

Sri Lanka, an island nation renowned for its agricultural heritage, boasts a thriving fruit sector that plays a crucial role in both domestic consumption and export markets. The country's diverse climatic conditions and fertile soils enable the cultivation of a wide variety of fruits, including bananas, pineapples, mangoes, and other tropical delights. However, the fruit supply chain in Sri Lanka, encompassing everything from cultivation and harvesting to processing, distribution, and consumption, faces unique challenges and opportunities that significantly impact rural development.

The complexity of the fruit supply chain is evident in the multiple stages involved, each with its own set of hurdles. Post-harvest losses due to inadequate handling and storage practices, limited access to modern technology and infrastructure, and the need to comply with stringent quality standards for domestic and export markets pose significant challenges. Moreover, the dominance of small-scale farmers in Sri Lanka's fruit production sector adds further complexities, as they often lack the resources and bargaining power to navigate the market effectively.

Despite these challenges, the fruit supply chain also holds immense potential for driving rural development in Sri Lanka. It serves as a vital source of income and employment for rural communities, contributing to poverty reduction and economic growth. Additionally, the development of infrastructure and logistics networks associated with the fruit supply chain can improve connectivity and access to markets for rural areas, thereby fostering broader socio economic development.

Global evidence consistently highlights the pivotal role of fruit supply chains in driving rural development, particularly in developing countries. Research by the Food and Agriculture Organization (FAO) demonstrates that well-functioning fruit value chains enhance farmers' incomes, create employment opportunities, especially for women and youth, and improve rural livelihoods. The positive impact extends beyond economics, contributing to social and environmental development by fostering community cohesion, empowering women, and promoting sustainable practices.

However, optimizing this impact faces challenges. High post-harvest losses, limited access to finance and technology, and inequitable benefit

distribution remain key issues. Climate change further exacerbates these challenges, affecting fruit production and quality. Inadequate infrastructure, market volatility, and weak institutional frameworks also hinder fruit value chain development.

In Sri Lanka, both the fruit supply chain and value chain face unique challenges and opportunities. Inefficient post-harvest practices, limited access to technology and markets, and fragmented value chains hinder the full potential of the sector. However, the country's diverse fruit production, growing consumer demand, and potential for value addition present significant opportunities for growth and development.

Sri Lanka, blessed with a tropical climate and diverse agro-ecological zones, boasts a thriving fruit cultivation sector that contributes significantly to the nation's economy and nutritional security. The country's fertile soils and favourable weather conditions allow for the cultivation of a wide variety of fruits, ranging from staple crops like bananas and pineapples to exotic varieties such as mangoes, mangosteens, and rambutans. Smallholder farmers and plantations play a crucial role in this sector, with their produce catering to both domestic consumption and export markets.

Bananas, pineapples, and papayas are the dominant commercially grown fruits in Sri Lanka, with a significant portion of the harvest destined for export, particularly to the Middle East and Maldives. These fruits, known for their sweet flavour and nutritional value, are cultivated in large-scale plantations, utilizing modern agricultural practices and technologies to ensure high yields and quality standards.

In addition to the major commercial crops, a wide range of other fruits are cultivated in home gardens and small-scale farms across the island. These include mangoes, watermelons, rambutans, mangosteens, wood apples, guavas, pomegranates, and jackfruits, among others. These fruits not only enrich the local diet with their diverse Flavors and nutritional benefits but also contribute to the cultural identity and culinary traditions of Sri Lanka.

Sri Lanka's fruit supply chain is a complex network of interconnected activities, beginning with cultivation and extending through harvesting, post-harvest handling, processing, distribution, and ultimately, consumption. The chain involves a diverse range of stakeholders, including smallholder farmers, large-scale plantations, traders, processors, exporters, retailers, and consumers. Each stage of this chain presents unique challenges and opportunities, impacting not only the livelihoods of those involved but also the overall economic development of the country.

Sri Lanka's fruit cultivation landscape is at a crossroads, with the potential shift from traditional mixed gardens to monoculture fruit cultivation sparking debate regarding its impact on rural development. Proponents of monoculture argue that specializing in specific high-demand fruits like bananas or mangoes could boost productivity, efficiency, and export earnings, contributing to economic growth (Dissanayake & Udari, 2023). This intensified production model could also simplify farm management and potentially lower costs, making Sri Lankan fruits more competitive in international markets (Hector Kobbekaduwa Agrarian Research and Training Institute, 2018).

However, critics raise concerns about the environmental and social consequences of monoculture. They warn of potential biodiversity loss, soil degradation, increased pesticide use, and market volatility due to reliance on a single crop (Advocata Institute, 2023). Moreover, the shift away from traditional mixed gardens could erode valuable indigenous agricultural knowledge and practices (Perera, 2019). The loss of biodiversity could also increase the vulnerability of crops to pests and diseases, necessitating greater pesticide use and further environmental damage. The debate underscores the need for a balanced approach that weighs the potential

economic benefits of monoculture against its potential long-term costs to the environment and rural communities.

Conclusion and Recommendation

The fruit supply chain in Sri Lanka presents a compelling narrative of untapped potential, persistent challenges, and promising opportunities for rural development. The sector, characterized by its diversity of fruits, smallholder farmers, and dynamic market interactions, is deeply intertwined with the livelihoods and well-being of rural communities. However, realizing this potential requires a comprehensive and collaborative approach that addresses the key bottlenecks hindering the sector's growth.

Post-harvest losses, limited access to technology and markets, and fragmented value chains pose significant challenges to the Sri Lankan fruit sector. These issues not only diminish the income of farmers but also constrain the sector's ability to contribute to national economic growth and food security. However, these challenges also present opportunities for innovation and improvement. By investing in infrastructure, promoting sustainable practices, and strengthening market linkages, Sri Lanka can unlock the full potential of its fruit value chain.

Empowering smallholder farmers through access to credit, technology, and market information is crucial for their participation in and benefit from the value chain. Additionally, promoting value addition through processing and developing niche markets can significantly enhance the competitiveness of Sri Lankan fruits in both domestic and international markets. Government policies and support, including investment in research and development, extension services, and market regulations, play a crucial role in creating a conducive environment for the fruit sector to flourish.

The future of the fruit supply chain in Sri Lanka is promising, but it hinges on concerted efforts from all stakeholders to address the challenges and seize the opportunities. By adopting a holistic approach that prioritizes sustainability, inclusivity, and innovation, Sri Lanka can transform its fruit sector into a powerful engine for rural development, improving livelihoods, fostering economic growth, and ensuring food security for generations to come.

While tea, rubber, and coconut have historically been the pillars of Sri Lanka's agricultural exports, the country is at a juncture where diversifying into new agricultural products is essential for sustainable economic growth, resilience, and rural development. Sticking solely to these colonial-era commodities limits the economic expansion of the country. In addition to that, to price fluctuations and market volatilities, as seen in recent times with the decline in some traditional agricultural exports. Moreover, changing global consumption patterns and the emergence of new competitors necessitate exploring alternative avenues for export revenue.

The recent initiatives to promote the cultivation and export of fruits like sour bananas and TJC mangoes, as well as high-value crops like king coconut, are steps in the right direction in this endeavour. However, a concerted effort to identify and develop new export-oriented fruits, invest in modern agricultural practices and technology, and improve market access is crucial for . Sri Lanka possesses a diverse agro-climatic environment suitable for cultivating a wide range of fruits. The untapped potential in these areas of fruits offers an opportunity for the country to expand its export portfolio and tap into high-value markets.

Sri Lanka's fruit industry is poised for growth, with the potential to increase its share in the global fruit supply chain through improvements in quality, quantity, and continuity of production. By focusing on high-quality produce that meets international standards, Sri Lanka can attract more buyers and command better prices in the global market. Implementing Good Agricultural Practices (GAP) and investing in modern post-harvest handling technologies can significantly enhance the quality of Sri Lankan.

Furthermore, expanding cultivation areas, introducing improved varieties, and promoting efficient resource management can increase production volumes to meet growing global demand. This, combined with the development of storage and cold chain facilities, can ensure a continuous supply of fruits throughout the year, building stronger relationships with international buyers. By diversifying crop varieties and investing in logistics, Sri Lanka can create a more reliable and resilient fruit export industry, contributing to its economic growth and rural development.

Sri Lanka's potential to establish fruit export villages is promising, offering a strategic pathway to enhance the country's fruit sector and increase exports. By concentrating cultivation of specific fruit varieties in designated areas, these villages can foster specialization, leading to improved quality and higher yields. This model enables economies of scale, reducing production costs and enhancing the competitiveness of Sri Lankan fruits in international markets. Additionally, fruit export villages can serve as hubs for infrastructure development, knowledge sharing, and market access, thus improving the efficiency of the entire supply chain and empowering farmer. Through the implementation of sustainable farming practices and value addition initiatives, these villages can contribute significantly to rural development, offering increased income opportunities, employment, and improved livelihoods for local communities.

Organic fruit cultivation in Sri Lanka presents a compelling opportunity for farmers to achieve premium prices in both domestic and international markets while significantly reducing environmental impact. By eschewing synthetic fertilizers, pesticides, and herbicides, organic farming practices enhance soil health, biodiversity, and water quality, promoting a sustainable and eco-friendly approach to agriculture. The resulting produce, free from harmful chemical residues, appeals to health-conscious consumers who are willing to pay a premium for safer and more nutritious food. This shift towards organic cultivation not only benefits farmers economically but also align with global trends towards sustainable agriculture and environmental conservation, opening up new market opportunities and contributing to a healthier planet.

Promoting medium and large-scale fruit farming in Sri Lanka is crucial to enhance the country's competitiveness in the global fruit market. By scaling up production through larger farms, Sri Lanka can achieve economies of scale, reducing production costs per unit and enabling competitive pricing in international markets. Larger-scale farms can also invest in modern technologies, efficient irrigation systems, and advanced post-harvest handling practices, leading to improved quality and increased yields. Additionally, consolidated production in larger farms facilitates better supply chain management, ensuring consistent supply to meet international demand and fostering stronger relationships with global buyers. This approach not only helps to increase Sri Lanka's export volumes but also establishes the country as a reliable supplier of high-quality fruits, thereby opening doors to premium markets and contributing to greater economic growth and rural development.

Foreign direct investment (FDI) can be a catalyst for transforming Sri Lanka's fruit sector, offering the potential for significant advancements in technology, crop variety selection, and management practices, while also securing access to lucrative international markets. The introduction of modern agricultural technologies and improved varieties can boost productivity and quality, positioning Sri Lankan fruits as competitive products globally. Additionally, the expertise and experience of foreign investors can enhance overall management practices, leading to more efficient and sustainable operations. Importantly, FDI can facilitate access to established international markets, ensuring a consistent demand for Sri Lankan fruits and enabling farmers to fetch better prices, ultimately contributing to rural development and economic growth. However, it's crucial to note that FDI

should be strategically managed to ensure its benefits are shared equitably and sustainably throughout the sector.

In order to truly revitalize Sri Lanka's fruit sector, a paradigm shift is needed in agricultural extension services. The focus must move beyond academic research papers and towards practical, grassroots support for farmers. This involves providing hands-on training in modern cultivation techniques, pest management, and post-harvest handling, as well as facilitating access to technology, financial literacy, and market linkages. By empowering farmers with the knowledge and tools they need to succeed, extension services can drive significant improvements in productivity, quality, and overall profitability of the fruit sector.

However, grassroots support alone is not enough. The commitment of government officials and policymakers is equally crucial. This involves investing in essential infrastructure such as irrigation systems and storage facilities, promoting relevant research and development, and streamlining regulations to create a favourable environment for fruit farmers. Supportive policies that incentivize sustainable practices, value addition, and export promotion are also vital. By working together, these stakeholders can create a thriving fruit sector that not only boosts exports but also empowers rural communities and contributes to sustainable economic development in Sri Lanka.

In Sri Lanka, with its diverse agro-climatic zones, it is crucial to recognize that not all fruits are suited to all regions. Each fruit variety thrives under specific conditions and cultivating them in unsuitable areas can lead to low yields, poor quality, and wasted resources. Therefore, a strategic approach is needed to identify the most suitable locations for each fruit type based on factors like soil type, temperature, rainfall, and altitude. Once these optimal growing zones are identified, focused promotion and extension services can be tailored to specific regions, providing farmers with the knowledge and support needed to cultivate the most suitable fruits for their area. This targeted approach can optimize production, enhance quality, and ultimately contribute to a more efficient and profitable fruit sector in Sri Lanka.

Providing overseas exposure to farmer leaders or the best fruit farmers of the year in Sri Lanka could be a catalyst for transforming the country's fruit cultivation landscape. By experiencing firsthand, the advanced agricultural practices, technologies, and market dynamics of other countries, these farmers can gain valuable insights and knowledge to bring back to their communities. This exposure can inspire them to adopt innovative techniques, improve crop yields and quality, and explore new market opportunities. Furthermore, interacting with international experts and peers can foster valuable networks and partnerships, opening doors for collaboration and knowledge exchange. Ultimately, this investment in human capital has the potential to create a ripple effect, inspiring other farmers and raising the overall standards of fruit cultivation in Sri Lanka.

To mitigate price fluctuations and post-harvest losses in the Sri Lankan fruit sector, it is imperative to incentivize the development of agro-processing industries. By offering financial incentives such as tax breaks, subsidies, grants, and low-interest loans, the government can attract investment in processing facilities and technology. Non-financial incentives like infrastructure development, market linkage support, streamlined regulations, and capacity building can further create a conducive environment for agro-processing businesses to thrive. These measures can not only reduce post-harvest waste and stabilize fruit prices but also add value to products, create employment opportunities, and diversify the economy, contributing to overall rural development and economic growth in Sri Lanka.

While a robust fruit supply chain can significantly contribute to rural development in Sri Lanka, it cannot be considered a standalone

solution. The fruit sector alone cannot address all the multifaceted challenges faced by rural communities. Complementary strategies are essential to ensure holistic and sustainable rural development. These may include investments in education and healthcare, development of other agricultural and non-agricultural sectors, improving infrastructure such as roads and irrigation, empowering women and marginalized groups, and promoting sustainable tourism. Furthermore, ensuring fair prices for farmers, strengthening farmer organizations, and providing access to credit and financial services are crucial for equitable growth within the fruit sector itself. A multi-pronged approach that integrates the fruit supply chain with these broader development initiatives is necessary to create a thriving and resilient rural economy in Sri Lanka.

References

Advocata Institute. (2023). Contemporary issues in agri-food supply chain in Sri Lanka. https://www.advocata.org/commentary-archives/2023/04/16/contemporary-issues-in-agri-food-supply-chain-in-sri-lanka

Bokusheva, R., & Hockmann, H. (2022). Climate change and fruit production: A review. Agronomy, 12(3), 632.

CBI: Centre for the promotion of imports from developing countries. (2023).

https://www.cbi.eu/market-information/

Citrus Growers' Association of Southern Africa. (2023). Citrus Industry Annual Report 2023.

Dahanayake, N. (2015). Critical analysis of the status of fruit crop industry in Sri Lanka. Acta Horticulture, 1278, 37-44.

Department of Agriculture (2019). Performance Report-2018. Retrieved from (https://www.parliament.lk/uploads/documents/paperspresented/performance-report-department-of-agriculture-2018.pdf)
Department of Agriculture, Sri Lanka. (2023). https://www.doa.gov.lk/

Department of Census and Statistics. (2016). Poverty indicators in Sri Lanka. Ministry of National Policies and Economic Affairs.

Department of Census and Statistics. (2016). Statistical pocketbook of Sri Lanka. Retrieved from http://www.statistics.gov.lk/

Dissanayake, A.K.A., & Udari, U.D.R. (2023). Sri Lankan fruit exports: Potentials, barriers and prospects. Colombo Economic Journal, 1(1), 87-101.

Economy Next. (2023, December 27). Sri Lanka tea prices down 18-pct in 2023. https://economynext.com/sri-lanka-tea-prices-down-18-pct-in-2023-147250/

EDB Sri Lanka. (2023). Fruit and Vegetable Export Performance. https://www.srilankabusiness.com/fruits-and-vegetables/fruit-and-vegetable-export-performance.html

EDB Sri Lanka. (n.d.). Fruits, nuts, and vegetables. Retrieved from https://www.srilankabusiness.com/fruits-and-vegetables/overview.html

FAO. (2017). The State of Food and Agriculture 2017. Leveraging Food Systems for Inclusive Rural Transformation. Rome.

FAOSTAT: Food and Agriculture Organization of the United Nations Statistical Database. (2020). [invalid URL removed]

Food and Agriculture Organization (FAO). (2014). Developing sustainable food value chains – Guiding principles. Rome.

Gereffi, G., Humphrey, J., & Sturgeon, T. (2005). The governance of global value chains. Review of International Political Economy, 12(1), 78-104.

Gulati, A., Minot, N., & Delgado, C. (2005). Growth in high-value agriculture in Asia and the emergence of vertical links with farmers. In A. Gulati & J. Fan (Eds.), The dragon and the elephant: Agricultural and rural reforms in China and India (pp. 261-282). Johns Hopkins University Press.

Hector Kobbekaduwa Agrarian Research and Training Institute. (2023). Export potential of major fruits in Sri Lanka. http://harti.gov.lk/images/download/reasearch_report/new/rf_251.pdf

Hector Kobbekaduwa Agrarian Research and Training Institute. (2018). Quality and Safety issues in fruit and vegetable supply chains in Sri Lanka: A Review.
Hellin, J., Lundy, M., & Meijer, M. (2009). Farmer organization, collective action and market access in Meso-America. Food Policy, 34(1), 16-22.

HLPE. (2021). Food security and nutrition: Building a global narrative towards 2030. Rome: Committee on World Food Security.

IICA. (2019). The Role of Agriculture in Rural Development in Latin America and the Caribbean. San Jose, Costa Rica.
International Fund for Agricultural Development (IFAD). (2020). Rural Development Report 2020: Creating Opportunities for Rural Youth. IFAD.

International Trade Centre (ITC). (2023). Market Access Map. Retrieved from https://www.macmap.org/
Jayasekara, R. G. A. S. & Jayawardena, W. A. (2016). Profitability and Competitiveness of Smallholder Banana Production in Sri Lanka. Tropical Agricultural Research, 27(4), 425-436.

Jayaweera, D. M. A. (1982). Medicinal Plants Used in Ceylon. National Science Council of Sri Lanka.

Kerr, R. B. (2020). COVID-19 and global food security. Global Food Security, 26, 100403.

Kitinoja, L., & Kader, A. A. (2021). Postharvest technology of horticultural crops (4th ed.). University of California, Agriculture and Natural Resources.

Lakshman, W. D. (1997). Rural Poverty in Sri Lanka: Measurement, Trends, and Analysis. World Bank Publications.

Maertens, M., & Swinnen, J. F. M. (2015). Trade, Standards, and Poverty: Evidence from Senegal. World Development, 67, 161–178.

Michelson, H. C. (2021). Inclusive business models in agricultural value chains: A review. Journal of Agribusiness in Developing and Emerging Economies, 11(3), 308-328.

Ministry of Agriculture Sri Lanka. (2023). It is decided to build the Third Sour Banana Export Processing Factory in Muravasihena area of Hambantota at a cost of Rs.65m. https://www.agrimin.gov.lk/web/index.php/en/en/news-scroll/2241-13-09-2023-1e
Ministry of Agriculture Sri Lanka. (2023).

The first batch of Sri Lankan organic sour bananas cultivated in Jaffna will be exported to Dubai on 28th April 2023. https://www.agrimin.gov.lk/web/index.php/en/en/news-scroll/2045-12-04-2023-1e

Moore, M. (1985). The State and Peasant Politics in Sri Lanka. Cambridge University Press.
Observatory of Economic Complexity. (n.d.). Tropical Fruits in Sri Lanka.

OECD. (2022). Review of Agricultural Policies: Chile 2022. Paris.

Perera, A.A.S.P., & Jayawardena, W.A. (2016). Supply chain analysis of fruits in Sri Lanka: A case study of banana. Journal of Agricultural Sciences - Sri Lanka, 11(1), 1-11.

Pushpakumara, R., Abeysinghe, D., & Kumarathunga, P. (2014). Antioxidant potential and phenolic content of underutilized fruits Flacourtia inermis and Flacourtia jangomas in Sri Lanka. Journal of Functional Foods, 10, 174-181.

Ray, C. (2000). The EU LEADER programme: Rural development laboratory. Sociologia Ruralis, 40(2), 163-171.

Scoones, I. (1998). Sustainable rural livelihoods: A framework for analysis. IDS Working Paper, 72.

Sri Lanka Export Development Board. (2023). Sri Lanka's Export Performance in May 2023. https://www.srilankabusiness.com/news/sri-lanka-s-export-performance-in-may-2023.html

Stamm, A., Gunasekara, T., & von Braun, J. (2011). Strengthening value chains in Sri Lanka's agribusiness: a way to reconcile competitiveness with socially inclusive growth? German Development Institute.
The Morning. (2023). Agri. Min. to double its sour banana exports by 2025. https://www.themorning.lk/articles/X6IePXgLEkQIjgfJ6bWZ

Trade Map: International Trade Centre. (2022). https://www.trademap.org/

UNCTAD. (2021). The State of Commodity Dependence 2021. Geneva.

United Nations Development Programme (UNDP). (2021). Sri Lanka Human Development Report 2020: Recovering Together – Leaving No One Behind. UNDP Sri Lanka.

USDA: United States Department of Agriculture. (2023).

Wanninayake, W.M.C.B., Weerasinghe, U.M.I.R.K., & Jayasinghe-Mudalige, U.K. (2018). Sri Lankan Fruit Exports: Potentials, Barriers and Prospects. The Colombo Journal of Economics, 1(1), 43-62.

Wimalaratana, W. (Ed.) (2011). Agriculture and Rural Development in Sri Lanka: S.M.P. Senanayake Felicitation volume, Department of Economics, University of Colombo, 2011.

World Bank. (2018). Sri Lanka Development Update: Strengthening Competitiveness and Accelerating Private Sector-Led Growth. World Bank Publications.

World Bank. (2018). World Development Report 2018: Learning to Realize Education's Promise. Washington, DC: World Bank.

World Bank. (2023). Sri Lanka. https://www.worldbank.org/en/country/srilanka

Wossen, T., Berger, T., & Qaim, M. (2023). The impact of digital technologies on agricultural value chains in developing countries: A systematic review. World Development, 155, 106321.

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Legal Recognition of Authentication of Electronic Transactions as Cyber Security

Abeyratne, S .D .B.

According to Black's Law Dictionary, signature means a person's name or mark written by that person or at the person's direction; for Commercial agreements – Any name, mark, or writing used to authenticate a document. In Morton vs Copeland, Maule, J decided, "Signature does not, necessarily, mean writing a person's Christian and surname, but any mark which identifies it as the act of the party, provided it be proved or admitted being genuine, and be the accustomed mode of signature of the party." The author's signature may be necessary to verify the genuineness of a document as the legal requirements, and it must fulfill two primary conditions: that it is unforgeable and authentic.

There is no formal requirement for signatures of documents under common law[1] or even UCC in the USA. However, section 18 of the Prevention of Frauds Ordinance (in Sri Lanka) requires the signature of the document maker (prom or agreement in writing) for its reliability. This legal requirement has lasted for more than a hundred years worldwide.

Signature expects to identify the Signature of the person, identify the signatory who placed the signature, and approve the document's contents as genuine by the signatory. Some countries have started accepting digital signatures, while others have electronic signatures. However, most states have explained digital signatures, applying the meaning of electronic signatures. Black's Law Dictionary defines a `digital signature' as a secure digital code attached to an electronically transmitted message that uniquely identifies and authenticates the sender. Regarding the exactdefinition, a limited the other hand, signatures provided in different forms, like placing it using a special pen on an electromagnetic field, providing biometric signatures like recognition of an individual's retina pattern, fingerprint or DNA, etc., cannot be explained as digital signatures.

Any person involved in a commercial transaction will expect confidentiality and integrity of their exchanges. This was fulfilled by placing the signature of the maker of the instrument. The significant difference between a handwritten Signature and an electronic signature is that a handwritten Signature is almost the same or similar on nearly every document he signed during his lifetime; however, different electronic signatures of the same person can be applied to other messages. Further, Considering the number of forgery cases and convictions of the accused in the world during the last couple of centuries, handwritten signatures can be easily reproduced and used for fraudulent activities. However, it is not easy to duplicate electronic signatures or digital signatures. The standard signature appears to be signed, and the physical dimension of the paper and layout of the texts are relied on to express any additions or alterations of the handwritten signed document. The involvement of mathematical formulas in digital Signatures and electromagnetic-optical methods in electronic Signatures will explain the message sought to be signed more definitely.

Currently, there is a rapid development of computer networking and the sharing of information in cyberspace. User expectations

[1]Bassano vs Toft [2014] EWHC 377 (QB) at 42

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of electronic transactions are its `reliability' and `security.' Even though electronic transactions and the Internet have been designed to target trade and commerce, the required tools and resources to maintain cyber-security, preventing them from cyber-attacks in cyberspace, are not automatically and freely available on the Internet. Confidentiality, integrity, and retrievability (and availability ofelectronic information) of electronic commercial transactions are identified as cybersecurity. Authentication methods fulfill cybersecurity as a significant component in managing electronic documentation for many organisations. The introduction of laws recognising such authentication to protect electronic records and electronic communication and information contained therein will achieve Electronic Commercial Transactions' desired level of trustworthiness.

Implementing cybersecurity standards as policies is a part of Compliance Management (the process of an organisation operating to achieve its expectations) has focused on various compliances involved in Information and Communication Technology, minimising the risk of threats against Electronic Commercial Transactions. This requirement is derived from laws and regulations under changing global regulatory and business environment as externally driven factors, e.g., Data Protection laws/Privacy policies, etc. and reasons to stay in business, earn profits, and maximize the benefits of compliance management, etc. as internally driven forces, e.g., Identifying `risk and opportunities' increasing efficiency of their services and customer responsibilities to stay in business. In this mission, security controls are applied to electronic commercial transactions at the organisational (top to bottom levels of management to the employment of the organisation), and technical standards of the organisation facing new challenges in cyberspace. As a result, an organisation must regularly identify threats and understand future trends and possible solutions to implement a well-defined ICT security compliance as its management solution.[2] Cybersecurity goals of electronic transactions are set up some recent challenges against IT security compliance management are ; to maintain confidentiality, integrity, and retrievability (availability).[3] Privacy builds the trustworthiness of the user of Electronic Commercial Transactions against disruption, retrieval or removal of `sensitive information' by unauthorised third parties, while the same is travelling through the Internet. These contribute to the loss of user confidence in electronic commercial transactions. If it is

[2]According to IBM IT Security Compliance Management Design Guide, the main dimensions of ICT security compliance management includes:

1.Selection of IT security controls
2.Random and periodic checking
3.Number of IT security controls
4.Follow up time frame
5.Scope of IT security compliance checking
6.Level and depth of reporting
7.Level of automation.

It will be derived from the Business environment of the organisation, regulatory & legal obligations, organizational complexity, technological complexity, the maturity of ICT security policy framework influence if and how IT security compliance management in a specific environment, etc.

undisclosed electronic information to the rest of the world, 100% confidentiality is expected without having any access to it by anyone other than its creator. On the other hand, there is no value in any transaction if the receiver to whom the sender expected to send such an electronic message also has no access.

Legal Recognition of Electronic Signatures

In Wilkens vs Iowa Insurance Commissioner,[4] the signature involved in the case was computer-generated rather than hand-signed, and it was held that the same had met the signature requirements of the statute. Itn Molodysky vs Vema Australia Pty Ltd, it was decided that the defendant vendor is making a Signature by facsimile and then faxing a document to the plaintiff considered as a copy signed by that person (vendor). Cohan J said `...copy of the agreement, when it bears the facsimile signature of the representative of the vendor, he intends it to be used for facsimile purposes and delivered as his signature, was a copy signed by that person'.

In the USA, UETA will act as the governing law for a contract between parties primarily. If there is no UETA enacted by a State, the E-Sign Act will apply. Both UETA and E-Sing Acts avoid denial of the legal effect of certain transactions in interstate or international commerce on the ground that a Signature, contract or record relevant to such transactions is in electronic form or electronic record or electronic signature was used to form a particular contract. However, the `prior consent' of the parties is a mandatory requirement under these two Acts. This concept is different from the need for `prior information' to enter into a contract under the EU E-Commerce Directive[5].

According to UETA, "Electronic Signature" is defined as,

(a)an electronic sound, symbol, or process,

(b)attached to or logically associated with an electronic record and

(c)executed or adopted by a person,

(d)with the intent to sign the electronic record.[6]

According to Section 9 of the UETA, an electronic record or electronic signature is attributable to a person if it was the Act of the person shown in any manner, including a showing of the efficacy of any security procedure applied to determine the person to which the electronic record or electronic signature was attributable. The effect of an electronic record or electronic signature (attributed to a person) is determined from the context and surrounding circumstances at the time of its creation, execution, or adoption, including the parties' agreement if any, and otherwise as provided by law.[7]

1.Maintenance of compliance over time
2.The complexity of the environment
3.he complexity of the IT security compliance criteria
4.Performance efficiency and cost pressure
5.Cloud computing and compliance

These policies on electronic transactions will create a new culture modifying business contracts, employment contracts, collective bargaining, etc. relevant to the organisation.

[3]Matt Bishop, Introduction to Computer Security, (Addison-Wesley Professional 2004)
[4]1990] 547 NW 2d1

[5]2000/31

[6]Horton, David. `Wills Without Signatures.' Boston University Law Review, vol. 99, No. 4, Boston University School of Law, September 2019, 1623

[7]Jared Arcari,. "Decoding Smart Contracts: Technology, Legitimacy, & Legislative Uniformity," Fordham Journal of Corporate & Financial Law, vol. 24, no. 2, Fordham Journal of Corporate & Financial Law, April 2019, 363.

E-Sign Act introduced the validity and legal effect of electronic contracts facilitating the use of electronic records and electronic signatures. E-Sign Act refuses the denial of legal effect, validity or enforceability solely because a signature, agreement or other record relating to the transaction is in electronic form.[8] However, the consumer shall provide affirmative consent demonstrating that he has consented to use electronic format.[9]

The UK Electronic Communication Act 2000 was enacted complying with the EU Directive 1999/93/EC.[10] Article 1 provides the scope of the same Directive. Accordingly, one of the purposes of the Directive is to facilitate the use of electronic signatures and to contribute to their legal recognition. It establishes a legal framework for electronic signatures and legislation in the Member Countries so as not to hinder the free movement of goods and services in the Internet market.[11] Further, to ensure freedom to provide service of certification service providers to ensure the proper functioning of the internal market even going outside.

Article 2 of the same Directive defines Electronic Signature as data in electronic form which are attached to or logically associated with other electronic data and which serve as a method of authentication.[12] In the meantime, item (6) of the objective of this Directive explains that it does not harmonise the provision of services concerning the confidentiality of information where they are covered by national provisions related to public policy or public security.

When a signature is in electronic form, it has the same legal effect as a handwritten signature and meets the requirements to qualify as a valid signature. There cannot be a denial of legal effect and admissibility of the same as evidence in legal proceedings purely on that ground. Further, according to Article 25 of Regulations (EU) No 910/2014[13] a qualified electronic signature in recognition of one Member State has the same effect in all other Member States and it explains the legal effects of electronic signatures.[14] Article 26 of the same Regulations (EU) provides requirements for advanced electronic signatures.

However, as far as the said Directive is concerned, it does not cover other legal obligations as requirements prescribed by national or community law nor does it affect rules and limits contained in national or community legislation governing the use of documents. According to definitions under EU Regulations "(5) 'authentication' means an electronic process that enables identification (electronically) of a natural or legal person or the origin and integrity of data in the electronic form to be confirmed".

The UK Electronic Communication Act, of 2000 and the Australian Electronic Transactions Act, of 1999 both have taken different attitudes on "electronic signature" leaving its

[8]eSignature (DocuSign), (University of Pittsburgh) <https://www.technology.pitt.edu/services/digital-signature-service-docusign> accessed 18 December 2022

[9]The E-Sign Act. s 101(c)(1)(C)

[10]Directive of the European Parliament and of the Council of 13 December 1999

[11]<http://www.columbia.edu/~mr2651/ecommerce3/1st/Statutes/ElectronicSignaturesDirective.pdf> accessed 11November 2020

[12]The eIDAS Regulation, An overview. <https://signeasy.com/eidas/> accessed 11 November 2020

[13]Regulation of the European Parliament and of the Council of 23 July 2014

[14]These requirements are :(a) it's linking uniquely to the signatory; (b) capability to identify the signatory; (c) creation to use an electronic signature with a high level of confidence under his sole control and (d) Capability to detect changes made subsequently.

determination to the Court if the requirements of the laws are met on a case-by-case basis. ETA 1999 (Commonwealth) and relevant State Acts were enacted removing certain legal impediments to recognise digital signatures in Australia. Section 10 of the Act explains the requirement for thename, and if a signature fulfils the requirements specified in the same section and those needed under the Law of the Commonwealth, it is considered that such conditions have been met for electronic communication.[15]

S.10 (2) does not affect the operation of any other law of the Commonwealth that makes provision for or about requiring an electronic communication to contain, an electronic signature (however described) or a unique identification in an electronic form or about electronic communication, a particular method to be used to identify the originator of the communication and to indicate the originator's intention in respect of the information communicated. Section 10(3) states that the law referred to in s.10 (1) requires the inclusion of a reference that provides consequences for the absence of a signature.

According to Stephen Mason,[16] s.11 ETA (1999) (Commonwealth) explains legal requirements to produce a document in electronic form as (a) method of generating the electronic document provides a reliable means of assuring the integrity of the information contained in the document,(b)such electronic information would be readily accessible to be usable for subsequent reference,(c)the person to whom the document is to be produced should be given the consent to the production through electronic communication, or an electronic form of the document, and (d) if the document is required to produce to a Commonwealth or State entity, requirements of IT and if the method used as mentioned in paragraph (a) be by particular information technology requirements; and likewise (d) If a signature is required to be given to neither a person is acting for Commonwealth nor a person who is Commonwealth entity and if the method used as mentioned in paragraph (a) being met, it is considered that the same requirement has been met.Commonwealth or states verification of receipt are met. It was discussed in Getup Ltd v Electoral Commissioner.[17]

Electronic Commerce Act, 1988 of India provides that, with limited exceptions, electronic records and signatures should be treated as paper records and Signature for evidentiary and record-keeping requirements complying with statutory provisions. The Act concentrates integrity of `secured electronic records' and `secured electronic signatures' providing evidentiary presumptions on them considering their trustworthiness.[18] IT Act 2008 of India[19] explains "Digital Signature" as the authentication of any electronic record by a subscriber using an electronic method or procedure following the provisions of section 3.[20]

[15]These requirements are, (a) in all cases, a method is used to identify the person and to indicate the person's intention in respect of the information communicated; and (b) in all cases, the method used was either (i) in the light of all the circumstances including any relevant agreement, as reliable as appropriate for the electronic communication was generated or communicated, or (ii) if the functions described in paragraph (a) are proved by itself or together with further evidence; and (c) if the signature is required to be given to a Commonwealth entity, or a person acting on behalf of a Commonwealth entity, it is considered that the same requirement has been met

[16] Stephen Mason, 'Electronic Evidence' (3rd edn, LexisNexis 2012) 260

[17][2010] FCA 869, 13.08.2010

[18]Divya Rohatgi, Cyber Law & Cyber Crimes, (Whites and Co 2017) 150

[19] IT Act 2008 of India, s 2(p)

[20]IT Act 2008 s 3(1), states that Subject to the provisions of this section any subscriber may authenticate an electronic record by affixing his Digital Signature

Electronic Signature is legally recognised Under Section 5 of the Act.[21]Initially, "digital signature" was introduced by the Information Technology Act 2000 in India. As far as the Rules made for the said Act, India had maintained a hybrid model to support both digital Signature and electronic Signature to coexist.

Later,an amendment was brought under the said Act in 2008 introducing "electronic signature" substituting the words "digital signature" for the same Act widening the scope of the same removing possible technical issues could create. Section 3A has been inserted by the IT Amendment Act 2008, defining electronic Signature and Electronic Signature Certificate. Accordingly, the IT Amendment Act 2008 accepts scanned, handwritten Signatures, biometric personal identification numbers and other methods like clicking on the "OK" or "I accept" buttons on a website. It shall be reliable if the signature creates data or authentication, data attached to the signatory and is not in the control of any other person and any change to the signature after it is signed, detectable and any change to the content of the message is also detectable if it is electronically signed. Further, standards of interpretation shall be laid down in consultation with organisations like NASSCOM and/or other bodies that can assist in the establishment of required rules. The said situation has been analysed by Karnika Seth.[22]

Nandan Kamath explains "The Act deals with digital signatures so that the electronic records can have legal effect or authentication...the signature summaries to identify a person by signing the signer marks the text in his unique ways and makes it attributable to him and to provide certainty and proof as to the personal involvement of that person in the act of signing."[23] S.15 of the IT Act 2008 considered electronic Signature as a `secured electronic signature' taking into account the nature of transactions, circumstances and other related matters. S.84[24] has empowered the central government to prescribe modes and methods for Encryption to promote electronic commerce. Section 3(2) of the same Act explains that the authentication of the electronic record shall be effected using the asymmetric cryptosystem and hash function which envelopes and transforms the original electronic record into another electronic record.[25]

An electronic signature is to be considered as a secured electronic signature if it can verify that at the time an electronic signature was affixed was

[21]"Where any law provides that information or any other matter shall be authenticated by affixing the signature or any document should be signed or bear the signature of any person then, notwithstanding anything contained in such law, such requirement shall be deemed to have been satisfied if such information or matter is authenticated by means of digital signature affixed in such manner as may be prescribed by the Central Government."

Explanation - For this section, "Signed", with its grammatical variations and cognate expressions, shall, with reference to a person, mean affixing of his handwritten signature or any mark on any document and the expression "signature" shall be construed accordingly."

[22]Karnika Seth, 'Computers, Internet and New Technology Law' (2nd edn, LexisNexis 2016) 490-491

[23]Kamath Nandan, 'Law Relating to Computers Internet & E-Commerce' (5th edn, Universal Law 2016), 90

[24]IT Act 2008

[25]For the purposes of this sub-section, "Hash function" means an algorithm mapping or translation of one sequence of bits into another, generally smaller, set known as "Hash Result" such that an electronic record yields the same hash result every time the algorithm is executed with the same electronic record as its input making it computationally infeasible
(a)to derive or reconstruct the original electronic record from the hash result produced by the algorithm;
(b)that two electronic records can produce the same hash result using the algorithm.
(3)Any person by the use of a public key of the subscriber can verify the electronic record.
(4)The private key and the public key are unique to the subscriber and constitute a functioning key pair.

unique to the subscriber, capable of identifying such subscriber, creation was done under the exclusive control of the signatory, and no other person and alteration of the electronic record would invalidate the same Signature according to section 15 of the IT Act, 2008.

Where the law requires a signature of a person, UNCITRAL Model Law on Electronic Commerce[26] fulfils such requirements for a data message if a method used to identify the person and to indicate the information contained in the data message with the approval of that person and the same method is fit and reliable for generation and communication of data message considering all circumstance including any relevant agreement. This provision is applied where the requirement is an obligation or the law provides consequences for the absence of a signature. A similar arrangement has been introduced under the UN Convention on the Use of E- Communications in International Contracts.[27]

Before ratifying the said UN Convention, section 7 of ETA 2006 Sri Lanka (repealed) had introduced provisions following Article 7 of the UNCITRAL Model Law on E-Commerce as if information or communication is required to be authenticated by affixing the signature, or that any document should be signed or bear the signature of any person, such requirement shall be deemed to be satisfied if such information or matter is authenticated using an electronic signature.

It was decided in Commissioner General of Inland Revenue vs. Janashakthi Insurance Co.Ltd[28] that the impugned notices of assessment have been issued under TIN (Tax Identification Number) No.134003642 since it has been mentioned in the letter dated 16th January 2006 that the impugned notices of assessment will be issued under the same TIN. Indeed, the said TIN No.134003642 had been mentioned in the letter dated 30th December 2005, the letter dated 16th January 2006 and the impugned notices of assessment. Thus, when considering these facts, it would be for the Court to form the view that the said TIN No.134003642 has served as an electronic signature. In the circumstances of this case, the Court has accepted the same as an electronic signature in terms of provisions of the Electronic Transactions Act No. 19 of 2006.

Legal Recognition of Digital Signatures

Some methods of authentication are; typing the sender's name at the end of the e-mail[29](on an e- mail) or internet order form,[30] display of one's e-mail address at the top of communication, using of Personal Identification Number (PIN), making a voiceprint, giving a retinal scan, use of a cookie left by a computer when the user visits a website, copy of one's signature and/or seal scanned into communication and place electronic signature and/or seal on communication by the device automatically and so on.

Digital Signature, a category of electronic signatures with the said primary conditions fulfilling the said requirement for electronic transactions, provides secured authenticity for electronic records or electronic communication. It is an authentication mechanism that enables the creator of a message to attach a code that acts as a signature. It can be used to authenticate the identity of the sender of a message or the signatory of such electronic information, and possibly to ensure that the original data of the message or document that has been sent is

[26]Article 7

[27]Article 9(3)

[28]CA (Tax) Appeal No. 10 / 2013 decided on 8.6.2018 by P.Surasena J. P C/A and K.K.Wickremesinghe J.

[29]Lamle vs Mattel Inc (2005) 394 F 3d 1355 (Fed Cir) – considered Common Law before the enactment of e-transactions legislation

[30]Cloud Corporation vs Hasbro Inc [2002] 314 F 3d 289

unchanged. It is formed by taking the hash of the message and encrypting the message with the private key of the creator.

American Bar Association Digital Signature Guidelines read "Digital Signature is created and verified cryptography, the branch of applied mathematics that concerns itself with transforming messages into seemingly unintelligible forms and back again. Digital Signatures use what is known as ' public-key cryptography ' which employs an algorithm using two different but mathematically related 'keys', one for creating a digital signature or transforming data into a seemingly unintelligible form, and another key for verifying a digital signature or returning the message to its original form. Computer equipment and software utilising two such keys are often collectively termed an 'asymmetric cryptosystem".[31]

A digital signature, can be automatically time-stamped and ensure the originality of the signed message arrives intact whether it is encrypted or not. It is easily transportable and can be applied easily for any kind of message and the receiver can get assurance about the sender's identity. Its effect cannot be limited by a third party and even the sender cannot easily reject its authority later.[32]

Accordingly, the use of a digital signature shall have the same force or effect as a manual signature if it is,
(a) Unique to the person using it,
(b) Capable of verification,
(c) Under the sole control of the person using it, andlinked to data and if the data is changed, the digital signature is invalidated.

Under normal circumstances, end of the long-written paper-based document or contract author of the document or parties to the contract will place their signatures fulfilling authentication of the same, and it will be an authorised document for legal purposes.[33] However, one cannot expect to set off an electronic signature at the end of such a document, and the requirement is to associate such an electronic signature with the electronic record.

Position of Electronic Transactions Act after ratifying the UN Convention by Sri Lanka

Sri Lanka on 7.7.2015 ratified the UN Convention and the new section 7 of ETA was introduced following the said Article 7 of the UNCITRAL Model Law on Electronic Commerce.[34] Following Article 9(3) of the UN Convention, Sri Lanka has repealed the original section 7 of ETA 2006 by section 5 of the Amendment Act No.25 of 2017 providing a clear and specific definition for legal recognition of Electronic authentication compared to the earlier section. By inserting the said new section, the country has taken a more liberal position to maintain functional equality between authentication using electronic methods and ordinary signatures. Accordingly, the requirement of the written law to sign or

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[31] American Bar Association Digital Signature Guidelines, (ABA: Chicago 1996) 9

[32] <www.SearchSecurity.com> accessed 12 August 2020

[33] Aiyar P.Ramanathan, the Law Lexicon, (1997 Edition) 1775

[34] Section 7 of the ETA directly recognised authentication of any information or communication by affixing the signature or any document should be signed or bears the signature of any person upon any law and irrespective of anything contained in such law using an electronic signature

Explanation of section 7– for the section, `sign' with its grammatical variations and cognate expressions, shall, concerning a person mean, the affixing of his hand-written signature or any mark on any document and the phrase,`signature' shall be construed accordingly."

bear the signature of any person is deemed to be met with a data message, electronic document, electronic record or communication electronically,

(a) if a method is used identifying that person and

(b) Indicating the intention of the person in respect of the information contained in the electronic communication.

(c) A reliable method used appropriately to generate, send or communicate the electronic communication, in the light of all the circumstances. It includes any relevant agreement or proven to have fulfilled the said functions described by itself or together with further evidence.

Section 7(a) confirms that the application of cybersecurity is for the information contained in electronic communication but not for the data message, electronic document, electronic record or bare communication. In the United States V Siddiqui[35] also it was decided that the admissibility of the e-mail will depend on the purpose of sending the same e-mail.

Section 26 of the ETA, 2006 of Sri Lanka has been amended following the said Convention, interpreting `electronic signature' as data in electronic form affixed to logically associate with a data message, e-document, e-record or communication used to identify the signatory to such information and to indicate the signatory's intention in respect of the information contained therein.[36] However, it is clear that words a method of authentication of electronic transactions under section 7 of the Amended ETA of Sri Lanka is not limited to `electronic signature' and it can be any method applied for electronic transactions if the other requirements of the same section are fulfilled. However, the legislature has not taken steps to change the headnote of the new section 7, and it carries the short explanation of the section as `Legal recognition of electronic signature' for no reason misleading the objective of the new section.

It further considers that technology used for electronic signature is reliable if it is created within the context in which the same is used, linked to the signatory but not with any other person and is under the control of the signatory and of no other person from the time of it's signing. The application of "Digital Signature" subject to section 23 of the ETA will play a vital role in fulfilling the requirements under section 7 of the same Act as amended in Sri Lanka. A digital signature is identified as a `secure signature' created by a computer under section 18(2) of the ETA, 2010 of Singapore.

Amended section (da) of 19 (3) of the ETA of Sri Lanka authorises Certification Service Providers to issue various types of electronic signatures following criteria and guidelines as may be prescribed, including operational framework and security procedure for the use of biometric data and other authentication technologies for verification purposes. However, all service providers have not authorised Certification Service Providers, and there is no compulsion to obtain a license or authority to engage in the business of providing certification services in Sri Lanka under the Amended ETA.

In the meantime, there is no legal protection defined under the ETA dealing with situations where change or error in an electronic record, e.g. changes of metadata (data of data) occur

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[35]235 F.3d 1318, 1323 (11th Cir 2000)

[36]Electronic signature' had been explained under repealed section 26 of the ETA of 2006 as `any letters, numbers, symbols, images, characters or any combination thereof in electronic form, applied to (incorporated in or logically associated with an electronic' < http://www.ft.lk/columns/Electronic-documents-and-transactions--Is-it-as-easy- as-it-seems--Part-I/4-707905> accessed 19 December 2020.

due to technical issues during the transmission of data. Such situations can create disputes between parties to a contract. Accordingly, clear provisions shall be introduced as an amendment to the ETA or regulations prescribing the method of application of an electronic signature as a reliable method of authentication by notification in the Official Gazette after accepting the same as reliable officially. The section should prohibit any electronic signature used as an authentication technique is unreliable. Even though there are no such provisions included under the Electronic Transactions Act in Sri Lanka, the proviso of section 21(2) of the same Act provides a requirement that there shall be no reason to believe that the information contained in a data message, or an electronic document, electronic record or other communication in electronic form is unreliable or inaccurate for admissibility of the same.

Following Article 9(3) of the UN Convention, Singapore also has introduced a new section 8 to the Electronic Transactions Act, 2010 inserting most of the similar provisions37 described under section 7 of the Amended ETA of Sri Lanka. Both section 7 of Sri Lanka and section 8 of Singapore are considered equivalent functional directions to electronic and other documentary evidence.

The functional requirement of electronic authentication is to identify the signatory and his intention concerning the information. However, there is no specified form of electronic Signature given in these two Acts. Accordingly, the method used to confirm the identity of the signatory who is involved in an electronic record and the intention of the signatory for the information is a matter of fact, and the same shall be reliable and appropriate considering its purpose.

As a result, it is the primary duty of the party who wishes to forward electronic information as evidence under the ETA to satisfy that such party has taken acceptable security measures applying adequate and reasonable authentication techniques removing possible doubts relating to the accuracy and reliability of the information contained in the data message, or an electronic document, electronic record or other communication in electronic form. Under these circumstances, providing explicit legal provisions needs more legal protection to build the trustworthiness of Electronic Transactions.

[37]Where the rule of law requires a signature or provides for inevitable consequences if a document or a record is not signed, that requirement is satisfied with an electronic record if, (a) a method is used to identify the person and to indicate that a person's intention in respect of the information contained in the electronic record; and(b) the method used is either (i) as reliable as appropriate for the purpose for which the electronic record was generated or communicated, in the light of all the circumstances, including any relevant agreement or (ii) proven in fact to have fulfilled the functions described in paragraph (a), by itself or together with further evidence.

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Dr Sunil D.B.Abeyaratne (Justice of Peace and Unofficial Magistrate) enrolled as an Attorney-at-law of the Supreme Court of Sri Lanka in 1986. He received Doctor of Philosophy degree (Faculty of Law, University of Colombo), LL.M in Commercial and Corporate Law (Queen Mary College of the University of London) and completed arbitration award writing of CCLS. He obtained MBA (Indira Gandhi National Open University, India) and a Diploma in Forensic Medicine, Science and Toxicology (Faculty of Medicine, University of Colombo). Currently, he holds the positions of Chair of the Data Protection, Communication and Technology Committee of LAWASIA, the Advisory Committee to Review the E-Commerce Law in Sri Lanka, Arbitration Centre of Kandy, the Institute of Legal and Management Studies in Sri Lanka, ICT Law Committee of the Bar Association of Sri Lanka and ICT Lawyers' Guild of SriLanka.

Thriving Amid Change: How Accounting, Finance, and Business Pofessionals Can Stay Relevant in a Competitive Landscape

Ansary, Z.

Abstract

In times of extraordinary change, it is crucial for professionals to invest in their development and evolve their skills to stay relevant. With rapid changes impacting all aspects of business, focusing in a few key areas will be critical for success. Adopting a growth mindset, committing to lifelong learning, outlining long-term goals, and building strong networks and platforms will enable today's professionals to future-proof themselves.

Introduction

Change is the only constant in today's world. If we take a moment to look around us, not just in Sri Lanka but across the world, we can see that uncertainty and disruption are everywhere – from a global economy in transition to geopolitical tensions and pivotal elections to digital transformation, we have a lot to think about and prepare our organisations for. Our profession is looked at to for guidance and stability in a rapidly changing world.

Highly-skilled accounting, finance, and business professionals should have no problem finding new opportunities to grow their careers, whether it's by taking on new responsibilities at work, getting a promotion, or changing jobs. However, with so many changes taking place around us, we must make sure that we stay relevant and build today the skills that we will need to succeed tomorrow.

Adopting a Growth Mindset

Uncertain times are less stressful when you approach them with a growth mindset, with the belief that skills and intelligence can be improved through effort. So when something unexpected happens, consider what you can learn from it and how you can apply the lesson to other aspects of your life.

The shift to remote work — for some of us, was an abrupt shift — and its accompanying rise in the use of cloud technology and automation tools have transformed the way many of us work. Rather than resisting (or resenting) these changes, consider how they could enrich your career. Embracing new tools might, for instance, allow you to spend more time with clients or, by freeing up mental bandwidth, spark new ideas and insights.

There are now ample opportunities to learn online, you can even gain new credentials and certifications. For example, the Government of Sri Lanka recently launched a website, which provides access to free learning resources for all Sri Lankans – www.publiclearn.lk – and we, at AICPA & CIMA, also offer a number of online learning resources, including conferences, courses, and practical guides.

Adopting a growth mindset and embracing lifelong learning can also help you anticipate future events. By continuously learning, speaking with people within and outside the profession and keeping up with developments

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within your specialty, you may spot trends that help you develop a better sense of the profession's future.

Learning to Pivot

The past few years have provided a crash course on adapting to change. Organizations had to pivot overnight from working in person to operating remotely, while also adjusting to a flurry of unexpected financial changes.

Organizations and professionals who met the challenge emerged with increased agility and a reputation for handling crises with grace. In our line of work, almost always, the leadership would refer to the Finance professionals (as they are the trusted advisers) during times of change, which is why it's so important to develop agility and critical thinking skills.

Professionals can hone these skills during periods of relative calm by scenario planning. You can conduct thought exercises or hypothetical projects to prepare for both negative and positive outcomes. For example, how would you pivot if your product had a raging negative review on social media? Or how would you make the most of a windfall?Although many don't want to even consider worst-case scenarios, doing so can alleviate anxiety — if the worst comes to pass, you'll have a plan in place.

Mapping Out Your Career

When planning for an uncertain future, it helps to think big but start small. In other words, pinpoint the skills essential to your long-term career goals and form a realistic plan to gradually develop and implement them.

Unless you're planning an immediate career change, it could be a waste of time to learn skills tied to a specific role you may want to land in the future. In ten years, that role could have completely transformed or might no longer exist.

Instead, consider your desired career trajectory more broadly and define the skills that would help you achieve it. For example, if you know you want to lead a team at some point, it makes sense to develop skills related to leadership and communication. And if you want to become more familiar with emerging technologies, you might earn a data analytics certificate.

Once you have selected a skill to focus on, develop a feasible plan and find ways to deploy those skills in your current role. If you want to develop your leadership skills, for example, you could start by taking an online course and reading top books on management. You could then seek to lead a small project that puts your skills to work. This could even be leading a Club at work – such as a Toastmasters club, or CSR club etc.

There are also ample opportunities now in Sri Lanka through other service driven organizations such as Rotaract, Rotary, Lions, Leo, etc.

Always Be Networking

Surveys suggest that around 85% of critical jobs are found through networking. Everyone knows the importance of networking but not everyone is intentional about doing it.

Networking will feel less like a chore if you approach it with genuine curiosity. Put yourself in a situation (an industry conference, for instance) where you will meet new people; set a goal to connect with five new people over the course of the event.

Of course, you don't even have to leave your desk to form and strengthen connections. Schedule networking into your workweek by setting up calls or virtual coffee breaks with one new and one existing connection each month.
Among those you connect with you might find a new friend, a new client or a valued mentor.

And they could be the key to your dream job.

Standing Out from the Crowd

In a deeply interconnected world, you must be able to show employers anywhere in the world your understanding of business, your commercial acumen, and your expertise as a business partner and value creator. This is precisely why having a global professional qualification in your chosen area of expertise, such as the Chartered Global Management Accountant (CGMA) designation, can be helpful to bolster your credibility in a competitive job market, enhance your career prospects, and showcase your dedication to continuous improvement.

References

Adopting a growth mindset - https://www.aicpa-cima.com/professional-insights/article/changing-competencies-and-mindsets

adapting to change. https://www.aicpa-cima.com/topic/people-leadership-and-advancement/people-leadership-and-advancement-change-management
critical thinking skills - https://www.aicpa-cima.com/cpe-learning/course/critical-thinking-skills

hone these skills during periods of relative calm by scenario planning - https://www.aicpa-cima.com/campaigns/earn-an-aicpa-certificate-and-amplify-your-expertise

long-term career goals - https://www.aicpa-cima.com/professional-insights/article/accounting-for-success-3-key-skills-to-elevate-your-career

skills related to leadership - https://www.aicpa-cima.com/cpe-learning/people-leadership-and-advancement

earn a data analytics certificate. - https://www.aicpa-cima.com/resources/landing/data-analytics-certificates

taking an online course - https://www.aicpa-cima.com/resources/landing/aicpa-leadership-academy
reading top books on management - https://us.aicpa.org/interestareas/youngcpanetwork/resources/

reading reading top books on management-https://us.aicpa.org/interestareas/youngcpanetwork/resources/

85% of critical jobs are found through networking. -https://www.linkedin.com/pulse/new-survey-reveals-85-all-jobs-filled-via-networking-lou-adler/

online learning resources, including conferences, courses, and practical guides. https://www.aicpa-cima.com/cpe-learning

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A Geological Study of Stream Sediments, Residual Soils Pinpoints Occurrence of Different Types of Gem Minerals in Elahera Area, Sri Lanka

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Abstract

Gem deposits frequently occur in certain terrains of high grade metamorphic rocks. Present study focuses on the Elahera gem field which is located in the north-central and central provinces of Sri Lanka, which has produced a significant amount of gemstones. This research has emphasized to identify different types of gem minerals in stream sediments, residual soils and past alluvial deposits in the area. Aerial photographs and geological maps were used to identify the geological features which have played a role in sediment deposition and to study the transportation of sediment. Gem minerals were separated from the mineral concentrates using heavy liquid (sodium polytungstate) and mechanical sieve separation (63-1000 micrometer range was used). Magnetic separation was carried out to separate the heavy minerals (Balage et al.,2023) Laboratory grain mounts were prepared for identification and quantification of gem mineral grains. Residual beds bear gem minerals which are mostly formed in-situ. These were located on flat regions bordering the Hunukotuwa - canal. Alluvial beds contain gem minerals transported along rivers and deposited farther from the source rocks and the deposits are located close to the rivers and they contain rounded and sub-rounded pebbles, sand and clay. Optical mineralogical studies revealed that there are several gem mineral types in the samples. It is discovered that especially, different colors of spinel and garnet were found as major gem minerals. Also there were tourmaline, kornerupine, calcite, quartz, zircon, corundum, chrysoberyl, topaz, kyanite and beryl (Balage et al.,2023).

Keywords: *Elahera gem field, Aerial photographs, Magnetic separation, Optical mineralogical studies, Gem minerals*

Introduction

Since ancient times Sri Lanka is well known as an Island in which gem deposits occur in certain terrains like Sabaragauwa Province, Elahera area in the Central Province and Badulla area in the Uva Province. These gem stones frequently occur in high grade metamorphic rocks. Sri Lankan gemstones predominantly occur in the Highland Complex.

Nearly all the gem deposits of Sri Lanka are derived from the granulite facies rocks of the Highland Complex, clearly indicating that there were pressure, temperature conditions and chemical compositions suitable for the formation of gemstones (Prame, 1991).

The source rocks of the gem minerals are skarn, garnetiferous gneisses, and charnockites and other meta-sedimentary gneisses (Dissanayake and Rupasinghe, 1995). Although most of the gem deposits in Sri Lanka are clearly derived from metamorphic gneisses which were formed from aluminium rich parent materials, in addition to that calcium rich bedrock is a source for gem minerals within the metamorphic terrain of Sri Lanka.

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Skarn bodies were formed by the reaction of pegmatitic fluids with marble (Dissanayake et al., 2000). On the basis of field and laboratory studies three major types of gem deposits are recognized as eluvial, residual and alluvial (Dahanayake et al., 1980).

Pegmatite and hydrothermal intrusive rock outcrops are commonly abundant in the Matale district (Fernando et al., 2011) and these rocks could be potential gem bearing rocks. Most of gem exploitation is done in the flood plains and hill slopes characterized by many ridges and broad valleys (Dahanayake et al., 1980). Residual beds bear gem minerals which are mostly formed in-situ. These are located on flat and sloping regions bordering the ridges and away from rivers. Eluvial beds have minerals transported along slopes of ridges and deposited away from the parent rocks (Dahanayake et al., 1980). It is still not known about the exact types of gem minerals which occur in the Elahera gem field as well as the probable bedrock source materials in the high hills from which gemstones were derived to be found as sedimentary alluvial deposits. This is considered as a research and knowledge gap and present research study will strive to address this research question by studying river and stream sediment samples collected in the streams and rivers in the Elahera area. It is understood that studying stream sediments could be the best approach to understand the possible gem mineral types occurring in the Elahera area as well as the origin and formation of gem mineral bearing sediments after liberating from the bedrock sources due to physical and biochemical weathering and subsequent erosion.

The study would emphasize how gem minerals were liberated from the source rock due to weathering, how these liberated gem particles are transported and the different types of depositions occur in different environments which caused formation and occurring of gem minerals in Elahera – Kalu ganga area. Also, formation of the gem mineral deposits within this area was covered in this study.

Streams are essential for the transportation and deposition of sediments derived from the weathering of the gem mineral bearing source rocks. In this area of Kalu ganga river catchment a network of 1st order 2nd order streams may have caused the transportation of gem minerals. A sedimentological, stream and river sediment study, and bedrock petrological and mineralogical studies are strong necessities to address the research question. This study had objectives, to investigate about different types of gem mineral occurrences in the study area, to attempt to pinpoint gem mineral bearing source rock areas, to understand the role of transportation agents of gem sediments. In order to compare gem mineral types in the study area (Figure 01).

The study area located between longitudes 7 o 34′ 54″ N and 7 o 37′ 51″ N and latitudes from 80o 48′04″E to 80o 50′ 34″E and covers about 14.36km2.The area under study extends from Elehera - Pallegama area which is located in Matale district to Polonnaruwa district and in the east of the Central province. When considering the Sri Lankan regional Geology, the study area is lying on the north eastern segment of the Highland Complex of Sri Lanka. Quartzite, Marble, garnet sillimanite biotite gneisses with tiny graphite flaks are the most dominant metasedimentary rocks in this area (Figure 1). Undifferentiated charnockitic gneiss can be seen as inter-banded metaigneous rocks (Figure 1). Following the East-West regional lineaments, Etamagolla canal and Hunukotuwa canal which are nearly parallel tributary courses of Kalu ganga and are flowing, passing across the lithological contact zones of above mentioned lithologies. But, the stream course of Kalu ganga is confined to garnet sillimanite biotite gneiss band within this study area. Also, its stream course is nearly parallel to the axial trace of Kalu ganga synform. The Etamagolla canal and Hunukotuwa canal are the well-known gem occurring areas of Sri Lanka which is connected to Hattota Amuna (Figure 1).

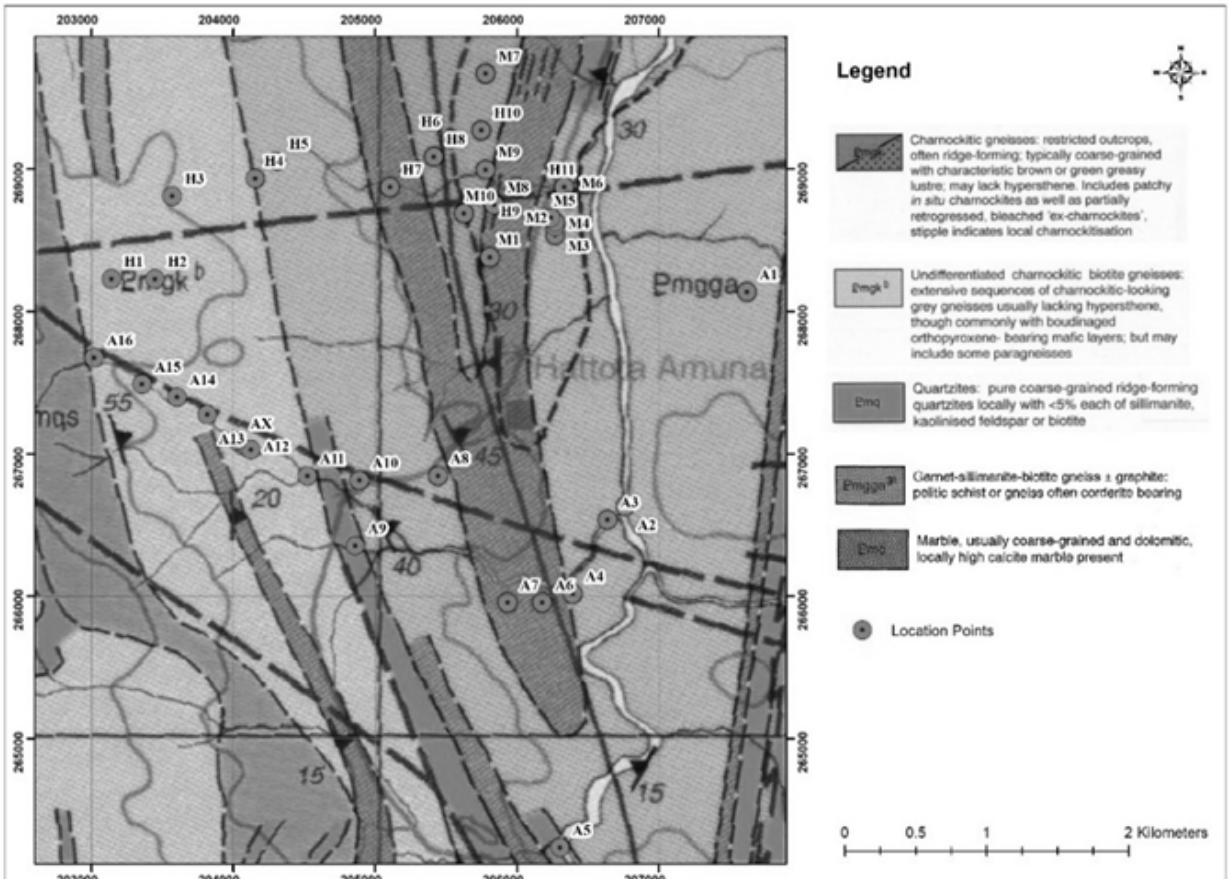

Figure 1 Geological map of the study area (after geological survey and mines bureau map).

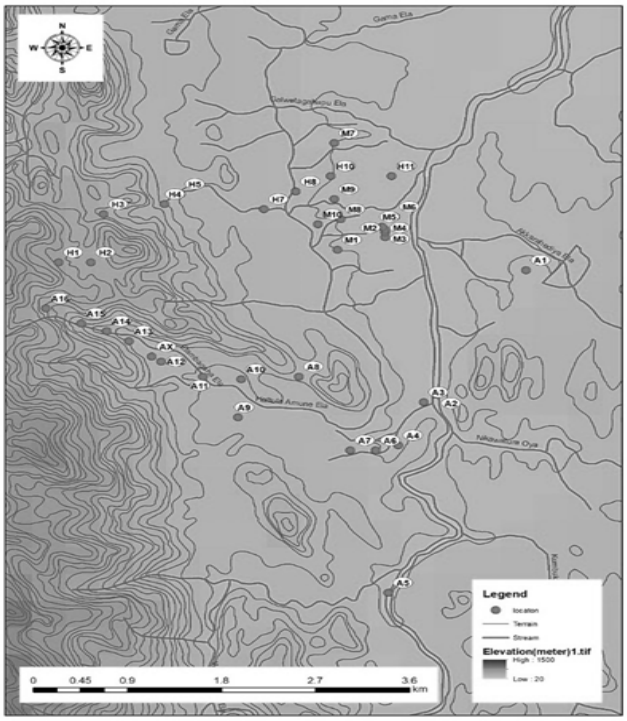

Figure 2. Drainage pattern and topography of the study area in relation to the stream sediments and all sediment sampling points

Drainage pattern of upper part of Kalu ganga is of dendritic type and there is a parallel flowing minor tributary known as Hunukotuwa canal and Etamagolla canal meet Kalu ganga. Some of the tributaries are seasonal streams which do not have water flow for more than 1-2 months. During the north-east monsoon period the heavy rainfall causes an increase of the runoff. In that period, Stream sediments are transported during high stream discharge.

As a result of selective concentration of gem minerals placer deposits are formed. Placer deposits are derived from the weathering of pre-existing rocks, and accumulated by wind, water and gravity. Running water transports detrital sediments to a place where they deposit, perhaps on a stream bed. Eventually, they would get deposited when forces of gravity overcome those trying to move them. The varieties of gem minerals in the alluvial deposits depend on the nature and mineralogical composition of the source rocks in the drainage basin. Normally, the gem minerals tend to be more resistant to weathering and destruction and become more robust and survive weathering processes. In a sedimentary terrain, gem minerals are fine to coarse grained, well rounded and consist of most resistant minerals.

Methodology

A literature study and an interpretation of aerial photographs, topographic sheets and a pilot field survey to study the geology of the area and geological samples was carried out. It was also intended to carry out a detailed field, mineralogical and sedimentological study. The profile relationship with grain sizes was studied. A number of gem mineral species had an affinity to certain grain sizes. This reflected their initial size in the source rocks. Identification of gem minerals was done by magnetic separation, optical analysis and using refractive indices (R I). For that purpose liquids were selected with high R I readings.

Sampling sites were selected along streams, residual soil formations and old sediment deposits based on the prior information about the regional geology, occurrence of gem mine fields and the processes that influence the existing sediment distribution. Geological and topographic maps, aerial photographs, and land-use maps were used to understand these processes and related stream characteristics (Dissanayake and Rupasinghe, 1993). Samples were collected from the catchment areas along which streams flow and deposit sediments in Elahera area (Figure 2). Using pre-cleaned hand shovel, 27 sediment samples (each samples approximately 1kg) were collected from stream sediment profiles. Another 10 samples were collected from former stream sediment profiles and residual formations which are now present in paddy fields in which mines are located. In this study it was identified two canals which originated from two separate hills and ended up at the Kalu ganga. The Canals named Etamagolla canal and Hunukotuwa canal are located dividing the present gem mining area of Elahera and they are very close to the mining sites. Etamagolla canal is descending from a hill to Kalu ganga River via 8km and Hunukotuwa canal is about 7km.

Taking samples from the canals at regular intervals as well as after changes of lithology, texture and flow regime were considered. Samples were picked from distance of 0.5km intervals. The canals running via certain places which are having water pools and bedrock masses. In those pools gem minerals may be deposited and while it goes through rocks, shapes of the mineral may change from its original shapes.

Even though grain sizes influence gem mineral composition, usually fine to medium grained sands were selected. Almost all samples contained few heavy minerals and organic materials which were not gem minerals. Grains were cleaned of adhering clay, mud and flocculated particles by drowning in water basin. It was done by mechanical stirrer. Then the

sand was separated to another basin. Residue sand was collected and same was put into a gold pan. Removal of organic substances and low dense minerals were carried out by panning and retaining high denser material in the pan. The remaining portion was dried under the temperature of 1050C for 24 hours and sieved to extract required grain sizes. First unwanted finer particles (<63 micrometer) were removed from the sands. Then in the range of 63<1000 micro meter sands were separated. This is the particle size range which gem bearing grains are most commonly occurring.

Laboratory grain mounts were prepared of stream sediment mineral grains and were studied under the microscopes for identification and quantification of gem mineral grains and other gem minerals. Gem minerals including heavy minerals were separated from the mineral concentrates using heavy liquids and sieve particle size separation. In preparation of grain mounts a selected fraction of grains was mounted on glass microscopic slide using epoxy resin (Refractive index (n) =1.53). In the grain mounts, it was essential to distribute the grains evenly on the slide, avoiding overlapping and denser packing of grains. Optical microscopes were used to identify the minerals. Grain counts were made under microscope on the microscopic slide and relative abundances were calculated. The data was tabulated, maps were prepared and a quantitative data analysis using computer systems was used in final interpretation.

The methods by which gem minerals are separated in laboratory is the separation by heavy liquid and by magnetic separation. The principle for liquid separation is that minerals with different specific gravities can be separated from each other by the liquid whose specific gravity lies between the two minerals. The gem minerals sink to the bottom and lighter mineral float at the surface. The apparatus used is known as the separating funnel.

A heavy liquid solution based upon Sodium polytungstate (3Na2WO4.9WO3.H2O) is widely used in mineral separation. Sodium polytungstate when chemically pure, has specific gravity of 2.8 at 25oC, which is an adequate criterion for the purity of the liquid. Use of water is essential or the recovery of a heavy liquid solution after the mineral separation. (Ijlst, 1973).
Magnetic separation of mineral particles depends on the magnetic susceptibility of the minerals to be separated. As much as there is wide variation in magnetic susceptibility of mineral particles of a given species, it is common practice to set the separator slope at 10o - 30o, the till at 5o to 20o and then determine the most effective amperage by trial and error. Minerals which are magnetic at 0.3, 0.4, 0.55, 0.8 and 1.2 amperes setting on the magnetic separator.

The principle of this technique is to apply successive refractive index liquids to stick the grains onto microscopic slide. First microscopic slide should be prepared by rubbing on a glass on which boric powder has been spread. Then it is dried by keeping on a surface of a hotplate for two hours. Selected sample grains also should be kept on the surface of hot plate to be dried, A mixture of thin section epoxy part A and part B (10:1 volume) is spread onto a microscopic slide and allowed to dry. Then grains are sprinkled evenly on the surface of the mixture of dry epoxy resin. Evenly dispersed and preferred grain orientations are promoted by gently sliding the cover glass backward and forward with plastic tweezers while the mounting medium is in a liquid state. To stabilize the grains it is necessary to keep in 700C temperature for 24 hours. Apart from using grain mounts grains which were subjected to heavy mineral separation and magnetic separation were sprinkled evenly on to a surface of a microscopic slide and then observed from both stereoscopic microscope and petrological microscope.

After the separation of mineral grains, they were mounted on glass slides. Internal features were observed firstly under a microscope. All sec-

tions thus obtained were initially examined using reflected light with a polarizing microscope. Grains showing evidence of textural features of interest were marked for further study. A few selected minerals were then photographed using a microscope. Various analysis was conducted on a criterion of physical properties, such as mineral color, inclusions, and striations. Further to that these characteristics were studied under the polarizing microscope. Grain sizes and shapes were examined.

Result and Discussion

The Figure 3 shows the aerial photograph taken in 1999 covering the study area. It provides a wealth of information about the geology, geological structure, topography, geomorphology and the natural drainage network. The photo also shows the natural vegetation cover and the influence of man-made activities.

The Figure 3 shows the aerial photograph taken in 1999 covering the study area. It provides a wealth of information about the geology, geological structure, topography, geomorphology and the natural drainage network. The photo also shows the natural vegetation cover and the influence of man-made activities. The western part of the photo shows the underlying structure of bedrock. The strike of foliation layers orients towards northwest to southeast direction (c of Figure 3). There are two joint fracture plains as sets of joints. One joint set runs roughly east west direction (a of Figure 3) and the other joint set runs north west- south east direction (b of Figure 3). The geomorphology shows a characteristic ridge and valley topography.

The main tributary Kalu ganga (d of Figure 3) runs as a strike river along the northwest - southeast strike valley (c of Figure 3). The two major valley flanks are dissected by stream drainage pattern/streams (f of Figure 3) which feed Kalu ganga. On the other hand the upper parts of the study area is mainly covered by forests. There are gentle to flat flood plain land areas (e of Figure 3). Since, Kalu ganga is running alone a strike valley the bedrock foliation layers which belong into different source rocks are found to be clearly subjected to weathering and erosion processes.

The source of Hunukotuwa canal, Kakkutu - ulpatha begins from a joint fracture of a gneiss bedrock. Gems which may occur in this bedrock and could be transported along with the water flow. Most of the samples were collected from the streams . The samples were good representation of the area, since a few streams have been joined and flown down to meet Kalu ganga covering a significant fraction of the area. The geological map (Figure 1) the study area also gives information about gem bearing source rocks exsisting in the drainage basin.

The Figure 4 shows a mining site of a residual gem deposit in the study area. Different kinds of layers could be seen clearly in the Figure 4 Malawa is the weathered bed rock (Dissanayake et al., 1993) and residual soil formations which indicate the gem bearing layer located in the upper part of that. Gem minerals are located at the layer (b) of the mine (Figure 4). Angular shapes of the minerals indicated that they are primary gem deposits.

It was observed that elevations of the selected locations of Elahera range from 340m to 110m. Even though it is a flat land it could be observed that a few hills are not having significant heights. But water springs occur from those hills and flow down to the Kalu ganga via these flat lands. But, apart from transportation of minerals through the streams to the area, it was observed that in-situ mineral deposits were also found. The shape of the minerals of the collected samples was observed. Most of the minerals were angular shaped. Therefore, it has indicated that other than transported minerals they are occurred in-situ deposits. As a result of that it could be identified those as placer deposits.

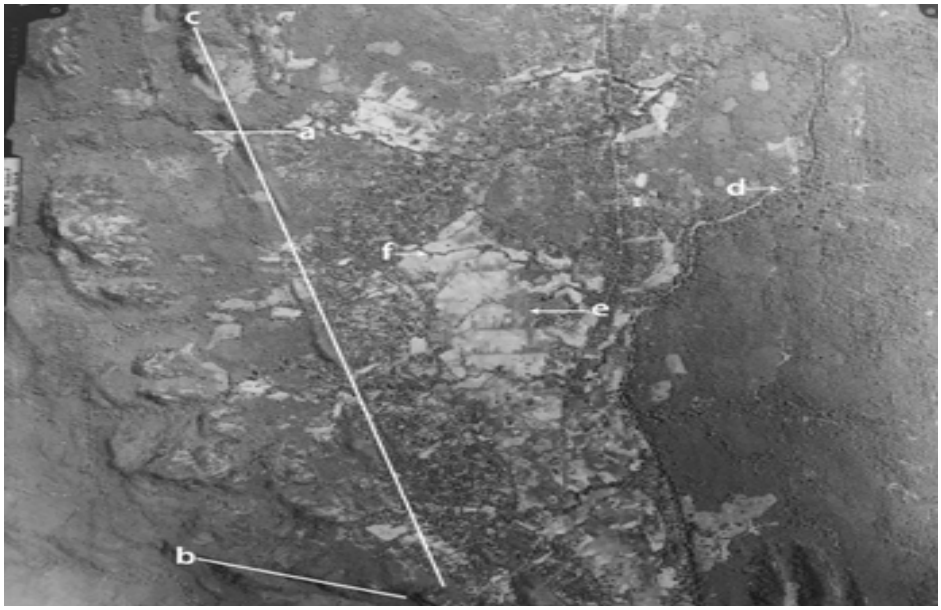

Figure 3. Scan image of an aerial photograph in the study area (a) a joint set, (b) another joint set to another direction, (c) strike, (d) Kaluganga, (e) flat area, (f) streams.

Figure 4. Mining site in a flat land area shows sediments layers. (a) malawa (b) gem bearing layer (c) gravel (d) river sediment (e) clay

When heavy minerals were separated from the low dense mineral by heavy liquid separation it was noticed that great percentage of weight of the samples was low dense minerals. The reason for this was quartz was abundant and it was a dominant mineral (Table 1,2 and 3). Then, it was noted that opaque minerals were dominant in the weight percentages and ilmenite and rutile were mostly among them (Table 1,2 and 3). Even though there was high percentage of quartz abundant and the gem quality quartz were about 30 percent from total quartz. Each and every gem mineral types which was discovered is described as follows.

Table 1. Mineral weight percentages of samples of Hunukotuwa – canal.

Mineral	H1 (W %)	H4 (W %)	H7 (W %)
Beryl	0	0.11	0
Calcite	0	7.96	0
Diopside	0.07	0	0.38
Feldspar	1.22	1.85	1.53
Garnet	10.01	8.99	16.89
Hornblende	4.51	0.57	1.09
Hypersthene	0.36	0.3	0.2
Ilmenite	34.9	12.74	22.2
Kornerupine	0	0.25	0
Leucoxene	0.39	0	0.49
Limonite	0.28	0.05	1.63
Magnetite	5.63	0.02	5.77
Mica	0	1.88	0
Monazite	0.43	0.06	0.29
Quartz	36.74	47.55	43.42
Rutile	0.99	3.05	3.76
Sillimanite	1.39	4.73	0.59
Spinel	0.15	8.22	0.2
Topaz	0	0	0
Tourmaline	0	0	0
Tremolite	0	1.55	0
Zircon	2.91	0.09	0.83

Spinel was an abundant gem mineral in the study area as indicated in the Table 1,2 and 3and Figure 5a. Multi colored spinels in different sizes were identified (Figure 5a). Bluish ash color was the dominant color of the spinel grains, from observed series of blue color. In addition to that pink color series was observed. Habit of octahedron was observed in most of the spinel grains and it helped to distinguish them from garnet, even as the reliefs of the both minerals are approximately similar. There are spinels which were in its original habit, octahedron. Although round shapes of spinels were observed and it indicated that they were transported through streams from hills to the flat lands.

Table 2. Mineral weight percentages of samples in flat land area

Mineral	M1 (W %)	M3 (W %)	M4 (W %)	M5 (W %)	M6 (W %)	M7 (W %)	M9 (W %)
Beryl	0	0	0	0	0	0	0
Calcite	0	6.66	0.13	14.98	5.14	1.91	0
Corundum	0	0	0.01	0	0.01	0	0
Diopside	0	0.44	0	0	0	0	0
Feldspar	4.28	4.44	2.55	2.13	1.7	5.26	1.65
Garnet	6.82	4.35	39.6	9.36	16.42	16.02	2.05
Hornblende	0.03	1.1	0.94	0.31	1.8	0.53	0.43
Hypersthene	0	0	0	0.04	0	0.17	0.09
Ilmenite	29.44	4.66	7.24	8.09	7.92	6.49	52.71
Kornerupine	0	0.28	0	0.27	0.06	0.01	0.03
Leucoxene	0.53	0.16	0.04	0.23	0.2	0.03	1.08
Limonite	0.39	4.96	0.25	0.27	0.08	0.46	6.12
Magnetite	0.01	0.01	1.19	0	0.01	0	0
Mica	0.63	7.34	0	0.58	1.32	0	0
Monazite	0.31	0	0.97	0.02	0.09	0.12	0.1
Quartz	23.65	49.68	37.58	45.98	50.97	59.66	26.47
Rutile	12.99	0.58	5.59	4.31	4.18	3.96	2.57
Sillimanite	4.85	1.29	2.98	2.64	1.71	2.91	1.19
Spinel	14.85	4.91	0.39	9.75	7.89	1.9	4.95
Topaz	0	0.05	0	0	0	0	0
Tourmaline	0.01	0.06	0	0	0	0	0.01
Tremolite	0.3	9.01	0	0.76	0.09	0.14	0
Zircon	0.88	0	0.52	0.26	0.4	0.41	0.51

Quartz was the most abundant mineral in the area and most of the gem quality quarts were observed as colorless. Here (Figure 5l), light pink to purple quarts were separated from garnet and spinel using cross polar microscope very easily, because quartz is an anisotropic mineral. Further to that quartz appeared with a low relief and had low density. Therefore, when heavy liquid separation was carried out, it was quartz appeared as the most of floating minerals.

Garnet was the most abundant gem mineral in the samples as indicated in Table 1,2 and 3 and Figure 5d. They were transparent and showed pink to dark red color and adamantine luster (Figure 5d). Most of them are angular larger grains with conchoidal fractures. Higher hardness of the garnet had protected the grain size which resistant to mechanical weathering. There were many varieties of garnet observed. Such as pyrope, almandine, hessonite, grossular and rhodolite. Euhedral crystals of garnet were observed and was easily separated under optical microscope in 0.4 A using magnetic separator fraction.

Colors of the tourmaline were identified as greenish brown to yellow. And also, there were opaque crystals in the grains which could be easily separated. Presence of the tourmaline indicates that the source rocks could be granitic pegmatites (Figure 5c). Conchoidal fractures and striations were observed under the optical microscope. Certain extent was in non- gem quality tourmaline.

Table 3. Mineral weight percentages of Etamagolla – canal

Mineral	A1 (W %)	A2 (W %)	A5 (W %)	A7 (W %)
Beryl	0	0	0	0
Calcite	0	0	0	0
Diopside	0.07	0.12	0	0
Feldspar	1.22	2.37	26.72	4.61
Garnet	10.01	9.2	9.38	29.08
Hornblende	4.51	2.73	0	0
Hypersthene	0.36	0.25	0.22	0.23
Ilmenite	34.9	14.43	6.29	6.3
Kornerupine	0	0	0	0
Leucoxene	0.39	0.83	0.42	0
Limonite	0.28	0	1.74	0.97
Magnetite	5.63	0.88	0	0.46
Mica	0	0.05	0	0
Monazite	0.43	0.36	0.49	0.46
Quartz	36.74	57.82	45.3	41.6
Rutile	0.99	4.67	6.42	11.26
Sillimanite	1.39	3.62	1.02	3.55
Spinel	0.15	0.37	0.52	1.46
Topaz	0	0	0	0
Tourmaline	0	1.12	0	0
Tremolite	0	0.02	0	0
Zircon	2.91	1.14	1.45	0

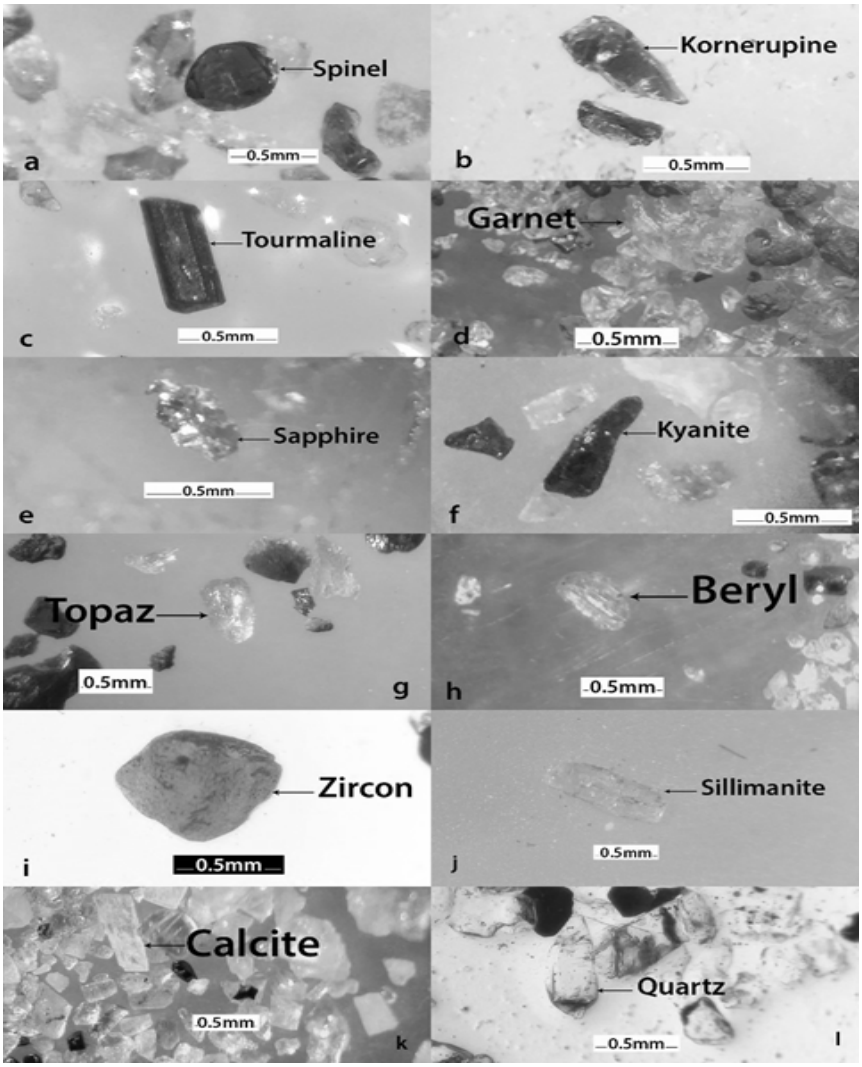

Figure 5. Identified gem minerals from the studied samples, (a) spinel (b) kornerupine (c) tourmaline (d) garnet (e) sapphire (f) kyanite (g) topaz (h) beryl (i) zircon (j) sillimanite (k) calcite (l) quartz

Only in the sample M3 colorless topaz was observed (Figure 5g). Topaz is a heavy gem and only found in the paddy field area. Because, it was not traced any amount of topaz in stream samples it was assumed that topaz in the Elahera area could be found in residual form only.

Most of the sapphires are colored varieties of corundum. In this area it was observed that colorless and yellow sapphires are prominent, but blue color sapphires are well known. Elahera produces particularly fine blue and blue sapphire with even coloration and transparency (Gunawardene and Rupasinghe, 1986). The asteriated stones are usually grayish blue, but dark blue star sapphires are found on occasion (Gunawardene and Rupasinghe, 1986). It was difficult to identify sapphire while observing the grain mounts which were made from sands of streams. But while observing the sands from flat area which were close to Kalu ganga, it was possible to identify sapphire in small quantity. Though it was hardly found in the samples they were confirmed as sapphires using R.I. liquids. The area consists of marble and appeared as residual deposits. Angular shape of the mineral reinforced the above concept.

Kyanite (Al2O3SiO2) was in dark blue color

which is showing a little higher refractive index than spinel and it shows pleochroism. Kyanite was observed (Figure 5f) in a negligible amount in one or two samples.

Zircon ($ZrSiO_4$) was not an abundant gem mineral in the mining area, but could be observed as few minerals in samples from Etamagolla canal. Color varies, but grains from the study area are generally clear to colorless, white and yellowish green with a dull luster (Figure 5i). Due to high resistance to weathering, most of the observed particles were in angular shape. Here, green colored oily lustered zircon minerals could be observed with a high relief. Zircon revealed many interesting internal features. Most abundant are the disc-like fissures that parallel one another (Gunawardene and Rupasinghe, 1986).

Study of characteristics of sillimanite (Figure 5j) in study area suggests that, they are largely derived from the khondalites of the Highland Complex. The prismatic shape of the minerals also suggests that they are derived from khondalitic rocks. Sillimanite has a higher hardness and most of the minerals were colorless. There are splintery fractures which provided elongated grains. Sillimanite was the most abundant mineral in the nonmagnetic fraction.

Beryl is not a heavy mineral. Therefore, it was separated from other heavy minerals by the use of heavy liquid. The quantity of beryl is not significant in the samples (Figure 5h). But it could be identified by observing separated low dense minerals. Here, colorless beryl was identified (Figure 5h). As per the views of the miners, aquamarine is not that rare in the area.

Negligible amount of chrysoberyl was observed and because it has been transported for a significant distance and it was no longer an angular though it is a hard grain. Cat's eye stones are also found here. Elahera chrysoberyls, including alexandrite and chatoyant stones were found to be relatively cleaned and transparent (Gunawardene and Rupasinghe, 1986).

Kornerupine was not an abundant mineral in the samples, but it could be identified easily by its color brownish green and was verified by the R.I. reading (Figure 5b).

Calcite (Figure 5k) is not a heavy mineral, therefore, calcite could be observed among floating minerals after the heavy liquid separation. Some of the calcite grains were in gem quality, but most of them were not.

Ilmenite ($FeTiO_3$) is a common accessory mineral in igneous and metamorphic rocks where it is often associated with hematite or magnetite. It is opaque, with a deep brown to black color and metallic to sub metallic luster. Ilmenite was commonly found in all samples with small variation of their concentrations. High concentration of ilmenite was observed in 0.3A fraction of magnetic separator.

Conclusion

On the basis of this research study the following conclusions could be made.

1.It was found that garnet, spinel, quartz, tourmaline, kornerupine, zircon, calcite, topaz, feldspar, beryl, corundum, chrysoberyl, kyanite are the different types of gem minerals occuring in the study area.

2.The study shows that primary gem minerals are associated in the gem mining location that have been found in the paddy field area in which present mines do exist. The secondary gem mineral deposits are associated with stream sediments that have been found along the Hunukotuwa and canal Etamagolla canal. But it was also observed that primary deposits are more predominant in the area.

3.The study reveals that gem minerals that were originated in country rocks belong to the Highland Complex, such as quartzite, marble, garnet sillimanite biotite gneisses and calc silicate rocks/skarns.

4.The visual study of sediments in the field revealed that gem mineral grains tend to be sorted out well by the influence of currents in the flowing water when sedimentary deposits are formed, but primary deposits are formed in-situ in the residual soils of the paddy field terrains due to weathering of the underlying bedrock.

Acknowledgements

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References

Balage, N.I., Amarasinghe, U.B. & Ransinghe, R.L.D.S., (2023). Genesis and occurance of gem minerals in the Elahera Gem Field, Sri Lanka: Insights from sedimentary, residual, and alluvial deposits in the Kalu ganga river catchment. Extended abstracts of Gemmologists Association Research Symposium 2023, 9-11.

Cooray, P. G., (1994). The Precambrian of Sri Lanka. A historical overview, Precambrian Research 66, 3-18.

Dahanayake, K., Liyanage, A.N. & Ranasinghe, A.P., (1980). Genesis of sedimentary gem deposits in Sri Lanka. Sedimentary Geology, 25(1-2),105-115.

Dissanayake, C.B. & Rupasinghe, M.S., (1995). Classification of gem deposits of Sri Lanka. Geologie en Mijnbouw, 74, 79-79.

Dissanayake, C.B. and Rupasinghe, M.S.,(1993). A Prospectors' Guide Map to the Gem. Gems and Gemology, 29(3),173-181.

Dissanayake, C.B. Chandrajith, R., & Tobschall, H.J. (2000_. The Geology, Mineralogy and rare element Geochemistry of the gem deposits of Sri Lanka. Bulletin of the Geological Society of Finland 72, Parts 1-2, 5-20.

Fernando, G.W.A.R., Pitawala, A. & Amaraweera, T.H.N.G., (2011) Emplacement and evolution history of pegmatites and hydrothermal deposits, Matale district, Sri Lanka. International Journal of Geosciences. 2, 348-362.

Gunawardene, M., & Rupasinghe, M.S. (1986). The Elahera gem field in central Sri Lanka. Gems and Gemology 22(2) , 80-95

Ijlst, L. (1973). New Diluents in heavy Liquid mineral separation and an improved method for recovery of the liquids from the washings. 58, 1084-1087.

Prame, W. K.B.N. 1(991). Metamorphism and nature of granulite facies crust in Southwest Sri Lanka- Characterization by pelitic/psammo- pelitic rocks and associated granulites. In; Kroner, A. (Ed.), The Crystalline Crust of Sri Lanka. Part 1, Summary of Research of the German- Sri Lanka Consortium. Geological Survey Department. Sri Lanka, Professional Paper 5, 188-200.

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Unlocking Economic Growth and Strategic Advantages: Potential Benefits for Sri Lanka from BRICS

Bulathsinghala , G.

BRICS is an acronym representing a coalition of the world's prominent emerging market economies: Brazil, Russia, India, China, and South Africa.

BRICS Photo: VCG

In 2006, Brazil, Russia, India and China created the "Bric" group. Subsequently South Africa joined in making it "Brics". The inaugural summit of the BRICS was held on 16 June 2009 in Yekaterinburg, Russia. This summit with its expanded membership signaled a renewed commitment to the principles of the cooperation and mutual benefit that have defined the coalition since its then. The inclusion of these new member states strengthens the coalition's collective voice in advocating for reforms in global economic governance and promoting a more equitable international order. The BRICS summit in Yekaterinburg holds particular significance as the birthplace of the coalition's formalization.

This city's status as a cultural and industrial hub underscores the BRICS' commitment to fostering cooperation across various sectors, from trade and investment to technology and innovation. The 1st BRIC Summit was attended by Dmitry Medvedev (Russia), Lula da Silva (Brazil), Manmohan Singh (India) and Hu Jintao (China).

Expansion of the BRICS

The expansion of the BRICS coalition to include Iran, Egypt, Ethiopia, and the United Arab Emirates on 1st January 2024 marks a significant milestone in its evolution. This enlargement underscores the growing influence and appeal

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of the coalition beyond its original founding members. With these new additions,the BRICS alliance now represents a more diverse array of geopolitical interests and regional perspectives.

The BRICS alliance's emphasis on non-interference, equality, and respect for sovereignty resonates strongly with the aspirations of many countries in the Global South, particularly in Latin America and Africa. By providing a platform for political, economic, and cultural exchanges, BRICS offers the regions an alternative avenue for cooperation and development that is not beholden to Western hegemony.

Influence in Global Economic and Political Landscape

As the BRICS alliance matured and expanded, its role in shaping the global economic and political landscape became increasingly significant. By fostering deeper cooperation and solidarity among member states, BRICS presented a compelling vision for a more multipolar world order grounded in principles of mutual respect, equality, and shared prosperity.

Together, the BRICS nations span approximately 30% of the world's land surface and are home to 45% of the global population. Brazil, Russia, India, and China rank among the top ten largest countries in terms of population, territorial expanse, and gross domestic product (GDP) both in nominal and purchasing

power parity (PPP) terms. The recent inclusion of Iran, Saudi Arabia, and the UAE expands BRICS' collective population to around 3.5 billion people, representing 45% of the world's inhabitants, with economies collectively valued at over $28.5 trillion, or roughly 28% of the global economy.

Among the BRICS nations, China leads with the largest GDP, reaching $16.86 trillion U.S. dollars in 2021, while the others maintain substantial economic clout, notwithstanding below the three-trillion-dollar mark individually. Collectively, the BRICS bloc boasted a GDP exceeding $25.85 trillion U.S. dollars in 2022, slightly surpassing that of the United States. Additionally, these nations jointly produce approximately 44% of the world's crude oil.

BRICS' ambitions extend beyond economic cooperation to challenge the dominance of the US dollar in global trade. While aspirations to de-dollarize the global economy persist within BRICS, the likelihood of fully replacing the US dollar remains uncertain. However, if successful, the introduction of a new BRICS currency could potentially weaken US sanctions and diminish the dollar's dominance, though experts debate the feasibility and consequences of such a shift. BRICS wants to see a "greater voice and representation" for emerging economies. In 2014, the BRICS nations set up the New Development Bank to lend money to boost infrastructure.

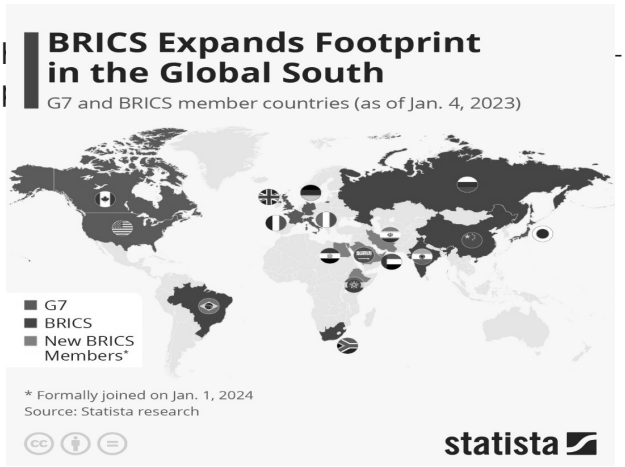
After Russia invaded Ukraine in 2022, many BRICS indexes dropped Russia from their portfolios, and Russia-specific ETFs were delisted from American exchanges. An exchange-traded fund (ETF) is a pooled investment security that can be bought and sold like an individual stock. ETFs can be designed to track specific investment strategies and are available to investors for various purposes, including income generation, speculation, price appreciation, and risk management. "The sanctions against Russia and China over the last 18 months have acted as a catalyst," said Christopher Weafer, the CEO of business consultancy Macro-Advisory Ltd. He noted that both Moscow and Beijing are now trying to reduce their reliance on Western economies, having seen the consequences of economic penalties firsthand.

Sri Lanka’s Intention to Join BRICS

On 21 May 2024 in an interview with news agency ANI, Sri Lanka's Foreign Minister Ali Sabry stated that the country wishes to join BRICS this year. Foreign Minister Sabry added that Sri

Lanka has been keen to join the global bloc and plans on reaching out to India for assistance in its membership bid. "We will look forward to BRICS. Also, I think the cabinet had appointed a sub-committee to look into that and recommend to us. We would like to see that becausewe would like to have multiple options. Who doesn't want to? So therefore BRICS is a good body, particularly since India is a part of it," Sabry told ANI.

Sri Lanka is among about 30 countries expressing interest in joining BRICS this year. Pakistan has also applied for membership, seeking support from Russia and China. Of the 30 interested countries, 15 have formally applied, including Algeria, Bahrain, Bangladesh, Belarus, Bolivia, Cuba, Kazakhstan, Kuwait, Pakistan, Palestine, Senegal, Thailand, Venezuela, Vietnam, and Nigeria.



https://www.statista.com/chart/30672/brics-expansion-map/

Promising New Opportunities for Sri Lanka

Analysts foresee substantial benefits for Sri Lanka upon joining BRICS, anticipating positive impacts on its economy, infrastructure development, and geopolitical positioning. Access to duty-free trade and financial support from BRICS development funds holds the promise of elevating living standards andtackling pressing economic challenges within. Moreover, Sri Lanka's strategic location at the nexus of major maritime trade routes positions it as an attractive destination for investment in infrastructure projects, potentially propelling it into a regional trade and technology hub.

The expansion of aviation and maritime facilities, alongside investments in local infrastructure by BRICS member states, stands to bolster Sri Lanka's connectivity and appeal to multinational corporations seeking access to emerging markets. This concerted effort could catalyze the diversification of Sri Lanka's industries beyond its reliance on tourism, empowering it to emerge as a vibrant participant in the global economy.

Moreover, joining BRICS could help Sri Lanka navigate the geopolitical tensions between China and India, leveraging its relationships with both countries while benefiting from the support of the entire BRICS community. By fostering a more balanced and conflict-free regional environment, Sri Lanka could pursue its economic and strategic interests more effectively within the framework of the coalition.

Circumnavigating the Complexities

However, it's essential to acknowledge both the praise and criticism surrounding BRICS. While supporters commend its efforts to promote global economic equity and cooperation among emerging economies, critics raise concerns about internal disparities and conflicting interests among member states. Additionally, questions about certain BRICS countries' records on democracy and human rights underscore the need for the coalition to uphold its

stated principles of equality and mutual benefit. Overall, BRICS remains a significant and influential player in the global arena, with its actions and decisions closely watched by both proponents and critics. The group's ability to navigate internal and external challenges will be crucial in determining its future impact on the world stage.

In conclusion, on observant reflection BRICS presents promising opportunities for Sri Lanka and other member states, its ability to address internal challenges and uphold its principles will determine its long-term impact globally. By circumnavigating these complexities, BRICS can continue to play a significant role in shaping the future of global economic governance and cooperation.

The writer has demonstrated a commitment to thoroughness by diligently integrating open-source information into this narrative. Also commendably recognize and value the personal insights shared within the discourse. In today's intricate and constantly evolving global and regional landscape, it is crucial tocomprehend the ongoing dynamics fully. Simply with such understanding effective strategies could be developed and executed to navigate the complexities of our world.

References

Garciam, A. (2023). The BRICS expansion, https://latinoamerica21.com/en/the-brics- expansion/

Caballero, J. (2024). The competitiveness strengths of the expanded BRICS. https://www.henleyglobal.com/publications/brics-wealth- report/competitiveness-strengths-expanded-bricsJames, C. (2024).

What is an exchange-traded fund (ETF) https://www.investopedia.com/terms/e/etf.asp

Katanich, D. (2023). How the BRICS expansion could shake up the world economy.

Euronews Business.euronews.com/business/2023/08/29/how-the-brics-expansion- could-shake-up-the-world-economy

Salim, K. (2024). Joining BRICS opens new possibilities for Sri Lanka. https://www.ft.lk/opinion/Joining-BRICS- opens-new-possibilities-for-Sri-Lanka/14-761845

Conte, N. (2024). Economic growth forecasts for G7 and BRICS countries in 2024: Visual Capitalist. https://www.visualcapitalist.com/economic-growth-forecasts-for-g7-and-brics-countries-in-2024/

O'Neill, A. (2024). Gross domestic product of the BRICS countries from 2000 to 2028. https://www.statista.com/statistics/254281/gdp-of-the-bric-countries/

Liaqat, S. (2023). BRICS and beyond: Shaping a new world order. Sri Lanka Guardian. https://slguardian.org/brics-and-beyond-shaping-a-new-world-order/
Samatha, M. (2016). Sri Lanka's participation in BRICS and BIMSTEC outreach summit. Indian Council of World Affairs Sapru House, New Delhi https://www.icwa.in/show_content.

Stuenkel, O. (2014). Emerging powers and status: The case of the first BRICs Summit. Asian Perspective, 38(1), 89–109. http://www.jstor.org/stable/42704855

Yadav, D. (2024). Sri Lanka joins list of countries eyeing BRICS membership . https://www.outlookindia.com/international/sri-lanka-joins-list-of-countries-eyeing- brics-membership-this-year

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Digitalization and Decarbonization of Sri Lanka's Electric Power System: A Way Forward for Sustainability

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Abstract

In the modern day, the global energy sector is undergoing a transformative shift driven by digitalization and decarbonization, essential for creating sustainable and resilient power systems. This article explores the integration of digital technologies and renewable energy sources within Sri Lanka's electric power system, aligning with the country's sustainability goals. Drawing on Elinor Ostrom's principles of polycentric governance, the study highlights how advanced digital tools and renewable energy can address key challenges, enhance system efficiency, and support the nation's transition to a carbon-neutral future.

Objectives

The objective of this article is to examine how the integration of digital technologies and renewable energy sources can transform Sri Lanka's electric power system into a resilient, efficient, and sustainable model. By leveraging the principles of polycentric governance and sustainable management frameworks, the study aims to highlight the benefits of digitalization and decarbonization, address the challenges faced in the transition, and propose actionable strategies to achieve a carbon-neutral future. This involves exploring the roles of smart grids, distributed energy resources, advanced control systems, and policy frameworks in driving

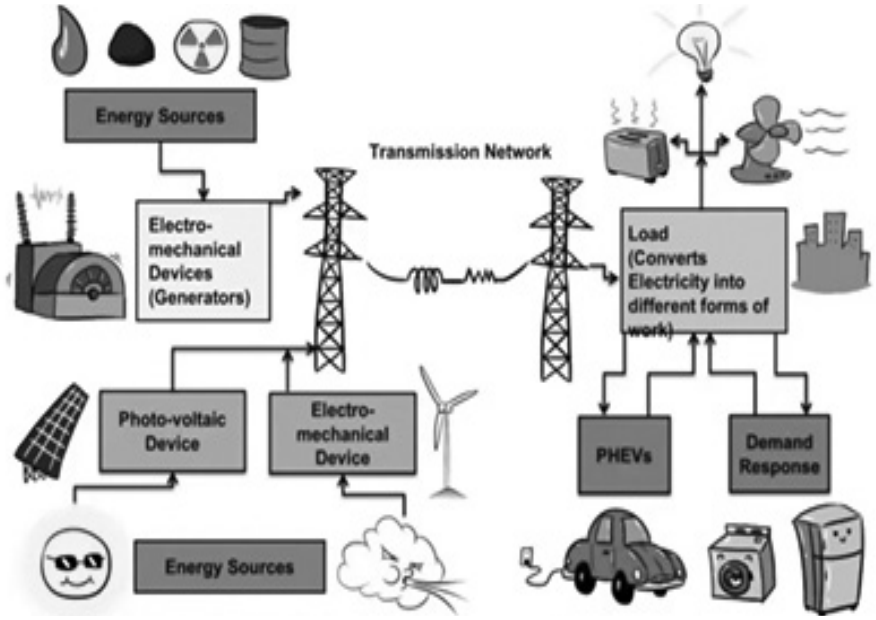

Figure 01: Future Power systems

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this transformation, ultimately contributing to the nation's sustainability goals and economic growth.

Importance and Uniqueness

The evolution of the energy industry has led to various schools of thought regarding the future of electric energy systems. Some advocate for large, clean nuclear plants and strong grids, while others favor hybrid systems with distributed energy resources (DERs) and active user participation. Another viewpoint suggests self-sufficient, decentralized microgrids. It is not prudent to take a singular position; instead, we emphasize scientific principles needed to integrate diverse stakeholders into a well-functioning dynamic system. This approach allows for the integration of advanced technologies and coordinated management of variable renewable energy sources (Sinsel et al., 2020), addressing key challenges such as aging infrastructure, reliability issues, and the need for increased access to clean energy.

The integration of specific digital technologies, such as smart grids, advanced metering infrastructure, grid-scale energy storage, and data analytics, holds immense potential for transforming Sri Lanka's power system. By embracing these technologies, Sri Lanka can address its pressing energy challenges, including aging infrastructure, reliability issues, and the need for increased access to clean energy. Smart grids, for instance, can optimize energy distribution, integrate renewable energy sources seamlessly, and improve the overall reliability of the grid (Amin & Wollenberg, 2005). Furthermore, advanced metering infrastructure empowers consumers with real-time data on their energy consumption, enabling them to make informed decisions and actively participate in demand-side management programs. Moreover, grid-scale energy storage solutions, such as battery systems and pumped hydro, can effectively balance the intermittency of renewable energy sources, ensuring a stable and reliable power supply.

Theoretical Framework and Sustainability Principles

Elinor Ostrom's principles of polycentric governance and local adaptation Ostrom, E. (2009), are crucial for designing resilient and adaptive energy systems . Her work on sustainable management of social-ecological systems (SES) provides a foundational framework for understanding how complex systems can be managed sustainably. These principles have been applied across various fields, including water management and forestry, and now offer valuable insights for energy systems. Ostrom's concepts suggest that sustainable energy systems should be managed through decentralized, interactive governance structures, aligning resource management with user needs and ecological constraints .

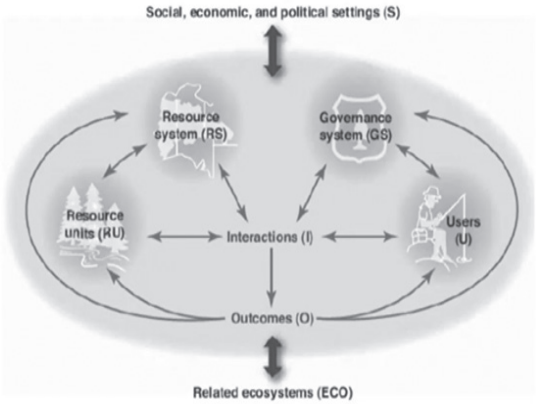

Figure 02: Elinor Ostrom's principles of polycentric governance and local adaptation

Digitalization in Electric Power Systems

Digitalization, involving the integration of advanced technologies into Sri Lanka's power grid, is crucial for enhancing monitoring, control, and communication capabilities. This transformation towards a smarter grid relies on several key components.

Smart Meters for Energy Efficiency: Deploying smart meters across Sri Lanka can empower consumers with real-time energy usage data. This enables better management of con-

sumption, facilitates demand-side response programs, and contributes to energy efficiency improvements. Smart meters provide detailed insights into energy patterns, allowing consumers to make informed decisions to reduce their energy consumption and costs.

Advanced Sensor Networks for Grid Reliability : Integrating advanced sensor networks across Sri Lanka's grid infrastructure can provide real-time data on grid performance. This data is crucial for identifying potential faults, enabling predictive maintenance, and minimizing outages. By enhancing the reliability of Sri Lanka's electricity supply, these sensor networks play a vital role in maintaining a stable and efficient power system.

Real-Time Data Analytics for Informed Decision-Making : Leveraging real-time data analytics is essential for harnessing the full potential of a digitalized grid. By analyzing data from smart meters and sensors, Sri Lanka can optimize energy distribution, predict and prevent outages, and make informed decisions regarding renewable energy integration. Real-time analytics enable dynamic adjustments to power flows, enhancing overall grid efficiency and reliability.

IoT and Big Data for a Smarter Grid : The Internet of Things (IoT) and big data are fundamental to transforming Sri Lanka's traditional power grid into a smart grid. Connecting various grid components through IoT and analyzing the resulting data can lead to more efficient grid management, improved reliability, and better integration of renewable energy sources. IoT devices enable seamless communication between grid elements, while big data analytics provide insights for proactive grid management and decision-making (Fang et al., 2012).

Decarburization Strategies

Decarbonisation aims to reduce carbon dioxide emissions by adopting low-carbon and renewable energy sources. Integrating renewable energy sources such as wind, solar, and biomass into the power grid can significantly reduce greenhouse gas emissions . Policy frameworks that support renewable energy deployment and grid integration are essential for successful Decarbonisation (IRENA, 2019).

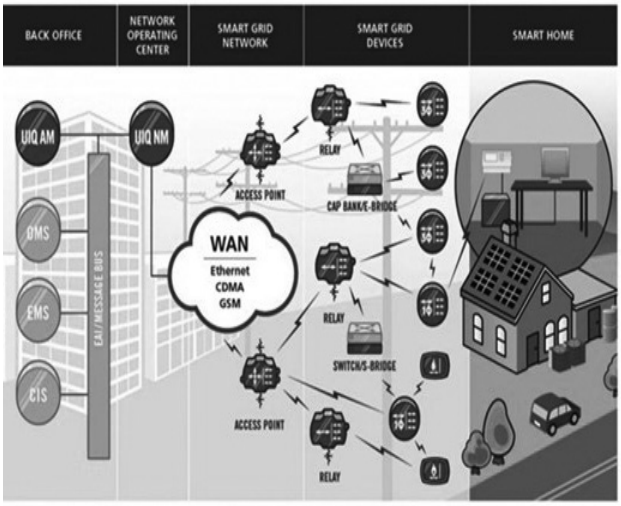

Figure 03: Digitalization of the energy systems

Hybrid Systems and Distributed Energy Resources (DERs)

Hybrid systems combining centralized and distributed energy resources are emerging as a sustainable solution. DERs include small-scale renewable energy installations, energy storage systems, and active consumer participation in demand response These systems offer flexibility and resilience, enabling the grid to adapt to variable renewable energy supply and changing demand patterns (Parhizi et al., 2015).

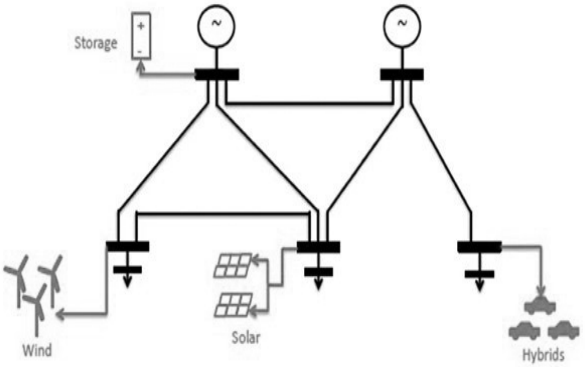

Figure 04: Emerging Distribution Systems- High DER penetration

Microgrids and Decentralization

Microgrids, which allow localized generation and consumption of electricity, enhance grid resilience by reducing dependence on centralized infrastructure . They can operate independently during grid outages, making them a valuable component of a sustainable energy system. The technical, economic, and regulatory challenges of integrating microgrids into the broader power system are well-documented and critical to address (Lasseter, 2002).

Figure 05: Distribution automation, a new effort

The Role of Advanced Control Systems

Advanced control systems are crucial for managing the complexity of modern power grids. These systems use machine learning algorithms and predictive analytics to optimize grid operations and ensure stability. Adaptive control techniques enable real-time adjustments to power flows, enhancing the efficiency and reliability of the grid (Huang et al., 2019).

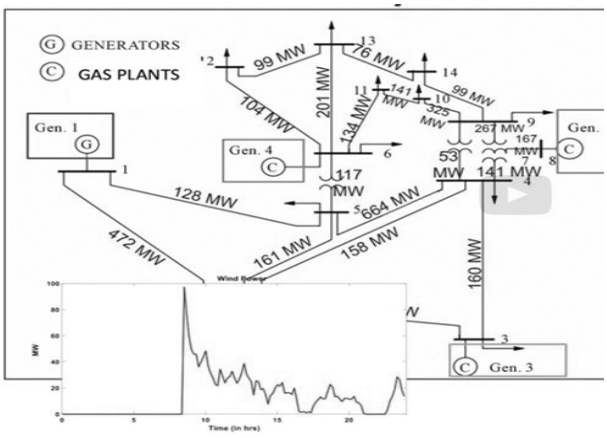

Figure 06: IEEE 14- bus test systems

Case Studies and Applications

Several case studies illustrate the successful implementation of digitalization and Decarbonisation strategies. For instance, the European Union's efforts to create an integrated energy market have resulted in significant advancements in renewable energy integration and grid management (European Commission, 2018). Similarly, the adoption of smart grid technologies in the United States has led to improved grid reliability and efficiency (DOE, 2015).

Advantages in Sri Lankan Context

Digitalization and decarbonization offer numerous economic, environmental, social, and technological advantages for Sri Lanka's power system. Economically, integrating renewable energy sources such as solar and wind, which are abundant in Sri Lanka, can significantly reduce reliance on expensive fossil fuel imports, leading to substantial long-term cost savings. Increased energy independence is another critical benefit, as generating more electricity domestically from renewable sources reduces the country's dependence on volatile global energy markets, enhancing national energy security. Furthermore, the transition to a digitalized and decarbonized power sector will create new job opportunities in renewable energy, technology development, and grid modernization, contributing to economic growth. Additionally, a commitment to a sustainable and modern power system can attract foreign investment in renewable energy projects and technology partnerships, further bolstering the economy.

Environmentally, shifting away from fossil fuels towards renewable energy sources will significantly reduce greenhouse gas emissions, helping Sri Lanka achieve its climate goals and mitigate the impact of climate change. Improved air quality is another important environmental benefit, as decreasing reliance on fossil fuel-based power plants will reduce air pollution, benefiting public health and reducing respira-

tory illnesses. Moreover, transitioning to a more sustainable power system will help preserve natural resources by reducing the environmental impact associated with fossil fuel extraction and transportation.

Socially, a diversified energy mix with a higher share of renewables enhances energy security by reducing reliance on a single energy source. This diversification ensures a more stable and reliable energy supply. Additionally, decentralized renewable energy systems, enabled by digitalization, can expand electricity access to rural and underserved communities, improving energy equity and fostering social development. As renewable energy costs continue to decline, a decarbonized power system will contribute to more affordable electricity prices for consumers, making energy more accessible and reducing the financial burden on households.

Conclusion

By leveraging advanced technologies and adopting sustainable management principles, Sri Lanka can create a resilient, efficient, and environmentally friendly energy system. There are tools to conceptualize, model, and control these complex systems, enabling a sustainable future for Sri Lanka's electric power system. The integration of digitalization and Decarbonisation strategies, supported by a unified approach to modeling and control, is essential for achieving these goals. Future research and development efforts should continue to explore innovative approaches to overcome existing challenges and achieve sustainability targets.

References

Amin, S. M., & Wollenberg, B. F. (2005). Toward a smart grid: Power delivery for the 21st century. IEEE Power and Energy Magazine, 3(5), 34-41.

DOE. (2015). Grid Modernization Initiative. U.S. Department of Energy.

European Commission. (2018). Clean energy for all Europeans.

Fang, X., Misra, S., Xue, G., & Yang, D. (2012). Smart grid—the new and improved power grid: a survey. IEEE Communications Surveys & Tutorials, 14(4), 944-980.

Huang, G., Gao, Z., & Xu, Y. (2019). Reinforcement learning for optimal operation and management of energy internet: review and classification. Applied Energy, 239, 704-728.

IRENA. (2019). Global Energy Transformation: A Roadmap to 2050. International Renewable Energy Agency.

Lasseter, R. H. (2002). Microgrids. In Power Engineering Society Winter Meeting, IEEE, 1, 305-308.

Lund, H., Østergaard, P. A., Connolly, D., & Mathiesen, B. V. (2015). Smart energy and smart energy systems. Energy, 137, 556-565.

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. Science, 325(5939), 419-422.

Ostrom, E. (2010). Beyond markets and states: Polycentric governance of complex economic systems. American Economic Review, 100(3), 641-672.

Parhizi, S., Lotfi, H., Khodaei, A., & Bahramirad, S. (2015). State of the art in research on microgrids: A review. IEEE Access, 3, 890-925.

Rugolo, J., & Aziz, M. J. (2012). Electricity storage for intermittent renewable sources. Energy & Environmental Science, 5(5), 7151-7160.

Sinsel, S.R., Riemke, R.L., & Hoffmann, V.H., 2020. Challenges and solution technologies for the integration of variable renewable energy sources: A review. Renewable Energy, 145, 2271-2285.

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Human Factors: The Last Frontier in Aircraft Accidents?

Fernando, G.

It has been said that engineering marvels made aviation the world's safest mode of transport. Unfortunately, aircraft accidents continue to happen.

The Weakest Link

With everything known about accident causation over the years, when safety experts reconsidered the reasons for loss of life due to air crashes in World War I, it was confirmed that 90% were due to human failures (acts of omission or commission), 8% were attributed to mechanical failures, and only 2% caused by enemy action.

Unlike then, modern aircraft are very reliable, and truly marvels of engineering. But the human condition has not progressed much beyond the Stone Age, is still imperfect, and therefore the weakest link. A popular adage asserts that a chain is as strong as its weakest link. In the past 120 years the fatal accident rate has been brought down to 2 to 3 per million departures. But as the number of operators has increased, the number of casualties also increased.

Many Innovations

Through the years, the search for greater range, capacity, speed and air safety was the driver of innovation. In this writer's opinion, one of the greatest safety improvements was introduced to the aviation industry after the 1935 crash of a prototype Boeing B-17 'Flying Fortress', when an experienced army pilot forgot to remove the control locks before takeoff. Accordingly, a simple paper checklist was introduced by Boeing to help pilots to 'do things right and to do the right things'. It was acknowledged that modern aircraft were 'a handful', as they were getting more complicated.

Boeing B-17 Flying Fortress

It was also realised that a single pilot was incapable of flying such a complex aircraft. Hence the 'crew concept', with a pilot (Captain) and Co-pilot, was born. Early captains did not involve the co-pilot much in handling the airplane. "I fly, you

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watch" was the Captain's mantra. Undoubtedly the presence of a second pilot brought with it a few more human interaction problems, as two people seldom thought alike.

Making matters more complicated on inter-continental flights, there were now three other crewmembers: a Flight Engineer, Radio Officer and Navigator. In multi-crew aircraft, the non-flying Flight Engineer or monitoring pilot would read the checklist aloud while the flying pilot responded. It was known as the 'Challenge and Response' method. This was adopted by all aircraft manufacturers and has since evolved into the form of electronic checklist displays on all modern airplanes.

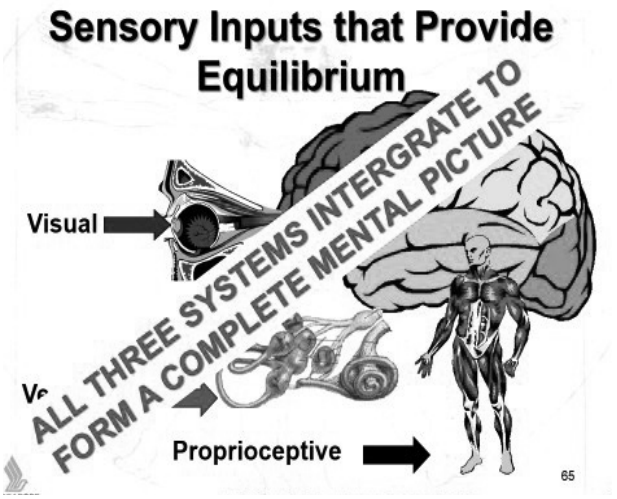
Nowadays, when each checklist task is completed the relevant item on the list changes colour (electronic tie-ins). But the checklist is still read by the monitoring pilot while actions are carried out and confirmed by the flying pilot. Over the years, innovations introduced to civil aviation percolated from the military, with the military being the first to benefit from the spinoff of space programs and agencies like NASA. Good examples of this spinoff are Inertial Navigation Systems (INS) in civil aviation, and Global Positioning Systems (GPS), used in aviation, marine navigation and even road navigation in motor vehicles.

Other innovative products, services and processes that come to mind are wind tunnel testing, light bulbs, de-icing and anti-icing systems, cabin pressurisation, two-way radio, airborne weather radar, electrical generators, batteries, hydraulic and pneumatic systems, retractable landing gear, autopilots, anti-lock braking, traffic collision avoidance systems (TCAS), ground proximity warning systems (GPWS), flight data recorders (FDR), cockpit voice recorders (CVR), digital computers, cathode ray tubes (CRT), composite materials, laser gyroscopes, fibre optics, light emitting diodes (LED), carbon brakes, the phonetic alphabet, extended twin-engine operations (ETOPS), flight time limitations (FTL) – the list goes on.

In order to manage all these new inventions, standard operating procedures (SOP's) and standard call-outs (between crewmembers) had to be developed. If the Wright brothers sat in a 21st century flightdeck they would find themselves baffled and lost.

Flying by the Seat of Your Pants

During aviation's pioneering days pilots flew by feel of the five senses: taste, smell, touch, sight and hearing. For instance, the wind on the face in an open cockpit and the sound of the wind in the bracing wires gave an indication of the direction of travel and speed, respectively. Engine noise gave the pilot an idea of the engine's power. If there was an equipment overheat, one could smell it. If there was a fire they could see or feel the heat. The muscular feel at the 'seat of the pants', the only point of contact with the aircraft, or human/machine interface, told the pilot how he/she was faring. In combination, these were Visual, Vestibular (inner ear and balance) and Proprioceptive (muscular) sensory aids.



Early flight instruments were not noted for their accuracy. When the first enclosed cockpit was introduced, it was unpopular with pilots. However, when more accurate blind flying instruments were invented to make it possible for all-weather and night flying operations, pilots had to learn to disregard their 'feel' and, instead, trust and obey their instruments. Many 'old school' stick-and-rudder pilots got into the dreaded 'graveyard

spiral' due to spatial disorientation, trusting only their senses, usually with fatal results to themselves and their passengers.

Automation

In 1914 an American, Lawrence Sperry demonstrated gyroscope-stabilised straight and level flight in Paris. This was the beginning of the automatic pilot. As years passed and flight distances got longer, automatic pilots for aircraft were introduced to carry out the mundane task of physical flying and to free the pilot's mind to navigate communicate and manage the flight. Not all Airline management people were happy when autopilots were introduced."I pay those guys to fly, so let them fly. I'll be damned if I'll pay them to just sit there." - Eddie Rickenbacker, WWI Veteran and Chairman of Eastern Airlines, USA

Those early autopilots were 'dumb and dutiful.' Pilots referred to the autopilot as 'George'. With the advent of digital computers and satellite technology, even the other two functions (navigation and communication) were taken over by automatics and a Flight Management System (FMS) was introduced. Once the route was programmed, the FMS even tuned the radio frequencies for navigation.

Flight Management System (FMS) Display and Input Keys, the Human/Machine Interphase in modern times

Airbus flight instructors would often say that if the Inertial Reference Systems were the brain of the aircraft the FMS was the heart. A host of parameters from the operating condition of the engines to what movies are being watched by passengers can be monitored through telemetry from the ground in real time.

Human Factors

A psychologist named David Beaty, formerly a World War II RAF pilot (for which he was awarded the DFC with bar) and BOAC Captain, propounded that there are many 'Human Factors' behind aircraft accidents. Beaty was born in Hatton, Ceylon in 1919 to a Methodist minister and his wife, both on a missionary posting from Britain, and received his early education at Kingswood College, Kandy. When Beaty first mooted his 'human factors in aircraft accidents' concept in 1967 it was regarded as controversial. After all, aviators were supposed to be supermen, not normal human beings.

As an extension of his passion for aircraft accident investigation, Beaty became a prolific and celebrated writer of novels, almost all with an air accident theme. Perhaps the best-known novel by Beaty is Cone of Silence, which was later adapted for the movie of the same name (renamed 'Trouble in the Sky' for US audiences). Another is The Temple Tree, the fictional story of the crash of a Boeing 707 on final approach in bad weather to an equally fictional international airport in Colombo.

It gradually dawned on accident investigators that what Beaty was saying was true, and indeed the human condition was the weakest link. As such, something needed to be done to improve that aspect of aviation safety. Two landmark accidents, both in the USA, provided added impetus: the crashes of an Eastern Air Lines Lockheed L-1011 TriStar in 1972, and a United Airlines DC-8 (1978). In both instances the pilots were distracted from the task at hand by mundane, peripheral matters and lost the 'big picture'.

Many human factors experts realised that pilots must be taught to (1) know themselves, (2) know their crew, (3) know their aircraft and equipment, (4) know their priorities and, above all (5) constantly evaluate the risks. Thus, a new classroom subject called 'Crew Resource Management' (CRM) was born. Although, at first, it was thought by some that CRM was a case of 'too many cooks' and no one 'minding the shop'.

To alleviate the situation further, some aircraft manufacturers attempted to automate more pilot functions and design the human out of the system. The first crewmember to be dispensed with was the Radio Officer. Then came the job of Navigator, and lastly the Flight Engineer. Airline managements welcomed the new cockpit complement as high crew salaries were a part of the companies' fixed costs, so the absence of those now-redundant jobs was a great saving. From the air safety point of view, the flightdeck lost extra pairs of eyes with only a Captain and First Officer at the 'pointy end'. Meanwhile, accident rates remained unacceptably high. There are suggestions now to have only a single pilot in large airliners purely to save money!

In reality, the reduction of errors on the flightdeck was an impossibility, as humans still designed, built, operated, maintained, managed and regulated aircraft operating systems. 'Threats and Errors' could exist anywhere. Automation was meant to support the crew in a set of given conditions, not replace them. It was incapable of judgement. An oft-repeated story is that of a computer which was asked: 'If there were two clocks, one of which had stopped, the other running one second slow, which would give the more accurate time?' In its high-tech 'wisdom' and logic, the computer deduced that it was the clock that had stopped, as it gives the correct time twice a day, while the other never gave the accurate time!

Fly by Wire Aircraft

In the 1980s, when Airbus designed the A320 aircraft, they said that the flight control computers (seven in all) were so advanced, software would have taken 800 man-years to check them. The manufacturer took the next best option of getting two different vendors to write the software for redundant systems so that one system could monitor the other.

Interestingly, some of the algorithms for 'fly by wire' computers were developed by a young Sri Lankan scientist/engineer named Gemunu Silva (1943-2021), who in the 1970s was given use of the only hybrid computer in France. His work at Toulouse eventually became the property of the French government.

Because of economic pressures, no aircraft is a mature product when it is introduced to the line. Modifications are done 'on the go', after introduction. Sometimes, blood needs to be spilt for positive changes to happen. That is a sad fact in aviation. The world's pilots were still unprepared to accept the A320's new level of automation.

Initially, Indian Airlines pilots went on strike and refused to fly the A320. It was called the 'Scare Bus'. After three fatal crashes the A320 was also dubbed the 'John Wayne of the Skies', because it crashed through forests (Basel, Switzerland; 1988), 'climbed' mountains (Strasbourg, France; 1992), and killed Indians (Bangalore; 1990). Many meetings were held by the International Federation of Airline Pilots' Associations (IFALPA) to address the A320's human factors problems. Thankfully, we humans adapted to the new technology, and today the A320 and its numerous derivatives are the world's safest and most popular aircraft.

In modern 'glass cockpit' aircraft, pilots are expected to disregard their feel to a large extent and fly by what they see on their electronic instruments displayed in colour-coded cathode ray tubes (CRTs) and LED (light-emitting diode) screens. The early A320 accidents, following the type's introduction, were mostly the result of pilots' misinterpretation of these instruments. This was the man-machine interface.

But automation brought a host of other problems for human operators who now had to spend more time on monitoring duties, which in turn caused complacency and boredom. However improbable, automatics tend to fail at the most critical time. Because of this, during critical phases such as automatic landings, aircraft have either two or three autopilots monitoring each other.

In modern 'glass cockpit' aircraft, pilots are expected to disregard their feel to a large extent and fly by what they see on their electronic instruments displayed in colour-coded cathode ray tubes (CRTs) and LED (light-emitting diode) screens. The early A320 accidents, following the type's introduction, were mostly the result of pilots' misinterpretation of these instruments. This was the man-machine interface.

The differences in basic autopilot philosophies of the two main big-jet manufacturers, Boeing and Airbus, are that while Boeing strived to have the automatics 'human-centred' with flight control feedback to give an indication to the pilots as to what the autopilots are doing, Airbus airplanes' controls didn't move at all, with pilots having to constantly update their situational awareness by asking "What is it doing now?"

Situational awareness is knowing what is going on around you and what will happen next. To know whether the engines were spooling (powering) up or down, in the early days of the A320 – as incredible as it sounds – pilots kept their feet flat on the flightdeck floor; unlike in Boeing aircraft, the Airbus engine throttles didn't move in keeping with engine power, so an immediate underfloor (engine) vibration, or lack of it, gave a good indication of what the engines were doing.

Another basic difference was that the warning systems in the older Boeings told pilots what was wrong. Calling for the relevant checklist was left to the pilots' judgement. In the more advanced Airbus airplanes not only did the warning tell you what was wrong but followed the pilot through a series of tasks to bring the unserviceable system back to an acceptable level of serviceability.

Later Boeings such as the 777 and 787 Dreamliner have fallen in line with Airbus practice by prioritising checklists. In both types of aircraft a statement commonly made by the pilots is: "I have never seen that happen before." Both manufactures absolve themselves by saying, "If unsure, fly manually or at an acceptable level of automation". However, in all 'fly by wire' aircraft there is no real manual mode, i.e. no cables and pulleys. What the pilots do is to program the autopilot computers through their flight controls.

Besides, all this high technology in the flightdeck has introduced more than 15 audio warnings in the form of synthetic voices, bells, and whistles which the pilots have to identify by memory, differentiate, and carry out a split-second rectification action. Identifying the warnings incorrectly could be a matter of life and death.

Such was the case in the Helios Airways Boeing 737 crash in August 2005. During routine pre-flight maintenance, automatic cabin pressurisation had been switched off by maintenance engineers in order to run a test; but the disabled system had been overlooked by the pilots when carrying out their pre-flight checks. On the climb-out, when the Cabin High Altitude audio warning horn sounded, the pilots identified it as the Take-off Configuration Warning horn and did nothing as they were climbing out safely and not in the take-off phase. Consequently, everyone on board was starved of oxygen at high altitude, becoming unconscious or dying before the aircraft, flying on autopilot, crashed when its fuel supply eventually ran out.

In another incident, an Air France Airbus A330 aircraft operating from Rio de Janeiro to Paris in June 2009 crashed in the Atlantic Ocean after encountering a heavy thunderstorm. The synthetic voice and an attention-getting bell sounded no fewer than 75 times, alerting the crew that they were falling out of the sky, before the aircraft descended to its watery doom. Why did the crew not react? Was there a 'startle factor'?

Was it a matter of inexperience and inadequate training? It all happened in the space of six vital minutes. The human factors element involved in that crash is the subject of an entire book.

Into the Future

The Pilot/Aircraft interaction is through the Flight Management System (FMS) in the long term and directly to the Autopilot in the short term. According to many experts, aircraft automation of today, while being quite smart, cannot be called 'Artificial Intelligence' (AI). Systems still rely on data that has been defined by fallible human beings (the old computing adage: "Garbage in, garbage out)".

Pilots are taught to operate modern aircraft on a 'need to know' basis due to economic pressures. Keeping a pilot in a classroom for a comprehensive 'nuts and bolts' program or simulator session is a loss of productivity.

While on the subject of automation, one of the 'coolest' devices the writer found when introduced to flying Boeing 747s was a warning light and an audio 'ping' that come on if no switch activation has taken place in the flightdeck for a specific period of time, with an accompanying message saying, "Pilot Input required". Cancelling the warning is itself a pilot action which silences the electronic 'watchdog' for a while. This effectively relieves boredom on long flight sectors while ensuring that pilots stay awake. (In basic principle this is not unlike the 'dead man's handle', or 'pedal', in modern railway locomotives and trams.)

Many experts believe that to achieve 'AI' status in automation, as many possible scenarios to specific problems as possible could be fed into voice warning such as "Cabin Pressure" have saved the Helios Airways crew and their passengers? Conversely, in the Air France crash the voice warning also urging the appropriate cor the on-board computers, which then will select the most appropriate solution in the case of an emergency. But more refinements to this need to be done. Without a confusing horn, could a rective action, e.g. "Stall. Stall. Get Nose Down" would have helped.

In the present context, the performance of 'Stone Age' human operators is still limited by hunger, humidity, lack of sleep, vibration, stress, fatigue, jetlag, optical illusions and spatial disorientation. There is a long way to go in addressing all of these factors. Airline managements, which are often 'bottom line only'-orientated, still indulge in 'penny pinching' and 'pilot pushing', thereby contributing additional mental and physical stresses to crewmembers.

Quick turnarounds, minimum rest, inadequate time to unwind among friends and relatives, inappropriate financial inducement to fly on days off which are planned for the specific purpose of reducing cumulative fatigue, are some of the challenges that the airline industry faces today. The chances of making mistakes are greater in such environments.

Each individual is different, therefore the lowest common denominator may have to be considered by the regulators. Human intelligence and the ability to make mistakes are two sides of the same coin. According to many experts, a 'zero error' target in air operations is impossible to achieve. What should be in place is an 'error tolerant' system, where human errors are detected, trapped and mitigated. The International Civil Aviation Organization (ICAO) recommends that rather than being reactive, the industry should be proactive, predictive and preventive. Understanding the cause behind the cause of incidents and accidents, in terms of human factors is indeed the 'Last Frontier'.

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Capt Gihan Fernando is a retired Airline Captain. Still flies light aircraft for pleasure. He was a Human Factors and Crew Resource Management (CRM) facilitator for a Far Eastern airline, and has flown Lockheed L-1011, Boeings 737, 707 & 747, and Airbus A320, A330 & A340 aircraft. Former member of the Civil Aviation Authority (CAASL) Accident Investigation Team. He is the incumbent OPA representative for 'Aviation'.

Supply Chain Due Diligence, Compliance, and Governance: Ensuring Ethical Business Practices

Gallehewa , J.

Inroduction

In today's globalised economy, the principles of supply chain due diligence, compliance, and governance are crucial for businesses aiming to operate ethically, transparently, and sustainably. These elements help companies manage risks associated with human rights, labour practices, environmental impact, and corruption. This article delves deep into these critical aspects, emphasising their significance and providing insights into effective implementation strategies that businesses can adopt to ensure ethical business practices.

Supply Chain Due Diligence

Supply chain due diligence is the proactive process through which companies identify, assess, and mitigate risks within their supply chains. It involves understanding the entire supply chain from sourcing raw materials to delivering finished products and evaluating potential risks associated with suppliers and subcontractors. Key components include risk assessment, mitigation strategies, performance monitoring & reporting, and Improvements. (Figure 01)

Risk Assessment: The first step in supply chain due diligence is conducting thorough risk assessments to identify potential issues such as human rights violations, labour exploitation, environmental degradation, and corruption. For instance, companies sourcing raw materials from regions with poor labour conditions must assess risks related to forced labour or child labour practices.

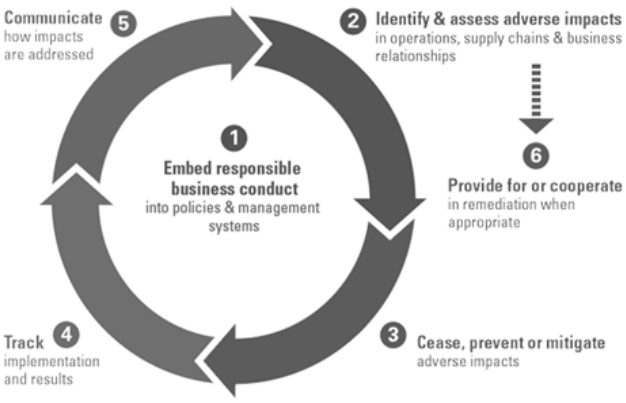

Figure 1: Due diligence process and supporting measures (Source: OECD Guidelines)

Mitigation Strategies: Once risks are identified, companies develop and implement mitigation strategies to address these issues effectively. This may involve working closely with suppliers to improve labour standards, enforce environmental regulations, and enhance transparency throughout the supply chain. Continuous engagement and collaboration with suppliers are crucial to ensuring that these strategies are implemented and maintained effectively.

Performance Monitoring and Reporting: Ongoing monitoring of supply chain activities is essential to evaluate the effectiveness of mitigation strategies and ensure compliance with ethical standards. Transparent reporting enables stakeholders, including consumers, investors, and regulatory bodies, to assess a company's commitment to ethical practices and hold them accountable for their supply chain operations.

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Regulatory Frameworks: Regulatory guidelines, such as those provided by the Organization for Economic Co-operation and Development (OECD), an international organization with 38 member countries, provides guidelines for responsible business conduct, including specific guidance for supply chain due diligence to address human rights, labor rights, environmental protection, and anti-corruption. The UN Guiding Principles on Business and Human Rights, play a significant role in shaping supply chain due diligence practices. Endorsed by the UN in 2011, UN Guiding Principles outline the responsibilities of states and businesses to prevent and address human rights abuses related to business activities. They require companies to perform human rights due diligence, ensuring their operations respect human rights throughout their supply chains. These frameworks provide standards and guidelines for companies to follow in identifying, preventing, and addressing adverse impacts associated with their operations and supply chains.

Technological Solutions: Companies can leverage technology to enhance supply chain due diligence processes. For example, blockchain technology offers transparency and traceability, enabling companies to track the origin of materials and verify compliance with ethical standards. Data analytics and artificial intelligence (AI) can also be utilised to identify patterns and trends that may indicate potential risks within the supply chain, facilitating proactive risk management strategies.

Case Studies: Examining case studies of companies that have successfully implemented supply chain due diligence provides valuable insights and best practices. For instance, electronics giant HP has implemented comprehensive supply chain due diligence programs that include regular audits, collaboration with NGOs, and the use of technology to enhance transparency. These efforts have enabled HP to identify and address risks related to labour practices, environmental impact, and conflict minerals in its supply chain effectively.

Despite the importance of supply chain due diligence, many companies face challenges in implementing effective practices. These challenges include the complexity of global supply chains, resource constraints, and the need for improved transparency and traceability. However, by adopting regulatory frameworks, leveraging technological advancements, and learning from industry leaders, companies can overcome these challenges and establish ethical and sustainable supply chains.

Compliance in Supply Chain Management

Compliance in supply chain management refers to the adherence to laws, regulations, and standards that govern business operations. These laws and regulations vary depending on the industry, geographic location, and specific supply chain activities. Key areas of compliance include labour laws, environmental regulations, and anti-corruption measures.

Figure 2: Compliance in Supply Chain

Labour Laws: Compliance with labour laws is crucial to ensuring fair treatment of workers and preventing labour exploitation within supply chains. Companies must ensure that suppliers adhere to labor standards, including the prohibition of forced labor, child labour, and discrimination. Upholding these standards not only protects workers' rights but also mitigates reputational risks and legal liabilities for companies.

Environmental Regulations: Environmental compliance focuses on minimising the environmental impact of business operations and

supply chain activities. Companies are required to comply with regulations concerning air and water quality, waste management, and greenhouse gas emissions. Implementing environmentally sustainable practices not only reduces ecological footprint but also enhances brand reputation and meets consumer expectations for sustainable products.

Anti-Corruption Measures: Compliance with anti-corruption laws is essential to prevent bribery, fraud, and other unethical practices within supply chains. Companies must implement policies and procedures to detect and mitigate corruption risks, including conducting due diligence on business partners and suppliers. Transparency and accountability are critical in building trust with stakeholders and ensuring ethical business conduct.

To ensure compliance with labor laws, companies can implement robust labour management systems that include regular audits, worker interviews, and grievance mechanisms. For example, the Fair Labor Association (FLA) conducts audits of member companies' supply chains to uphold labour standards and promote fair labour practices globally. Collaborating with industry associations and NGOs further supports compliance efforts by sharing best practices and fostering industry-wide standards.

Environmental compliance can be achieved through the adoption of environmental management systems, such as ISO 14001, which provide a framework for managing environmental impacts. Companies can also engage in partnerships with environmental organisations and industry groups to develop and implement sustainable practices.

Anti-corruption compliance is strengthened by implementing robust policies and procedures that promote transparency and ethical behaviour. Companies can conduct risk assessments to identify potential corruption risks within supply chains and implement measures to mitigate these risks. Training programs for employees and suppliers also play a crucial role in promoting awareness of anti-corruption policies and fostering a culture of integrity and accountability.

Governance in the Supply Chain

Governance in the supply chain refers to the systems, policies, and procedures that companies establish to ensure ethical behaviour, accountability, and transparency throughout their supply chains. Effective governance frameworks provide clear guidelines and expectations for suppliers, establish mechanisms for monitoring and enforcement, and promote stakeholder engagement and transparency.

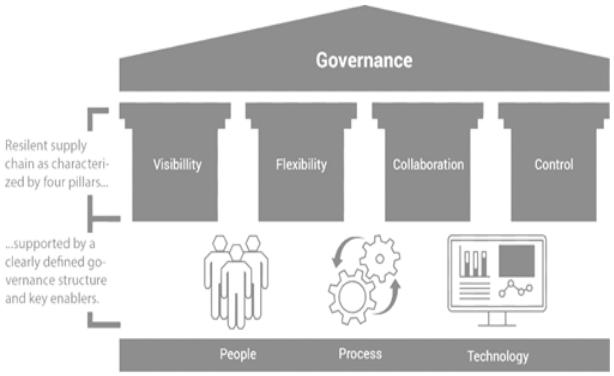

Figure 3: Governance flow in Supply Chain Management

Supplier Codes of Conduct: Companies establish supplier codes of conduct that outline expectations regarding labour practices, environmental standards, and ethical behaviour. Suppliers are required to adhere to these standards as a condition of doing business with the company. Regular audits and assessments ensure compliance with the code of conduct and identify areas for improvement.

Transparency and Accountability: Transparency is essential for building trust with stakeholders and demonstrating commitment to ethical practices. Companies disclose information about their supply chains, including the sources of raw materials, production processes, and sup-

plier relationships. This transparency enables stakeholders to assess the social and environmental impact of a company's operations and hold them accountable for their supply chain practices.

Stakeholder Collaboration: Collaboration with stakeholders, including suppliers, industry associations, NGOs, and local communities, enhances the effectiveness of supply chain governance. Multi-stakeholder initiatives bring together diverse perspectives and expertise to address common challenges and promote ethical practices within supply chains. For example, initiatives like the Ethical Trading Initiative (ETI) and the Fair Labor Association (FLA) engage companies, NGOs, and trade unions to improve labour standards and working conditions globally.

Industry Standards and Certifications: Industry standards and certifications provide frameworks for companies to report on their sustainability practices and supply chain governance. For example, the Global Reporting Initiative (GRI) standards enable companies to disclose information on their environmental, social, and governance (ESG) performance in a transparent and standardised manner. These standards promote accountability and help companies benchmark their progress against industry peers.

Technology and Innovation: Technology plays a critical role in enhancing supply chain governance by improving transparency, traceability, and efficiency. Digital supply chain platforms integrate data from suppliers, logistics providers, and customers, enabling real-time monitoring and decision-making. Blockchain technology provides secure and transparent records of transactions, enhancing traceability and authenticity throughout the supply chain. Artificial intelligence (AI) and data analytics tools analyse supply chain data to identify potential risks and opportunities for improvement, supporting proactive risk management and decision-making.
Case Studies:

Case studies of companies that have implemented effective governance practices provide insights into best practices and lessons learned. For example, Intel has established a comprehensive ethics and compliance program that includes regular training for employees and suppliers, a whistleblower hotline, and a commitment to transparency and accountability. These initiatives have helped Intel maintain high ethical standards and mitigate risks within its global supply chain.

Implementing Due Diligence, Compliance, and Governance: Best Practices

Implementing due diligence, compliance, and governance involves adopting best practices that promote transparency, foster stakeholder collaboration, leverage technology and innovation, and prioritise continuous improvement.

Promoting Transparency: Transparency builds trust and accountability by providing stakeholders with clear and accurate information about supply chain practices. Companies should disclose information about their suppliers, production processes, and sustainability initiatives to enable stakeholders to assess their performance and impact.

Fostering Stakeholder Collaboration: Collaboration with stakeholders, including suppliers, NGOs, industry associations, and local communities, enhances supply chain governance effectiveness. Multi-stakeholder initiatives bring together diverse perspectives and expertise to address common challenges and promote ethical practices within supply chains.

Leveraging Technology and Innovation: Technology enables companies to enhance supply chain transparency, traceability, and efficiency. Digital platforms and blockchain technology provide real-time data on supply chain activities, enabling companies to monitor compliance with ethical standards and identify potential risks.

Prioritising Continuous Improvement: Continuous improvement involves regularly assessing supply chain performance, identifying areas for enhancement, and adapting to changing regulatory requirements and stakeholder expectations. Companies should conduct regular audits, engage in dialogue with stakeholders, and leverage feedback to refine their due diligence, compliance, and governance practices continually.

Conducting Thorough Risk Assessments: Comprehensive risk assessments are the foundation of effective supply chain management. Companies should map their entire supply chain to identify potential risks, including human rights abuses, environmental degradation, and corruption. This process involves engaging with suppliers to understand their practices and conducting on-site inspections where necessary.

Developing Clear Policies and Procedures: Clear policies and procedures provide a framework for ensuring compliance and governance throughout the supply chain. Companies should develop codes of conduct for suppliers, outlining expectations for labour practices, environmental standards, and ethical behaviour. These codes should be communicated clearly to suppliers, and regular training should be provided to ensure understanding and compliance.

Engaging Suppliers in Ethical Practices: Building strong relationships with suppliers is crucial for promoting ethical practices. Companies should work collaboratively with suppliers to improve labour conditions, enhance environmental sustainability, and implement anti-corruption measures. This engagement may include capacity-building initiatives, joint projects, and sharing best practices.

Implementing Monitoring and Reporting Mechanisms: Effective monitoring and reporting mechanisms are essential for evaluating the implementation of due diligence, compliance, and governance practices. Companies should establish regular audit schedules, conduct supplier assessments, and utilise third-party verification where appropriate. Transparent reporting on supply chain practices builds trust with stakeholders and demonstrates a commitment to ethical standards.

Utilising Technology for Supply Chain Transparency: Technological solutions, such as blockchain and supply chain management software, enhance transparency and traceability within the supply chain. These technologies provide real-time data on supplier performance, enable secure and transparent records of transactions, and facilitate the identification of potential risks. Leveraging these tools supports proactive risk management and ensures adherence to ethical standards.

Fostering a Culture of Ethical Behaviour: A culture of ethical behaviour within the company and its supply chain is fundamental to ensuring long-term compliance and governance. This culture is fostered through leadership commitment, regular training, and the establishment of ethical policies and procedures. Companies should promote values such as integrity, accountability, and respect for human rights throughout their supply chain operations.

Case Studies of Best Practices: Examining case studies of companies that have successfully implemented due diligence, compliance, and governance provides valuable insights and best practices. For example, the electronics company Intel has implemented a comprehensive ethics and compliance program that includes regular training for employees and suppliers, a whistleblower hotline, and a strong commitment to transparency and accountability. These initiatives have helped Intel maintain high ethical standards and mitigate risks within its global supply chain.

Conclusion

In conclusion, supply chain due diligence, compliance, and governance are integral to promoting ethical business practices and sustainability in today's global economy. By adopting these principles and implementing best practices, companies can build resilient supply chains that uphold ethical standards and create long-term value. Ensuring ethical supply chain practices not only protects human rights and the environment but also enhances corporate reputation, builds stakeholder trust, and contributes to sustainable business success.

Companies must prioritise comprehensive risk assessments, develop clear policies and procedures, engage suppliers in ethical practices, implement effective monitoring and reporting mechanisms, leverage technology for transparency, and foster a culture of ethical behaviour. By doing so, they can navigate the complexities of global supply chains, mitigate risks, and ensure compliance with ethical standards.

The commitment to due diligence, compliance, and governance is not just a legal or regulatory requirement but a moral imperative that reflects a company's values and commitment to responsible business conduct. As businesses continue to operate in an increasingly interconnected and transparent world, the importance of ethical supply chain practices will only grow.

It is the responsibility of companies to lead by example, set high standards for their supply chains, and work collaboratively with stakeholders to address common challenges and promote ethical practices. By doing so, they can contribute to a more sustainable and equitable global economy, benefiting not only their business but also society at large.

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Evaluating Occupational Radio Frequency Electromagnetic Radiation Levels

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Abstract

N*on-ionizing radiation is not perceived as a significant threat compared to ionizing radiation, and the radio frequency (RF) range is frequently regarded as safe because many devices around us meet existing safety standards. However, there is a significant gap in current knowledge and guidelines primarily concerned with short-term thermal effects rather than long-term biological consequences. This difference is critical because prolonged exposure to non-ionizing radiation poses potential health risks that are not adequately addressed by current safety standards. The purpose of this study is to look into the levels of Electric Field (EF), Magnetic Field (MF), and Radio Frequency (RF) power density emitted by everyday electronic devices and compare them to international safety guidelines.*

EF, MF, and RF radiation levels were measured by an EXTECH model 450 multifield EMF meter from various household electronics, including mobile phones, laptops, power lines, power cables, switches, and plugs, considering time and distance variations separately. The measurements were then compared with internationally accepted safety standards. The study also looked at safe distances to limit exposure and potential health risks. While some devices operate within safe limits for short-term thermal exposure, many are unsafe compared to the long-term biological guidelines. This study identifies a critical gap in existing guidelines, which fail to address the long-term health risks associated with prolonged exposure. Notably, there needs to be more awareness and concern about these risks, even among those with advanced education. It is concluded that there is an urgent need to re-evaluate and update commercial product safety standards to account for long-term biological effects. Raising public awareness of these risks is critical, especially in environments where electronic devices are used frequently throughout the day. This study emphasizes the importance of conducting more comprehensive studies to fully understand the health consequences of prolonged non-ionizing radiation exposure and providing clear recommendations for mitigating these risks through informed policy changes and public education initiatives.

Keywords: *- Electromagnetic Fields, Electro-hypersensitivity, Non-ionizing Radiation, Radio Frequency, Safe Distances.*

Introduction

The rapid proliferation of electronic devices has resulted in increased Radio Frequency Electro Magnetic Field (RF-EMF) exposure in occupational settings. Radiation is classified as ionizing or non-ionizing according to its energy level. Ionizing radiation, which includes X-rays, gamma rays, and ultraviolet (UV) light, is known for its ability to ionize atoms and molecules, potentially causing cellular damage and increasing cancer risk. As a result, there is widespread awareness and concern about limiting ionizing radiation exposure.

Non-ionising radiation does not possess the energy necessary to ionise atoms or molecules. Instead, it interacts with matter using molecular vibration and thermal excitation.

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A wide range of frequencies, such as microwaves, infrared radiation, and radio frequency (RF) radiation, are included in the category of non-ionising radiation. For example, radio frequency (RF) radiation is used in wireless communication modes such as mobile phones and Wi-Fi, whereas infrared radiation is typically connected to heat and thermal imaging. Comparing non-ionising radiation to ionising radiation, the former usually presents less immediate health risks.

Diseases and Complications Caused by EMF

NIR, especially radiofrequency radiation and electromagnetic fields within the legally allowed levels, has been linked to several health problems, including but not limited to memory damage, neurological effects, reproductive problems, altered biological rhythms, and an increased risk of some cancers (Press Release N° 208, 2011). These effects might not show up immediately and might take time to become noticeable after prolonged exposure. As a result, there may be less rigorous regulatory oversight and public concern regarding non-ionising radiation. Following are major health risks associated with Electromagnetic Field Exposure.

Electro-Hypersensitivity (EHS)

as an environmentally induced disability : EHS is increasingly recognized as a disability caused by environmental factors. Non-ionizing radiation exposure that falls below international guidelines has been linked to anxiety, depression and cognitive impairments (Bevington, 2022). Animal studies suggest that prenatal exposure to mobile phones can lead to behavioural issues in offspring (Karipidis et al., 2023).

Disruption of the Blood-Brain Barrier (BBB): Prolonged exposure to EMFs can change the permeability of the BBB, allowing harmful substances to enter the brain and cause neurological damage (Stam, 2010).

Infertility: Radiofrequency electromagnetic fields (RF EMFs) have been linked to decreased fertility, with studies indicating that long-term exposure may impair sperm quality and reproductive health (Pacchierotti et al., 2021).

Auditory Nerve Cancer: Evidence suggests that prolonged exposure to EMFs, particularly from mobile phones, increases the risk of developing auditory nerve tumours, such as acoustic neuromas (Kim et al., 2019).

Neurodegenerative Diseases: Chronic EMF exposure has been linked to the development of Alzheimer's and Parkinson's, possibly through oxidative stress and cellular damage (Consales et al., 2012).

Mechanistic Paths and Genetic Variants : In 2008, the first genetic variant associated with EMF sensitivity was observed in a case of childhood leukaemia near powerlines. Genotypes were later identified as markers of increased oxidative stress susceptibility (Lai, 2021). Mechanistic pathways, such as calcium flux and the radical pair mechanism, also play a role in EHS symptoms, emphasizing the need for additional research into its biological basis.

Guidelines Associated with Controlling the EMF Level

Many international guidelines have been established to protect people from electromagnetic radiation, and the values are tabulated in Table (1) and Table (2). Regulatory standards established by reputable organizations; short-term thermal guidelines issued by the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 2021) and the Federal Communication Commission, and long-term biological guidelines issued by the Bio Initiative report and the International Guideline for Non-Ionizing Radiation (IGNIR, n.d.) are a few of them.

ICNIRP guidelines focus on tissue power absorption (SAR for <6 GHz, absorbed power density for >6 GHz) to restrict exposure to electromagnetic fields (100 kHz to 300 GHz) and minimize harmful health consequences (ICNIRP, 2021).

IGNIR guidelines are impartial suggestions that prioritize long-term exposure consequences for safeguarding susceptible groups against the non-thermal effects of non-ionizing radiation (IGNIR, n.d.).

2016's EUROPAEM EMF guideline recommends mitigating and treating health problems caused by electromagnetic fields, emphasizing the dangers of long-term exposure to EMFs, including cancer and Alzheimer's disease (Belyaev et al., 2016).

The Austrian Medical Association's guidelines for diagnosing and treating illnesses connected to electromagnetic fields highlight the health risks associated with elevated exposure to electro smog (Guideline of the Austrian Medical Association for the Diagnosis and Treatment of EMF-Related Health Problems and Illnesses (EMF Syndrome), n.d.).

The SBM-2008 Standard, with its clear goal of outlining standards for detecting and reducing EMF-related indoor environmental risks, inspires us to work towards creating exposure-free living environments (Maes, 2008).

Location	Reference	Limit Based On	AC Magnetic Fields mG	AC Electric Field V/m
Canada	ICNIRP 1998	Nerve and Muscle Stimulation	833	5,000
USA	ACGHI 1998	Nerve and Muscle Stimulation	1,000	25,000
Germany	DIN/VDE	Nerve and Muscle Stimulation	50,000	20,000
Sweden	MRP	Biological / Precautionary	3	25
Sweden	TCO	Biological / Precautionary	2	10
Switzerland		Biological / Precautionary	10	
WHO "possibly carcinogenic"		Biological / Precautionary	3-4	
Bio-Initiative Report recommendation	Bio-Initiative Report 2007	Biological / Precautionary	1	
US Congress	Recommendation 1996	Biological / Precautionary	2	10
Building Biology Guidelines Germany (Sleeping Areas)	SBM2008 - Level of No Biological Concern	Biological / Precautionary	0.2	0.3
Natural Radiation	MAES 2008	Natural Exposure	0.0002	0.0001
Average Indoor Urban Exposure Toronto, Canada	Safe Living Technologies Inc. 2011		0.4 to 2.0	5 to 25

Table 1 : International Guideline comparison for Electric and Magnetic Fields

Location	Reference	Exposure time	Limit Based On	Lower by	µW/m2	V/m
Most of Western Europe	IEEE C95.1-1999 and ICNIRP	30 minutes	Thermal / Heating	-	10,000,000	61.4
USA	(FCC) IEEE C95.1-1999 and ICNIRP	30 minutes	Thermal / Heating	-	10,000,000	61.4
Canada	Safety Code 6, Table 5 (2015)	6 minutes	Thermal / Heating	2.3 x	4,393,278.4	40.7
Russia	Sanitary Norms and Regulations 2.2.4/2.1.8.055-96	3 hours +	Biological Effects	100 x	100,000	6.14
China	UDC 614.898.5 GB 9175 –88	3 hours +	Biological Effects	100 x	100,000	6.14
Italy	Sanitary Norms and Regulations 2.2.4/2.1.8.055-96	3 hours +	Biological Effects	100 x	100,000	6.14
Most of Eastern Europe	Sanitary Norms and Regulations 2.2.4/2.1.8.055-96	3 hours +	Biological Effects	100 x	100,000	6.14
Switzerland	Ordinance on Protection from Non-ionising Radiation (NISV)	Long Term	Precautionary	100 x	100,000	6.14
Toronto Board of Health, Canada	Proposed 1999	Long Term	Precautionary	100 x	100,000	6.14
Salzburg Resolution on Mobile Telecommunication	Preventive public health protection, Salzburg, June 7-8, 2000	Long Term	Precautionary	10,000 x	1,000	0.614
European Parliament	Resolution 1815, Strasburg, May 27, 2011	Long Term	Precautionary	10,000 x	106	0.2
Bio-Initiative Report recommendation	BioInitiative Report 2012	Long Term	Biological / Precautionary	3,300,000 x	3 - 6	0.03 - 0.05
Building Biology Guidelines Germany (Sleeping Areas)	SBM2008 - Level of No Biological Concern	Long Term	Precautionary	100,000,000 x	0.1	0.006,14
Cell Phone Operational Requirements				10,000,000,000 x	0.001	0.000,061,4
Natural Cosmic Radiation	MAES 2000	Long Term	Natural Exposure	10,000,000,000,000 x	0.000,001	0.000,000,061,4
Average Indoor Urban Exposure Toronto, Canada	Safe Living Technologies Inc. 2020	Long Term			200 - 5000	0.3 - 1.4

Table 2 : International Guideline comparison for Electric Fields and Radio Frequency Power Density

However, the concern with the thermal effects of radiation rather than the non-thermal biological effects that can have long-term consequences is inadequate to face this issue. Living beings are exposed to these fields for long periods in everyday settings, but the majority of the widely used guidelines do not adequately address this extended exposure.

Research Funding Bias : Industry-funded research frequently downplays the health risks of RF exposure, emphasizing the importance of transparent and independent studies to ensure accurate results (Huss et al., 2007).

Understanding the characteristics and impacts of radiation and electromagnetic fields is essential since they are pervasive in modern society. Therefore, monitoring the amounts of electromagnetic fields and radiofrequency radiation in various locations, including homes, workplaces, and public areas, is crucial. Through rigorous measurements and evaluations, this study seeks to obtain critical data regarding the amount of non-ionizing radiation exposure and its potential health impacts, a matter of significant concern. Knowing electromagnetic fields and radio frequency radiation levels will help make more informed judgments about safety precautions, legal requirements, and risk management strategies to protect the health and welfare of the general population.

Methodology

The study employs a mix of field measurements and surveys. The Electric Field, Magnetic Field and Radio Frequency power density levels were measured at distances such as 10cm, 30cm and 100cm from standard electronic devices with an EXTECH type 450 multifield EMF meter in various occupational settings, including offices and manufacturing facilities. The parallel and orthogonal orientations at prolonged time periods were considered.

Data were analyzed using SPSS software to determine the time varying patterns and Wolfram Mathematica 12.0 to observe the distance varying patterns. Then they were compared to international safety standards and tabulated. Optimum distances to use them to avoid all identified risks were calculated and tabulated as well.

Results and Discussion

The measured values' alignment with safety limits established by guidelines, such as those from the International Commission on Non-Ionizing Radiation Protection (ICNIRP) and the International Guidelines on Non-Ionizing Radiation (IGNIR), is visualized by these graphical comparisons. With this technique, researchers can identify any situations in which exposure levels are close to or above the advised thresholds, enabling more thorough evaluations and choices about the safety of electromagnetic fields. By consistently observing and examining these fluctuations, we can guarantee that the general public is shielded from electromagnetic radiation's potentially harmful health consequences. Here, Figures (1), (2), (3) and (4) demonstrate the distance and time variances of EMF, respectively.

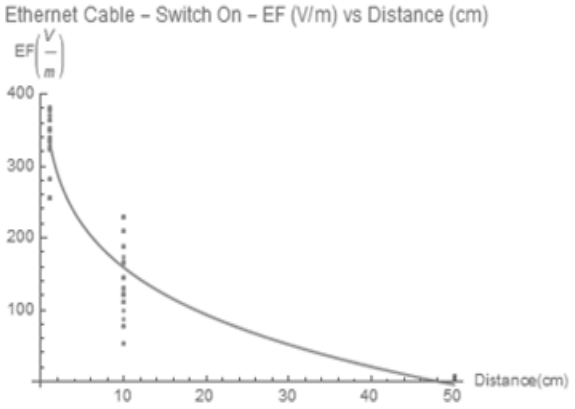

Figure 1: EF(V/m) vs Distance(m) of Ethernet Cable

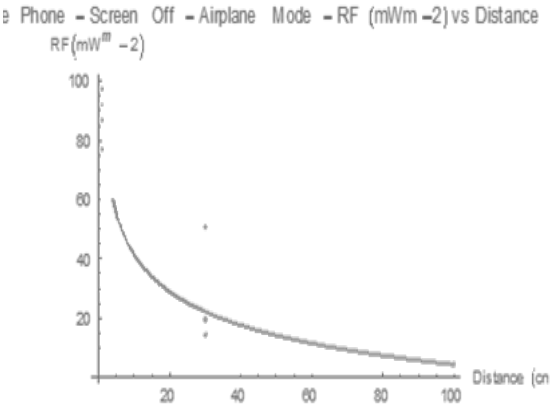

Figure 2: RF(W/m^2) vs Distance(m) of Mobile Phone on Airplane mode

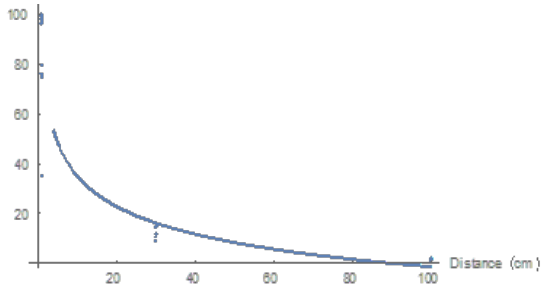

Figure 3: MF(mT) vs Distance(m) of Ethernet Cable

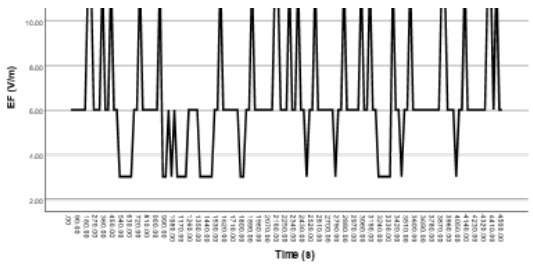

Figure 4: EF(V/m) vs Time(s) of Background

Conclusion

The study emphasizes the importance of updated occupational safety standards that account for the thermal and non-thermal effects of RF-EMF. Workers need to be more aware of and educated about RF-EMF risks.

Protective measures must be implemented to ensure employee health and safety and adherence to comprehensive international guidelines. It is critical to understand that the effects of electromagnetic fields (EMFs) are strongly influenced by proximity, so it is necessary to distance oneself from EMF radiation sources.

Ordinary household objects can significantly increase cumulative exposure despite being frequently disregarded for their EMF emissions.

Thus, we must take precautions like minimising usage, shutting off Wi-Fi and power sources when not in use, and maintaining distance. The findings of the survey emphasise how crucial it is to raise people's understanding of EMF sensitivity and its impacts across various socio-economic backgrounds and educational attainment. Misconceptions abound, even among experts in radiation and electricity, underscoring the necessity of focused educational initiatives. Future research should concentrate on long-term health impacts and effective mitigation strategies.

References

Belyaev, I., Dean, A., Eger, H., Hubmann, G., Jandrisovits, R., Kern, M., Kundi, M., Moshammer, H., Lercher, P., Müller, K., Oberfeld, G., Ohnsorge, P., Pelzmann, P., Scheingraber, C., & Thill, R. (2016). EUROPAEM EMF Guideline 2016 for the prevention, diagnosis and treatment of EMF-related health problems and illnesses. Reviews on Environmental Health, 31(3), 363–397. https://doi.org/10.1515/reveh-2016-0011

Bevington, M. (2022). "Proof of EHS beyond all reasonable doubt". Comment on: Leszczynski D. Review of the scientific evidence on the individual sensitivity to electromagnetic fields (EHS). Rev Environ Health 2021; Https://doi.org/10.1515/reveh-2021-0038. Online ahead of print. Reviews on Environmental Health, 37(2), 299–301. https://doi.org/10.1515/REVEH-2021-0101/MACHINEREADABLECITATION/RIS

Consales, C., Merla, C., Marino, C., & Benassi, B. (2012). Electromagnetic Fields, Oxidative Stress, and Neurodegeneration. International Journal of Cell Biology, 2012, 16. https://doi.org/10.1155/2012/683897

Guideline of the Austrian Medical Association ( ) for the diagnosis and treatment of EMF-related health problems and illnesses (EMF syndrome). (n.d.).

Huss, A., Egger, M., Hug, K., Huwiler-Müntener, K., & Röösli, M. (2007). Source of Funding and Results of Studies of Health Effects of Mobile Phone Use: Systematic Review of Experimental Studies. Environmental Health Perspectives, 115(1), 1. https://doi.org/10.1289/EHP.9149

ICNIRP. (2021).

IGNIR. (n.d.). www.ignir.org

Karipidis, K., Brzozek, C., Mate, R., Bhatt, C. R., Loughran, S., & Wood, A. W. (2023). What evidence exists on the impact of anthropogenic radiofrequency electromagnetic fields on animals and plants in the environment: a systematic map. Environmental Evidence, 12(1), 1–23. https://doi.org/10.1186/S13750-023-00304-3/FIGURES/12

Kim, J. H., Lee, J. K., Kim, H. G., Kim, K. B., & Kim, H. R. (2019). Possible Effects of Radiofrequency Electromagnetic Field Exposure on Central Nerve System. Biomolecules & Therapeutics, 27(3), 265. https://doi.org/10.4062/BIOMOLTHER.2018.152

Lai, H. (2021). Genetic effects of non-ionizing electromagnetic fields. Electromagnetic Biology and Medicine, 40(2), 264–273. https://doi.org/10.1080/15368378.2021.1881866

Maes, W. (2008). STANDARD STANDARD OF BUILDING BIOLOGY TESTING METHODS. www.baubiologie.de

Pacchierotti, F., Ardoino, L., Benassi, B., Consales, C., Cordelli, E., Eleuteri, P., Marino, C., Sciortino, M., Brinkworth, M. H., Chen, G., McNamee, J. P., Wood, A. W., Hooijmans, C. R., & de Vries, R. B. M. (2021). Effects of Radiofrequency Electromagnetic Field (RF-EMF) exposure on male fertility and pregnancy and birth outcomes: Protocols for a systematic review of experimental studies in non-human mammals and in human sperm exposed in vitro. Environment International, 157, 106806. https://doi.org/10.1016/J.ENVINT.2021.106806

PRESS RELEASE N° 208. (2011). http://www.iarc.fr/

Stam, R. (2010). Electromagnetic fields and the blood-brain barrier. Brain Research Reviews, 65(1), 80–97. https://doi.org/10.1016/J.BRAINRESREV.2010.06.001

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Managing Online Scientific Information Resources for Professional Works

Illangarathne, S.K.

Introduction

Although organized libraries are considered the proper domains to collect information for professional works, many professionals today are drawn to information through the use of the Internet via their smartphones or tablets. The internet or World Wide Web (WWW) is a massive collection of information which is uploaded by the worldwide people at any age limit as well as any education level of life without any control. This information has been widely criticized for its accuracy, timeliness, and authenticity. Information Scientists have confirmed that many of the information sources on the Internet are outdated and uploaded by non-professionals.

When considering the current epidemic situation, and the ease with which information can be obtained, access to the Internet is becoming more and more common. Accurate information can be obtained through databases and educational information systems designed specifically for scientific information retrieval. Therefore, when accessing information sources on the Internet for professional purposes, it is essential to make sure that they are accurate. This article explores the basics that professionals should pay attention to when pursuing their information needs online.

What is an Online Information Resource?

Online information sources can be simply defined as the use of electronic books, newspapers and periodicals using computers and information technology to replace printed books, newspapers and periodicals that are traditionally used as sources of information. Tsakonas et al (2006) define Online Information resources as information sources provided in electronic form, and they include resources available on he Internet such as research guides by subject, online indexes, electronic books and texts, electronic journals, and library catalogs, online reference sources, sound or video. These information sources can be accessed both online and offline. The online system also requires an Internet connection with a computer, tablet, or smartphone to access these information sources.

What are Data, Information, and Information Life Cycle?

Anyone seeking information for professional purposes must first understand the difference between data and information and have a broad understanding of the life cycle of any information. Facts that

give us a basic meaning that we encounter in our daily lives but have not been processed can be identified as data and information can be created by processing them in a formal way. Simply put, the raw material used to process information can be identified as data. The information contains considerable power compared to the data. They are authoritative compared to the data and are also timely. Accordingly, the majority of professionals must make extensive use of processed data to corroborate scientific findings. Tutorials et al., 2022 explain the major difference between data and information as follows;

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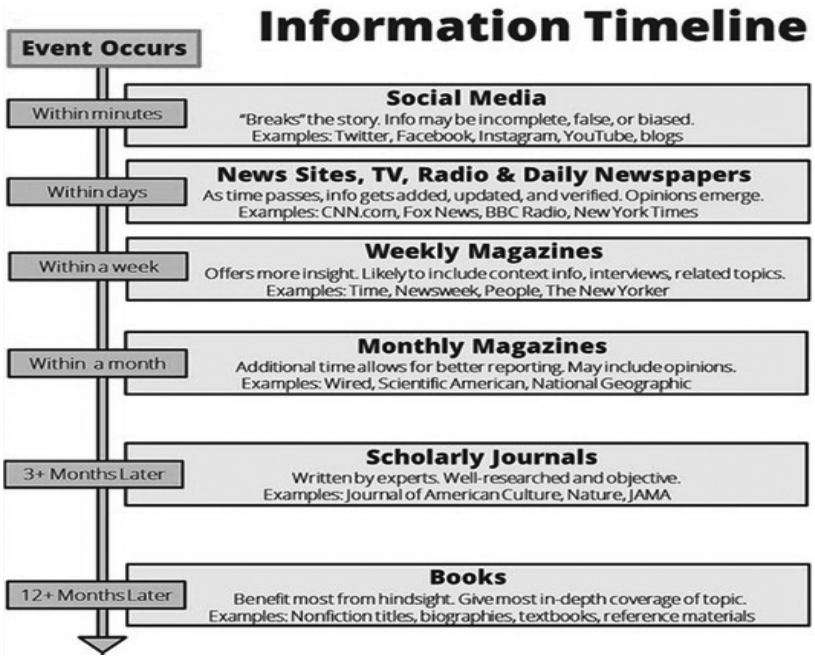
Data	Information
Data refers to raw facts that have no specific meaning	Information refers to processed data that has a purpose and meaning
The word 'data' is derived from the Latin word 'datum', which means 'something that is given'	The word 'information' is derived from the Latin word 'informatio', which means 'formation or conception'.
Data is independent of the information	Information is dependent on data.
Data or raw data is not enough to make a decision	The information is sufficient to help make a decision in the respective context.

Any information has a specific lifespan. After the lifetime of that information, that information becomes obsolete. Depending on the nature of the professional, the information he or she may need may be very fresh as well as historical. For example, a physician may need up-to-date information on a particular disease, and an archaeologist may need information on historical sources about ancient diseases in the world. Accordingly, the life cycle of information varies from profession to profession. Depending on its nature, the source of information to be consulted will also vary. The following is how the life cycle of information sources varies according to different information needs (Illinois.edu, 2019).

The Life Cycle of Information Sources

every aspect of the world has its life cycle. Information also has its lifecycle. The following diagram and table show the life cycle of the Information and the source of information that should be selected according to the information needs of the seeker.



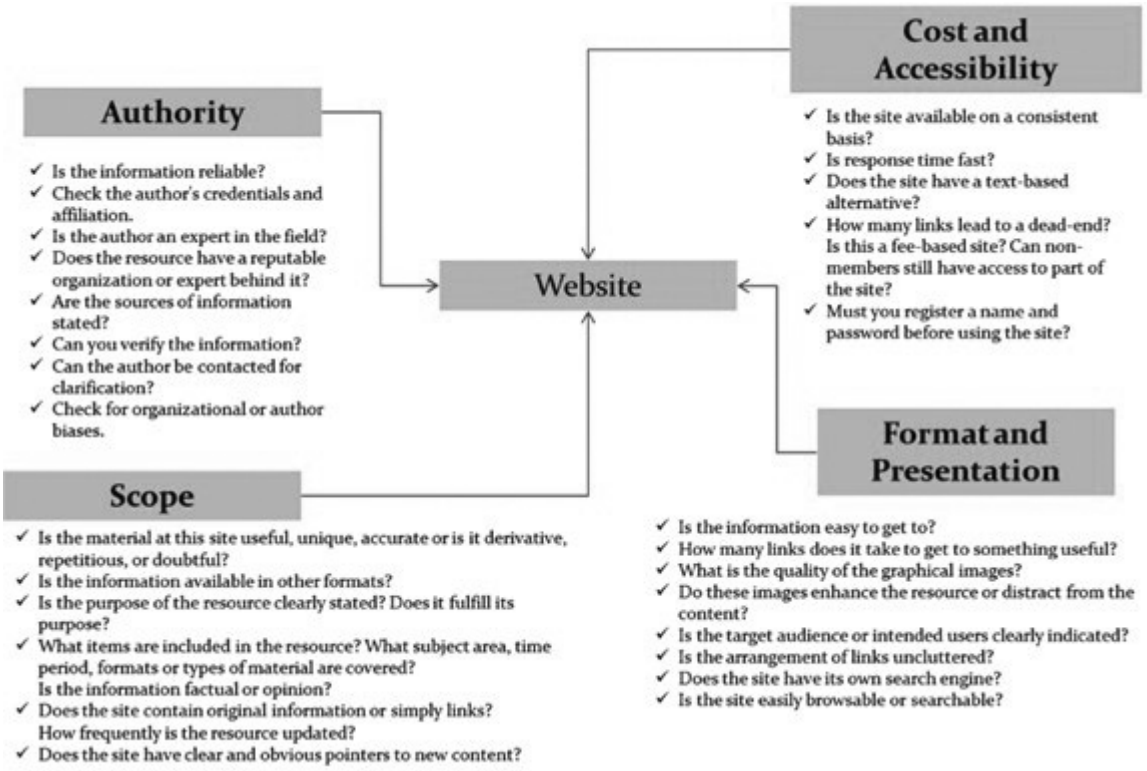
Source: https://libguides.uidaho.edu/c.php?g=1082469&p=7889675

Time duration	Suitable information Source	Evaluation Criteria
The Day of an Event	Television, Social Media, and the Web	The who, what, why, and where of the event Quick, not detailed, regularly updated Authors are journalists, bloggers, social media participants Intended for general audiences
The Day After an Event	Newspapers	Explanations and timelines of the event begin to appear More factual information, may include statistics, quotes, photographs, and editorial coverage Authors are journalists Intended for general audiences
The Week or Weeks After an Event	Weekly Popular Magazines and New Magazines	Long form stories begin to discuss the impact on society, culture, and public policy More detailed analyses, interviews, and various perspectives emerge Authors range from journalists to essayists, and commentary provided by scholars and experts in the field Intended for a general audience or specific nonprofessional groups
Six Months to a Year or More After an Event	Academic, Scholarly Journals	Focused, detailed analysis and theoretical, empirical research Peer-reviewed, ensuring high credibility and accuracy Authors include scholars, researchers, and professionals Intended for an audience of scholars, researchers, and university students
The Week or Weeks After an Event	Weekly Popular Magazines and New Magazines	Long form stories begin to discuss the impact on society, culture, and public policy More detailed analyses, interviews, and various perspectives emerge Authors range from journalists to essayists, and commentary is provided by scholars and experts in the field Intended for a general audience or specific nonprofessional groups
Six Months to a Year or More After an Event	Academic, Scholarly Journals	Focused, detailed analysis and theoretical, empirical research Peer-reviewed, ensuring high credibility and accuracy Authors include scholars, researchers, and professionals Intended for an audience of scholars, researchers, and university students
A Year to Years After an Event	Books	In-depth coverage ranging from scholarly in-depth analysis to popular books Authors range from scholars to professionals to journalists Include reference books which provide factual information, overviews, and summaries.
	Government Reports	Reports from federal, state, and local governments Authors include governmental panels, organizations, and committees Often focused on public policy, legislation, and statistical analysis

Checklist for Evaluating Web Resources

As we have seen above, when accessing the information on the Internet or the World Wide Web, to what extent are the websites that present it relevant to obtain information? It is essential to have an understanding of whether.

Before obtaining information from a website, it is necessary to examine its validity through the following checklist.



Source: https://usm.maine.edu/library/checklist-evaluating-web-resources

Common Search Techniques

The information seeker should save time by limiting the amount of information available when accessing information using the Internet search engine. We have the ability to use a number of exploration strategies for that. For example, using the following search terms can limit your search as much as possible.

Search Social Media
Put @ in front of a word to search social media. For example: @twitter.

Search For a Price
Put $ in front of a number. For example: camera $400.

Search Hashtags
Put # in front of a word. For example: #throwbackthursday Exclude words from your search
Put - in front of a word you want to leave out. For example, jaguar speed -car

Search for an Exact Match
Put a word or phrase inside quotes. For example, "tallest building".

Search within a Range of Numbers
Put .. between two numbers. For example, camera $50..$100.

Search for an Exact Match
Put a word or phrase inside quotes. For example, "tallest building".

Search within a Range of Numbers
Put .. between two numbers. For example, camera $50..$100.

Combine Searches
Put "OR" between each search query. For example, marathon OR race.

Search for a Specific Site
Put "site:" in front of a site or domain. For example, site:youtube.com or site:.gov.

Search for Related Sites
Put "related:" in front of a web address you already know. For example, related:time.com.

In addition, always try to use Professional Strategies to make your Google search environment user friendly.

Use your web browser log in with your e-mail
Use a bookmark facility to keep your frequently used websites to get to remember.
Use an updated web browser (Firefox, Chrome or Edge)
Try to use a unique user name using your surname
Keep remember your digital library login credentials
Use Android apps instead of laptop/desktop versions

Obtain Scholarly Information via Open Access

If possible always try to use scholarly information via open access sources instead of the paid sources. Some logos of Scholarly paid and open access sources are as follows;

Open Access information Sources of Medicine and Health Science Sector

Open Access information Sources of Technology / Science Sector

Open Access information Sources of Social Sciences and Humanities & Law

Open Access Information Resources
Following table show the name, link and coverage of some of the Open Access Resources

Name	Link	Coverage
Open Access Library	https://www.oalib.com/	Free Access to 5,703,611 Academic Articles
Information Research	http://informationr.net/ir/27-1/infres271.html	fields of information science, information management, information systems, information policy, archives and records management and librarianship.
DOAJ	https://doaj.org/	DOAJ is a community-curated online directory that indexes and provides access to high quality, open access, peer-reviewed journals.
The ACM Digital Library	https://dl.acm.org/	The Full-Text Collection of journals, conference proceedings, technical magazines, newsletters and books.
CiteSeerx	http://citeseerx.ist.psu.edu/index	CiteSeerx is an evolving scientific literature digital library
The Collection of Computer Science Bibliographies	http://www.hcibib.org/	Search over 126,000 publications on Human-Computer Interaction
Science.gov	https://www.science.gov/	over 60 databases and over 2,200 scientific websites to provide users with access to more than 200 million pages
EBSCO Open Dissertations	https://www.ebsco.com/product s/research-databases/free- databases	EBSCO provide free research databases covering a variety of subjects for students, researchers and librarians. Researchers can also use EBSCO Essentials to search for free, reliable articles and connect to their library to access additional EBSCO content.
Shodhganga	https://shodhganga.inflibnet.ac.i n/	349327 Thesis
Project Gutenberg	https://www.gutenberg.org/	60,000 free eBooks
DOAB	https://directory.doabooks.org/	DOAB is a discovery service for peer- reviewed open access books and book publishers that indexes and provides access to high quality, open access, peer-reviewed books.
The Center for Computer-Assisted Legal Instruction (CALI)	https://www.cali.org/	Law Books
Information Research	http://informationr.net/ir/27-1/infres271.html	Fields of information science, information management, information systems, information policy, archives and records management and librarianship.
DOAJ	https://doaj.org/	DOAJ is a community-curated online directory that indexes and provides access to high quality, open access, peer-reviewed journals.
The ACM Digital Library	https://dl.acm.org/	The Full-Text Collection of journals, conference proceedings, technical magazines, newsletters and books.

References

Oxford Languages (2022). Oxford Languages and Google - English. [online] languages.oup.com. Available at: https://languages.oup.com/google-dictionary-en/.

McLeod, S. (2022). Maslow's Hierarchy of Needs. [online] Simply Psychology. Available at: https://www.simplypsychology.org/maslow.html.

Tutorials, B., Questions, I., Edge, C., to, H., Forms, F., Information, G., Tutorial, B., Questions, I., Edge, C., to?, H., Forms, F. and Information, D., 2022. Difference between Data and Information. [online] Tutorials Mate. Available at: <https://www.tutorialsmate.com/2021/11/difference-between- data-and-information.html> [Accessed 29 April 2022].

Illinois.edu. (2019). The Information Cycle – Undergraduate Library – U of I Library. [online] Available at: https://www.library.illinois.edu/ugl/howdoi/informationcycle/.

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Strengths, Weaknesses, Opportunities, and Threats: Analyzing the Dual Use of Traditional and Modern Medicines in Healthcare - A Review

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Abstract

Background: *Concomitant use of allopathic medications and herbal medications is a common practice among patients all over the world. This practice could affect both negatively and positively. A SWOT analysis helps to identify positive and negative outcomes of concomitant use of allopathic and herbal medications.* **Objective:** *To critically analyze the strengths, weaknesses, opportunities, and threats associated with the integrated use of allopathic and non-allopathic medicines to inform future research and policy.* **Methodology:** *Scopus and Google Scholar were searched using search terms, "SWOT analysis", "Concomitant use of allopathic and non-allopathic medicines", "SWOT on herbal medicines", "SWOT analysis of allopathic medicines", and "Common diseases with concomitant use of medications" in relevant combinations to identify relevant articles published in English from the year 1998 to 2022. Fifty-two articles resulted from the search. After reviewing all the full articles, 38 were selected as relevant for this narrative review.* **Results:** *There were no articles related to SWOT analysis on concomitant use of allopathic and non-allopathic medications. However, there were literature on SWOT of using allopathic medicines alone and SWOT of using non-allopathic medication alone. SWOT analyses regarding use of non-allopathic medicines were higher in number compared to allopathic medicines. However, there were some research articles that assessed outcomes of combination therapies of allopathic and non-allopathic medication but not specifically a SWOT.* **Conclusion:** *Patients used allopathic and herbal medications concomitantly for many diseases without guidance from healthcare professionals or proper knowledge about either treatment. Research emphasizes many reasons for the concomitant use of both treatment types. This practice leads to several types of positive and negative outcomes, and the integration of both types can improve health treatments as well as patient lifestyles.*

Introduction

With the development of knowledge and technology, medicines and treatment methods have rapidly changed with time. However, some treatment methods used in the past are still in use. Now a days there are many types of treatment options like Western, Acupuncture, Ayurveda, Homeopathy, and Naturopathy, Chinese or Oriental medicine, Chiropractic and Osteopathic medicine. Broadly they can all be categorized as allopathic medicines and non-allopathic medicines.

Allopathic medicine or mainstream medicine is a system of healthcare with the most evidence-based scientific research. Non allopathic medicine refers to health practices, approaches, knowledge and beliefs incorporating plant, animal and mineral based medicines, spiritual therapies, manual techniques and exercises, applied singularly or in combination to treat, diagnose and prevent illnesses or maintain well-being.

People nowadays have a huge tendency to use herbal/traditional medicines over allopathic medicines, especially in countries where there is a rich biodiversity and cultural heritage. Affordability, availability, easy accessibility, and the perception that natural sources have less side effects are some reasons for that. Further, new trends on leading natural life styles have also hugely impacted these practices.

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Studies have shown that a sizable proportion of patients co-used herbs with allopathic medicines. (Agbabiaka et al., 2017; Ameade et al., 2018; Saleh Ahmad and Sharma, 2020). People who live in countries with a culture of traditional medicines (China, India, Africa, Brazil, Sri Lanka) had a high tendency to use traditional or herbal medicines together with allopathic medicine for a long time. Now this trend has also shifted to Western countries, especially because of the trend towards leading a natural life style (Djuv, Nilsen and Steinsbekk, 2013; Akram et al., 2016).

Non-allopathic medicines are widely used for the management of many chronic conditions. There is a favorable perception about the effectiveness of herbal medicine among people because some believe that it brings about complete cure of certain disease E.g. liver disease, asthma, sinusitis, gastro intestinal diseases, gynecological problem, hair falling, sexual problem, and joint pain. They are often used along with allopathic medicines, sometimes without the knowledge of either prescriber (Akram et al., 2016; Gouws and Hamman, 2020). For chronic diseases, patients must take most allopathic medicines throughout their lifetime (Agbabiaka et al., 2017) and thus, their compliance reduces with time. Instead, patients try to use non-allopathic medicines concomitantly with allopathic medicines expecting a complete and quick recovery (Djuv, Nilsen and Steinsbekk, 2013). Some patients are especially desperate for alternative and additional treatments to assist in curing their disease or to reduce the severe side-effects of allopathic medications treatments (SGD, 2015; Gouws and Hamman, 2020). According to literature, prescription medicines combined with herbal medicines were mostly, antihypertensives like b-blockers, diuretics, antihyperlipidemic agents, anticoagulants, analgesics, antihistamines,diabetics, antidepressants and statins (Agbabiaka et al., 2017; Knowledge and 2018, 2018).

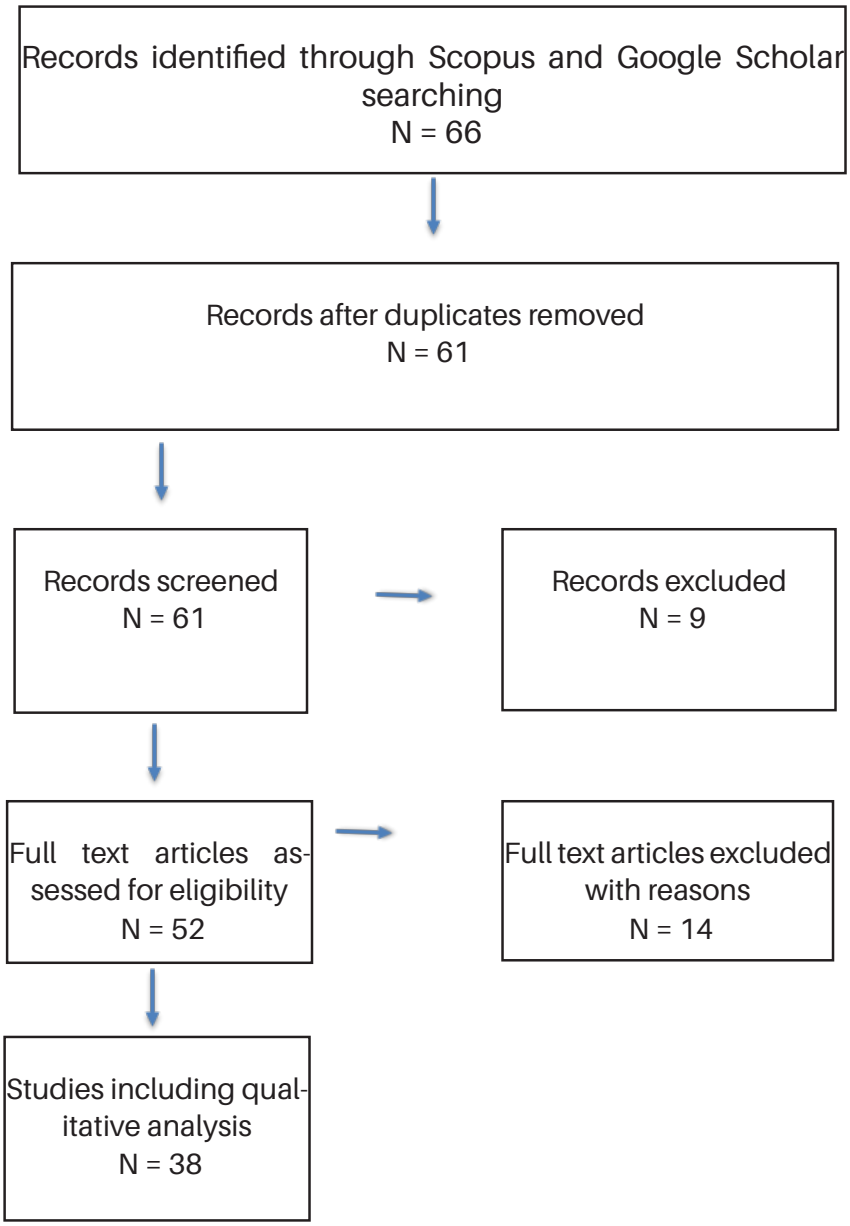
When herbal or traditional medicines, and allopathic medicines are co-administered improperly by a patient, they may exhibit chemical or pharmacological interactions which may alter the effect of either agent, leading to decreased or increased effectiveness, or severity of adverse effects, resulting in negative outcomes of this concomitant use. On the other hand, there could also be benefits of using these two treatment options together, if used under supervision of healthcare professionals. Therefore, knowing strengths, weaknesses, opportunities and threats of using allopathic and non-allopathic treatment options alone and in combination will be helpful and timely.

One of the main research gaps is the unavailability of SWOT analysis on concomitant use of allopathic and herbal medicines in patients which is a very complex situations found in the society. Even though both treatment types are used for treating patients with different diseases, the concomitant use of both types is explored well. Hence, there were no review articles on SWOT analysis on concomitant use of allopathic and herbal medicines. Therefore, this narrative review aims to summarize findings of studies that explored strengths, weaknesses, opportunities, and threats of using allopathic medicines and non-allopathic medicines (only herbal medications, herbal diets with therapeutic intention, and Ayurveda medications) both alone and in combination based on published literature.

Methodology

Scopus and Google Scholar were used as search databases and literature was searched using search terms, “SWOT analysis”, “Concomitant use of allopathic and non-allopathic medicines”, “SWOT on herbal medicines”, “SWOT analysis of allopathic medicines”, and “Common diseases with concomitant use of medications” in relevant combinations to identify relevant articles published in English from the year 1998 to 2022. No search filters were applied. Fifty-two articles resulted from the search. After reviewing all the full articles, 38 were selected as relevant for this narrative review.

The following flow chart indicates the process of article selection;



Results

There were no articles related to SWOT analysis on concomitant use of allopathic and non-allopathic medications. However, there were literature on SWOT of using allopathic medicines alone (Fosgerau and Hoffmann, 2015; Von Kodolitsch et al., 2015) and SWOT of using non-allopathic medication alone (Jain and Rao, 2016; Arshad, Fauzan and Bint, 2017; Appiah et al., 2018; Tang et al., 2018; Vankova, 2018; Ajala et al., 2019; Singh et al., 2019; Lian and Chen, 2020; Memişoğlu and Bilen, 2021). Most articles were based in China, India, Brazil, and Bulgaria, and the results reported were generally similar. The dissimilarities in results of these articles were mostly due to their cultural, political and geographical differences.

SWOT analyses regarding use of non-allopathic medicines were higher in number compared to allopathic medicines. Even the few that were

found on allopathic medicines, were only specific to a certain medicine (Fosgerau and Hoffmann, 2015). E.g. Analysis of the strengths, weaknesses, opportunities, and threats (SWOT) of naturally occurring peptides in their use as therapeutics.

However, there were some research articles that assessed outcomes of combination therapies of allopathic and non-allopathic medication but not specifically a SWOT. They too seemed biasedly reported based on researcher intentions. A summary of findings of these studies are described below.

SWOT Analysis on Using Non-Allopathic Medicine Alone

There were many reports on SWOT analysis (N=8) published on using non-allopathic medicines including traditional medicines, herbal medicines, and Eastern medicines. Governments, healthcare professionals, academics had all shown an interest to evaluate positive and negative characteristics of using non-allopathic medicines but with different intensions. Most of the time, the SWOT was to elaborate and justify the perspectives of the researcher and appeared to be biased. China (Tang et al., 2018; Lian and Chen, 2020), India (Jain and Rao, 2016; Parveen et al., 2020), West Africa (Appiah et al., 2018; Ajala et al., 2019), Bulgaria (Vankova, 2018), frequently reported SWOTs on using non-allopathic medicine use.

The strengths, weaknesses, opportunities, and threats in using non-allopathic medicines such as traditional medicines, herbal medicines, and Ayurveda medicines were reported as follows in published studies (Vankova, 2018; Ajala et al., 2019; Lian and Chen, 2020).

Strengths of Non-Allopathic Medicine Use

The following were strengths reported in published articles on using non-allopathic medicines.

Having a solid foundation rooted with thousands of years of past experience in using traditional medicines in the world.

Having treatment options for various diseases or illnesses which has no other pharmaceutical remedy, especially treating incurable diseases and chronic diseases.

Having international demand for traditional medicines with a trend towards healthy living and people increasingly pursuing improvement in health and quality of life.

Favorable government policies/recognition with increasing number of Governments and National Agency for Food and Drug Agency and Control Boards, approving traditional medicinal products to be sold to the public.

Freely available at a low cost especially in some countries rich in natural medicinal resources (E.g. China, India and Japan).

Being nature-centered, stable and conservative.

Use of a holistic approach to health in line with the current "Back to Nature" or "Green" trends among the younger generation in world.

Little or no pathogenic resistance to traditional formulations. Non-allopathic medicine helps reduce the need for antibiotics, thus reducing the problem of antimicrobial resistance.

Safe with hardly any adverse effects.

Ability to restore the patient's energy and helps the immune system to manage the disease.

Low product development time. Non-allopathic medicines take 3-5 years, in comparison to allopathic medicine that take about 10-15 years to come into the market.

Capacity to handle spiritual mysteries for diagnosis and healing.

In many parts of the world, it is widely believed that some diseases are a result of afflictions of evil spirits and powers of darkness including witchcraft and wizardry. Traditional medicinal techniques are said to tackle these aspects of the disease too.

Weaknesses of Non-Allopathic Medicine Use

The following were weaknesses reported in published articles on using non-allopathic medicines.

Based on incorrect or uneven diagnosis and imprecise dosages.

Traditional medical practitioners lack skills required for correct diagnosis of serious disorders.

Poor documentation processes regarding treatments.

Lack scientific basis or proof.

Not revealing of actual contents and/ or difficulty in determining actual ingredients.

Intermingled with witchcraft, separatism and sorcery.

Low standard of hygiene in the manufacturing process and in the preparation of medicines.

Yield is dependent on nature resulting in difficulty in continuous supply of herbal plants.

Lack of interest on doing scientific studies on plants and their products.

Opportunities of Non-Allopathic Medicine Use

Some opportunities related to use of non-allopathic medicines were also identified in the literature.

The existence of green vegetation.

Large and increasing number of users.

Promotion of entrepreneurship or ability to manufacture or create new products with new innovative ideas.

Possibility of integrating with allopathic medicines.

Availability of training opportunities for entrants into the trade.

Existence of a numerous ageing rural population.

Possibility of standardization of medicines.

Protection of the public from harmful practices of quacks.

Establishment of the efficacy of native therapies.

Threats of Non-Allopathic Medicine Use

The following threats were identified and reported in literature regarding the use of non-allopathic medication.

Ethical issues in using non-allopathic medicines where the system is fraught with a lot of unethical procedures and unstandardized practices.

Sustainability of non-allopathic medicines where the biodiversity conservation of medicinal plants which is considered the major raw material for non-allopathic medicine practice is at risk since some of the plant species are already endangered in some localities.

The issue of witchcraft and sorcery where its practices are intermingled with witchcraft, spirits and sorcery.

The secrecy of non-allopathic practitioners and poor documentation of its procedures, and as a result of the poor literacy level of some of the non-allopathic practitioners and their secrecy, a lot of useful information has perished with aged originators due to lack of organized record keeping and documentation.

Possibility of serious drug interactions and side effects when used together with allopathic medicine.

Availability of alternate chemical methods for production and these alternate chemical products could be obtained for a lower price than original herbal products.

Lack of interest in cultivation where low harvest or difficulty in collecting proper amount of harvest to prepare traditional medicines in adequate amounts.

Lack of scientific evidence makes it difficult to convince people to purchase products as they are keen to know every detail about their purchased products.

The fake herbal products are difficult to identify and differentiate among correct herbal plants.

Higher prices of some herbal products especially some plants that are very valuable in different ways are unbearable to people.

Climate change and global warming which will directly impact to the cultivation and harvest.

SWOT Analysis and Revelation in Traditional Chinese Medicine (TCM) Internationalization

Strengths	**Weaknesses**
TCM in theory and in treating diseases International demand for TCM Natural medicine resources The scale and power of TCM enterprises	Cultural diversity Quality control of TCM Difficulty in identification of active principle from TCM composition Limited research input into TCM and challenge for technological innovation
Opportunities	**Threats**
Continuous improvement of attention to TCM by the international community Opportunity for economic globalization Chinese government policy support Continuous recognition of the advantages of TCM	Differences between Chinese and Western cultures Dual risks in Chinese and foreign markets Limitation of technical trade barriers Challenges in intellectual property related to TCM

Traditional Medicine Practices in Nigeria : A SWOT Analysis

Strengths	Weaknesses
Favorable Nigerian climate and vegetation Long tradition and usage of AM Effectiveness of AM. Availability, affordability, accessibility of AM Capability to handle mysteries associated with diseases through spiritual mediums-trance Can handle impossible cases for OM for example insanity In tune with the culture of the people. Acceptable to the generality No side effects because they are organic Possession of supernatural knowledge about sickness Capacity to address and heal the spiritual aspects of illness. Diverse number of specialists and accessibility to rural dweller.	Activities of dubious and charlatans Poor record of activities. Secrecy and cultic activities Scientifically unverifiable. ncorrect diagnosis and imprecise dosage Low hygienic standards Failure of the AM Practitioners to accept the limitation of their knowledge Lack scientific basis or proof Fake AMs Intermingled with witchcraft, spiritism and sorcery. Unorganized and different training levels of the CAM apprentices
Opportunities	**Threats**
The existence of green vegetation. Existence of a Traditional medicine policy for Nigeria, 2007 Possibility of integration of OM with AM Availability of training opportunities for entrants into the trade. The existence of a numerous ageing rural population. Possibility of standardization of medicines Protection of the public from harmful practices of quacks. Establishment of the efficacy of native therapies Conducive climatic. Existence of a virile Herbs and Leaves Traditional Medicines Practitioners' Association of Nigeria. Large number of populations of CAM practitioners with great spread over all ethnic groups. A large Nigerian population of about 170 million consumers.	The activities and practices of charlatans. Witchcraft and occultism in AM The fake AM products The importation of higher quality CAM products Higher prices of some AM products Climate change and global warming Some herbs are going to extinction Diseases and pests attack on of herbs Sometimes explicable knowledge Opposition by certified OM practitioners Performance of sacrifices Perception by some religious leaders as idolatrous

SWOT Analysis of Using Allopathic Medicine Alone

Unlike in herbal or traditional medicines, there were not many SWOTs done on allopathic medicines, possibly because of the popularity and rapid development of allopathic medicine backed up by clinical trials which are better assessments than tools like SWOT. However, a few have been done targeting specific objectives. For example, SWOT analysis on prospects of short peptides was done to bring out

the interests of specific organizations or entities that hosted them and did not clearly evaluate strengths, weaknesses, opportunity and threats of allopathic medicines (Von Kodolitsch et al., 2015; Singh et al., 2019).

Findings on Possible Negative Outcomes of Interaction between Allopathic and Non-Allopathic Medicines

There is a global concern about the adverse effects of drug-drug, drug-herbal and drug-food interactions because many serious, and occasionally life-threatening, adverse consequences have occurred in humans when allopathic medicines were taken along with some herbal remedies, foods, fruit juices, and dietary supplements.

As described earlier, the use of herbal remedies has increased in developed and developing countries and this practice has led to interactions of synthetic medicines with plant-based medicines. Many patients tend to self-treat their medical conditions with herbal medicines along with allopathic medicines, resulting in drug-herbal interactions (SGD, 2015; Gouws and Hamman, 2020).

The quality, purity and potency of herbal medicines are not generally regulated by many drug regulatory agencies as they are done for synthetic medicines. As a result, some undesirable effects can happen (Welz, Emberger-Klein and Menrad, 2018; Tangkiatkumjai, Boardman and Walker, 2020). However, to overcome these negative outcomes, the need for effective doctor patient communication and active questioning in treatment history about non-allopathic medicines usage and other traditional treatment methods has been highlighted (Ekor, 2014; Gouws and Hamman, 2020).

Findings on Possible Positive Outcomes of Concomitant use of Allopathic and Non-Allo-Pathic Medicines

Most research have attempted to discuss or identify the negative outcomes of concomitant use of allopathic and non-allopathic medicines. However, due to the growing interest on herbal medicines, several entities have explored the positive side of using allopathic and non-allopathic medications concomitantly as well.

There is a favorable perception about concomitant use of allopathic and non-allopathic medications and its effectiveness in achieving complete cure of certain diseases in many countries. Regulation of herbal medications, concurrent use with allopathic medicine and scientific testing has always been a concern (Clement et al., 2007; Ekor, 2014). The regulatory authorities in many countries are also patronizing concomitant use of allopathic and non-allopathic medications (Nahin, Dahlhamer and Stussman, 2010).

It is very important to inform the allopathic prescriber regarding correct information of herbal drugs while their taking allopathic medicines to enhance positive outcomes. Some of the positive outcomes of concomitant use of allopathic and herbal drugs in the literature were as follows (Clement et al., 2007; SGD, 2015; Edussuriya et al., 2021).

Both works together to manage a condition.
Makes patients more comfortable about managing their condition with their own traditional medicines.
More effective in treating diseases.
Quickens recovery.
Treatment cost is lower.
Increase immune system to enhance the recovery.

SWOT Analysis on Using Allopathic Medication Concomitantly with Non-Allopathic Medicines

There were no research articles directly carried out on SWOT analysis of concomitant use of allopathic and non-allopathic medicines although there were several research articles regarding concomitant use of allopathic and non-allopathic medicines. (Djuv, Nilsen and Steinsbekk, 2013; SGD, 2015; Agbabiaka et al., 2017; Ameade et al., 2018; Saleh Ahmad and Sharma, 2020).

Concomitant Use of Non-Allopathic Medicines with Allopathic Medicines

With the development of knowledge and technology, medicines and treatment methods have rapidly changed with time. However, some treatment methods used in the past are still in use. Now a days there are many types of treatment options like Western, Acupuncture, Ayurveda, Homeopathy, and Naturopathy, Chinese or Oriental medicine, Chiropractic and Osteopathic medicine. Broadly they can all be categorized as allopathic medicines and non-allopathic medicines.

Non-allopathic medicines have been considered a safer and holistic way of treatment and believed to be safe with less side effects, cost effective, and easily accessible (Akram et al., 2016; Knowledge and 2018, 2018). Non-allopathic medicines improve the self-healing ability of the body by improving the immune system. Non-allopathic medications are prescribed as individualized medications, but the allopathic medicinal system has little or no individualization and focus on treating a particular disease or disorder by focusing on its symptoms (Akram et al., 2016; Saleh Ahmad and Sharma, 2020, Ameade et al., 2018).

Due to these several reasons, people intend to use allopathic and non-allopathic medicines concomitantly. A sizable proportion of patients co-used herbs with conventional drugs (Agbabiaka et al., 2017; Ameade et al., 2018; Saleh Ahmad and Sharma, 2020). People who live in countries with a culture of traditional medicines (China, India, Africa, Brazil, Sri lanka) had a high tendency to use traditional or herbal medicines concomitantly with allopathic medicine for a long time. Now the trend has also shifted to western countries where herbal drugs are used due to several reasons especially because of the trend towards leading a natural life style (Djuv, Nilsen and Steinsbekk, 2013; Akram et al., 2016).

Discussion

A vast number of people use non-allopathic medication together with their allopathic medications for their chronic diseases. When using lifelong allopathic medication, patients often become dissatisfied and develop poor adherence, thereby result in poor disease control. To overcome this problem, patients often try using non-allopathic medications together with allopathic medications (Djuv, Nilsen and Steinsbekk, 2013; Rutebemberwa et al., 2013). However, such concomitant use of different treatment types, when initiated by patients themselves, could result in, unwanted side effects, adverse drug reactions, and worsening of medication adherence issues. This could harm patients or further distract patients from their allopathic medication treatments. (Agbabiaka et al., 2017; Gouws and Hamman, 2020).

Patients use non-allopathic medicines concomitantly with their daily allopathic medications due to various reasons, especially for diseases like diabetes. However, it is evident that most diabetes patients use both these types of medications concomitantly, without having proper knowledge and without knowing long term consequences (Welz, Emberger-Klein and Menrad, 2018; Tangkiatkumjai, Boardman and Walker, 2020). There are many reasons for selecting non-allopathic medicines over allopathic medicines by people according to their perception. Mainly in rural areas, non-allopathic medicines are accessible, available, acceptable and met people's expectations, and was affordable than allopathic medicines (Nahin, Dahlhamer and Stussman, 2010; Akram et al., 2016; Welz, Emberger-Klein and Menrad, 2018). Non-allopathic medicines are easy to use, with no strict drug regimen like allopathic medicine which helps improve patient compliance. They are perceived safer as they were used for a long period of time (Astin, 1998; Ekor, 2014; Tangkiatkumjai, Boardman and Walker, 2020). Traditional or herbal medicines are used from ancient times, so people have faith and trust on traditional medicines than allopathic medicines.

It is perceived that allopathic medicines have lots of side effects than traditional medicine, so especially people who use long term medicines for chronic disease conditions tend to rely on herbal medicines (Astin, 1998; Liwa et al., 2017). Some older people with different experiences of long-term medicines for non-communicable diseases, believe that herbal medicines can cure these diseases completely and faster than allopathic medicines (Astin, 1998; Clement et al., 2007). Most people like to use anything with a natural base and less of synthetic chemicals.

A SWOT analysis helps to identify the underlying causes for problems and reasons for using non-allopathic medicines together with allopathic. Although we did not identify SWOT analyses that looked at the concomitant use, the SWOTs, on using each treatment type alone was helpful in obtaining insights. Reviewing of strengths, weaknesses, opportunities and threats of using non-allopathic medicines therefore provides a clear pathway on how to improve allopathic medication treatment according to patient expectations.

With our cultural background, Sri Lankans prefer natural entities, and most favor non-allopathic treatment options even without a scientific basis. On the other hand, the general public do not have a clear idea about allopathic medicines, their chemical entities, and the harmful consequences of using different treatment options together. At the same time, the easy access and low cost of non-allopathic medicines is an opportunity that the government can explore at this point of time. With correct research and development techniques, and proper integration between allopathic and non-allopathic healthcare providers, we can make use of easily available, non-allopathic medicines at a low cost to replace some of the costly allopathic medicines.

Most of the non-allopathic medicines used are not standardized and lack a regulatory framework for practice. The government should focus on improving herbal medicines with a traditional history, so that patients have a choice of using these traditional medicines safely if they wish to. This initiative will also help to integrate the allopathic and non-allopathic treatments in a sustainable way. We can then ask or give chance for people to select their preferable treatment type, allopathic or non-allopathic treatment types, which will minimize negative outcomes of concomitant use without guidance.

There are limitations in this review article which must be acknowledged. Although the objective of this review was to assess SWOT on concomitant use of allopathic and non-allopathic medicine use, there were very limited articles on this aspect in the literature. Further, most of the research included in articles were focused on a limited number of countries, such as China and India.

The content of all the reports in this review related many strengths, weaknesses, opportunities and threats of using allopathic medicines, non-allopathic medicines and their concomitant use. These SWOT analysis reports could be used for a large positive difference in the delivery of the healthcare system in Sri Lanka with greater patient engagement.

Conclusion

Most literature reported that patients perceived non-allopathic medicines to be more efficacious and having fewer side effects than allopathic medicines. Further, non-allopathic medicines were perceived to be closer to nature, and were trusted by people due to its existence from ancient times. There were many reasons for patients to select non-allopathic medicines over allopathic medicines as well, but most on allopathic medicines concomitantly used non-allopathic medicines according to their preference or as influenced by someone they trusted.

There were many strengths, weaknesses, opportunities, and threats of using non-allopathic medicines reported when compared to using allopathic medicines, especially because there were only a very few articles on SWOT analysis

of allopathic medicines published. Affordability, accessibility, nature-centeredness, safety with adverse effects, having many treatment options were some strengths reported on using non-allopathic medicines. Lack of a scientific basis, doses not being standardized, and poor documentation practices were among the weaknesses.

The use of non-allopathic medicines is not without risk, and when they are administered together with allopathic medicines, they can lead to unwanted and unsafe interactions. The outcome of these interactions ranged from negligible to life-threatening. The potential dangers associated with herb-drug interactions were reported too.

Researchers viewed the integration of the two healthcare systems, allopathic and non-allopathic medicines positively, but there are challenges that need to be addressed. The integration could offer better acceptance of allopathic medicines by patients. More training for healthcare professionals who are offering allopathic and non-allopathic treatments, in integrating the two systems could increase care for patients. Additionally, strong advocacy and publicity is needed to educate more people on safety and risks of integration and the utilization of these services.

References

Accreditation Council for Graduate Medical Education (2017). A Quick Guide to the SWOT Analysis Department of Field Activities, p. 4. Available at: https://www.acgme.org/Portals/0/PDFs/SelfStudy/SS_SWOTGuide.pdf.

Afifah, I., & Sopiany, H.M. (2017) 'No Title 87(1,2), pp. 149–200.

Agbabiaka, T.B. et al. (2017). Concurrent use of prescription drugs and herbal medicinal products in older adults: A systematic review, Drugs and Aging, 34(12), 891–905. Available at: https://doi.org/10.1007/s40266-017-0501-7.

Ajala, A.O. et al. (2019). Traditional medicine practices in Nigeria: A SWOT analysis', International Journal of Mechanical Engineering and Technology, 10(2), 117–126.

Akram, M. et al. (2016). Herbal drugs: knowledge, attitude and practice of its concurrent use with allopathic drugs, scientific testing and effectiveness in common diseases among educated class, International Journal of Basic and Clinical Pharmacology, 5(4), 1275–1280. Available at: https://doi.org/10.18203/2319-2003.ijbcp20161881.

Alqathama, A. et al. (2020). Herbal medicine from the perspective of type II diabetic patients and physicians: what is the relationship? BMC Complementary Medicine and Therapies, 20(1), 65. Available at: https://doi.org/10.1186/s12906-020-2854-4.

Ameade, E.P.K. et al. (2018). Concurrent use of herbal and orthodox medicines among residents of Tamale, Northern Ghana, who patronize hospitals and herbal clinics, Evidence-based Complementary and Alternative Medicine, 2018(2002). Available at: https://doi.org/10.1155/2018/1289125.

Sammut-Bonnici, T. and Galea, D. (2015). SWOT Analysis. In Wiley Encyclopedia of Management (eds C.L. Cooper, J. McGee and T. Sammut-Bonnici). https://doi.org/10.1002/9781118785317.weom120103

Appiah, B. et al. (2018). Identifying strengths and weaknesses of the integration of biomedical and herbal medicine units in Ghana using the WHO Health Systems Framework: A qualitative study', BMC Complementary and Alternative Medicine, 18(1), 1–8. Available at: https://doi.org/10.1186/s12906-018-2334-2.

Arshad, A., Fauzan, M. and Bint, R. (2017). A Synthesis on SWOT analysis of public sector healthcare knowledge management information systems in Pakistan, International Journal of Advanced Computer Science and Applications, 8(8), 130–136. Available at: https://doi.org/10.14569/ijacsa.2017.080817.

Astin, J.A. (1998). Why patients use alternative medicine: Results of a national study, Journal of the American Medical Association, 279(19), 1548–1553. Available at: https://doi.org/10.1001/jama.279.19.1548.

Baser, T., Aypak, C. & Gorpelioglu, S. (2018). Use of herbal products in type 2 diabetes mellitus patients, Family Medicine and Care, 1(1), 1–2. Available at: https://doi.org/10.15761/fmc.1000106.

Clement, Y.N. et al. (2007). Perceived efficacy of herbal remedies by users accessing primary healthcare in Trinidad. BMC Complementary and Alternative Medicine, 7, 1–9. Available at: https://doi.org/10.1186/1472-6882-7-4.

Demirkol, M.E. et al. (2020). An evaluation of hospital practices using Swot analysis during Covid-19. Journal of Academic Research in Nursing, 6(2), 341–351. Available at: https://doi.org/10.5222/jaren.2020.90958.

Djuv, A., Nilsen, O.G. & Steinsbekk, A. (2013). The co-use of conventional drugs and herbs among patients in Norwegian general practice: A cross-sectional study. BMC Complementary and Alternative Medicine, 13. Available at: https://doi.org/10.1186/1472-6882-13-295.

Dworkin, S.L. (2012). Sample size policy for qualitative studies using in-depth interviews. Archives of Sexual Behavior, 41(6), 1319–1320. Available at: https://doi.org/10.1007/s10508-012-0016-6.

Edussuriya, A.S.J. et al. (2021). Experiences of patients on natural herbal treatments for diabetes mellitus at the Diabetes Clinic in Base Hospital - Matara, Sri Lanka. Journal of Patient Experience, 8(92), pp. 1–5. Available at: https://doi.org/10.1177/23743735211039313.

Ekor M. (2014). The growing use of herbal medicines: Issues relating to adverse reactions and challenges in monitoring safety. Frontiers in Pharmacology, 4, 177. https://doi.org/10.3389/fphar.2013.00177

Gouws, C. & Hamman, J.H. (2020). What are the dangers of drug interactions with herbal medicines?', Expert Opinion on Drug Metabolism and Toxicology, 16(3), 165–167. Available at: https://doi.org/10.1080/17425255.2020.1733969.

Jain, R. & Rao, B. (2016). Causal-loop and SWOT analysis of Indian herbal industry, International Conference on Inter Disciplinary Research in Engineering and Technology , 26–30. Available at: https://pdfs.semanticscholar.org/028b/e8ff307879bdf41603c6f7a4936132a1532a.pdf.

Narayan, J.P. (2018). Synergistic combination of ancient Indian herbal formulations with modern allopathic prescriptions is need of the hour. Conference: National Conference on Ancient Indian Knowledge, Science and Technology, At: NCERT, New Delhi, 17: 1-15

Von Kodolitsch, Y. et al. (2015) 'Analysis of Strengths, Weaknesses, Opportunities, and Threats as a Tool for Translating Evidence into Individualized Medical Strategies (I-SWOT)', Aorta, 3(3), pp. 98–107. Available at: https://doi.org/10.12945/j.aorta.2015.14.064.

Lian, Y. and Chen, G. (2020) 'SWOT Analysis of Integrating Traditional Chinese Medicine into Health Service Industry', 496(Ichess), pp. 597–601. Available at: https://doi.org/10.2991/assehr.k.201214.570.

Liwa, A. et al. (2017) 'Herbal and Alternative Medicine Use in Tanzanian Adults Admitted with Hypertension-Related Diseases: A Mixed-Methods Study', International Journal of Hypertension, 2017. Available at: https://doi.org/10.1155/2017/5692572.

Modak, M. et al. (2007) 'Indian herbs and herbal drugs used for the treatment of diabetes', Journal of Clinical Biochemistry and Nutrition, 40(3), pp. 163–173. Available at: https://doi.org/10.3164/jcbn.40.163.

Nahin, R.L., Dahlhamer, J.M. and Stussman, B.J. (2010) 'Health need and the use of alternative medicine among adults who do not use conventional medicine', BMC Health Services Research, 10. Available at: https://doi.org/10.1186/1472-6963-10-220.

Naylor, T.H. (1983) 'Strategic planning and forecasting', Journal of Forecasting, 2(2), pp. 109–118. Available at: https://doi.org/10.1002/for.3980020203.

Parveen, B. et al. (2020) 'Challenges and opportunities for traditional herbal medicine today with special reference to its status in India', Annals of Phytomedicine: An International Journal, 9(2), pp. 97–112. Available at: https://doi.org/10.21276/ap.2020.9.2.8.

Rutebemberwa, E. et al. (2013) 'Use of traditional medicine for the treatment of diabetes in Eastern Uganda: A qualitative exploration of reasons for choice', BMC International Health and Human Rights, 13(1), pp. 1–7. Available at: https://doi.org/10.1186/1472-698X-13-1.

Ahmad, A. S., & Sharma, R. (2020) 'Comparitive Analysis of Herbal and Allopathic Treatment systems', European Journal of Molecular & Clinical Medicine , 7(7), pp. 2869–2876.

SGD, O. (2015) 'The Possibility of Interactions between Medicinal Herbs and Allopathic Medicines used by Patients Attended at Basic Care Units of the Brazilian Unified Health System', Natural Products Chemistry & Research, 3(2). Available at: https://doi.org/10.4172/2329-6836.1000171.

Singh, A. et al. (2019) 'Opportunities and Challenges in Development of Phytopharmaceutical Drug in India- A SWOT Analysis', Journal of Young Pharmacists, 11(3), pp. 322–327. Available at: https://doi.org/10.5530/jyp.2019.11.66.

Tang, H. et al. (2018) 'SWOT analysis and revelation in traditional Chinese medicine internationalization', Chinese Medicine (United Kingdom), 13(1), pp. 1–9. Available at: https://doi.org/10.1186/s13020-018-0165-1.

Tangkiatkumjai, M., Boardman, H. and Walker, D.M. (2020) 'Potential factors that influence usage of complementary and alternative medicine worldwide: a systematic review', BMC Complementary Medicine and Therapies, 20(1), pp. 1–15. Available at: https://doi.org/10.1186/s12906-020-03157-2.

Vankova, D. (2018) 'SWOT analysis of Eastern Medicine developments in Bulgaria', Scripta Scientifica Salutis Publicae, 4(0), p. 34. Available at: https://doi.org/10.14748/sssp.v4i0.5580.

Welz, A.N., Emberger-Klein, A. and Menrad, K. (2018) 'Why people use herbal medicine: Insights from a focus-group study in Germany', BMC Complementary and Alternative Medicine, 18(1), pp. 1–9. Available at: https://doi.org/10.1186/s12906-018-2160-6.

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Education, Cultural Identity and Globalization: A Comparative Study

Kiriella , M.

Abstract

Education is a fundamental pillar that underpins the socio-economic development and cultural enrichment of a nation. This article presents an in-depth comparative analysis of the education systems in Sri Lanka, Japan, Finland, and New Zealand, focusing on both school and postgraduate education. It explores the historical evolution of Sri Lanka's educational framework, identifying significant milestones and reforms that have shaped its current state. The analysis extends to a critical examination of primary, secondary, and tertiary education, highlighting structural inefficiencies and comparing them with the holistic and innovative approaches employed in Japan, Finland, and New Zealand. The study employs a qualitative comparative analysis of secondary data sources, including an extensive review of literature, official educational policies, and case studies. The importance of integrating life skills into the curriculum is emphasized, with case studies from these countries demonstrating best practices in fostering critical thinking, problem-solving, and social responsibility among students. Furthermore, the article addresses the challenges faced by Sri Lanka's tertiary education sector, including limited research opportunities and brain drain, while suggesting actionable recommendations for reform. A key focus is on the interplay between education, cultural identity, and globalization, examining how different countries balance the preservation of cultural identity with the demands of a globalized world. This comparative study aims to provide valuable insights and practical strategies for enhancing educational outcomes, ensuring students are well-prepared to navigate the complexities of modern life while maintaining their cultural roots.

Keywords: *Comparative Education, Cultural Identity, Globalization, Life Skills, Educational Reform.*

Introduction

Education serves as a cornerstone for societal development, shaping the cultural, social, and economic fabric of a nation. This article delves into the intricate evolution and contemporary dynamics of the education system in Sri Lanka, juxtaposing it with educational paradigms in Japan, Finland, and New Zealand. Through this comparative analysis, it elucidates the strengths, systemic inefficiencies, and potential avenues for reform within Sri Lanka's educational framework, covering both school and postgraduate education, and highlighting the importance of life skills and the interplay between education, cultural identity, and globalization.

Methodology

The research methodology adopted for this study involves a qualitative comparative analysis of secondary data sources. This includes an extensive review of literature, official educational policies, reports from government and international organizations, and case studies from the countries in focus. The study compares the educational frameworks, policies, and outcomes of Sri Lanka with those of Japan, Finland, and New Zealand, using a thematic analysis to identify key trends, challenges, and best practices.

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Historical Evolution of Education in Sri Lanka

Sri Lanka's educational heritage dates back over 2300 years, originating during the reign of King Devanampiya Tissa. Early educational institutions were predominantly centered around Buddhist temples and pirivenas, serving as monastic colleges for clergy and higher education.

Colonial Influence and Reforms

The advent of British colonial rule in the 19th century marked a watershed moment, with the Colebrooke Commission's recommendations in 1836 catalyzing the establishment of a structured formal education system. The Royal College in Colombo epitomized this transformation, and the period witnessed the proliferation of single-sex schools such as St. Thomas' College in Mount Lavinia and Trinity College in Kandy, primarily financed through government grants and local philanthropic contributions (Ministry of Education, 2020).

Post-Colonial Developments

The post-colonial era heralded significant reforms aimed at democratizing education. In 1938, education was declared free, a landmark initiative spearheaded by Dr. C.W.W. Kannangara and the Executive Committee of Education. The establishment of Madhya Maha Vidyalayas (Central Colleges) was instrumental in decentralizing education, providing broader access across the island, and ensuring instruction in native languages, Sinhala and Tamil. Despite these progressive measures, the contemporary education system in Sri Lanka is characterized by a fragmented governance structure, with responsibilities divided between the Central Government and Provincial Councils, resulting in administrative inefficiencies and coordination challenges (World Bank, 2020; UNDP, 2019).

Current Structure of Sri Lankan Education

Sri Lanka's education system encompasses primary, secondary, and tertiary levels, predominantly funded and overseen by various governmental ministries. This management framework, however, has engendered significant inefficiencies, particularly at the tertiary level where several public universities and institutes fall under different ministerial jurisdictions. These structural divisions have perpetuated mismanagement and resource allocation issues (Ministry of Education, 2020; World Bank, 2020).

Primary Education

Primary education in Sri Lanka spans grades 1 to 5 and is compulsory for all children. The curriculum focuses on core subjects such as Mathematics, Science, Language, and Social Studies. Despite high enrollment rates, the system faces challenges, including outdated teaching methods, rote learning, and inadequate infrastructure. The emphasis on memorization over critical thinking and problem-solving, insufficient resources and facilities in rural areas, and the need for continuous professional development for teachers are significant hurdles (Ministry of Education, 2020).

Secondary Education

Secondary education covers grades 6 to 13, divided into junior secondary (grades 6-9) and senior secondary (grades 10-13). The curriculum includes a broader range of subjects, including vocational and technical education in the senior years. Challenges include high dropout rates, disparities in education quality between urban and rural areas, and a curriculum that often fails to link directly with employment opportunities (UNDP, 2019).

Tertiary Education

Sri Lanka's tertiary education system includes universities, technical colleges, and vocational training institutes. Despite the establishment of several universities, access to higher education remains limited due to high competition and limited seats. The quality of higher education is affected by insufficient funding, outdated curricula, and a lack of alignment with job market needs. The University Grants Commission Act

No. 16 of 1978 plays a crucial role in the administration of university education, overseeing the allocation of funds, maintaining academic standards, and ensuring coordination among universities in Sri Lanka (World Bank, 2020).

Challenges include limited research opportunities, inadequate funding, and a significant brain drain, with many graduates seeking better opportunities abroad. Enhancing research infrastructure, increasing funding, and fostering industry-academic partnerships are essential steps to address these challenges (World Bank, 2020; UNDP, 2019).

Relevant Laws and Policies in Sri Lanka

The principal legislative enactment governing general education in Sri Lanka is the Education Ordinance No. 31 of 1939 (Ministry of Education, 2020). This ordinance, although outdated, remains the core law for education in the country. It has been amended several times, but the need for a comprehensive and modern Education Act is evident to address the current educational needs and challenge (Ministry of Education, 2020).

Sri Lanka has approved Compulsory Education Regulations aimed at increasing access to education (Ministry of Education, 2020). These regulations mandate education for children of specific age groups, ensuring that every child has the opportunity to receive a basic education (Ministry of Education, 2020).

The National Education Commission (NEC) was established under the National Education Commission Act No. 19 of 1991 to formulate national education policy and provide recommendations to the government (Ministry of Education, 2020). The NEC plays a crucial role in ensuring that the education system aligns with national goals and international standards (Ministry of Education, 2020).This act established the National Institute of Education (NIE), which is responsible for curriculum development, teacher education, and educational research (Ministry of Education, 2020). The NIE plays a significant role in enhancing the quality of education through innovative practices and continuous professional development of educators (Ministry of Education, 2020).

The Thirteenth Amendment to the Constitution devolved the subject of education to provincial councils (Ministry of Education, 2020). This decentralization aimed to improve efficiency and responsiveness to local educational needs. However, it has also led to challenges in coordination and standardization across provinces (Ministry of Education, 2020).

Comparative Analysis : Primary Education

Japan's primary education system, covering grades 1 to 6, emphasizes a holistic approach. The curriculum includes traditional subjects, moral education, physical education, and integrated studies aimed at developing problem-solving skills and social responsibility. Life skills integration is a standout feature, with lessons on hygiene, manners, and community participation embedded in the curriculum. Japanese schools incorporate moral education to instill values such as respect, responsibility, and empathy. For instance, students participate in cleaning activities, fostering a sense of community and responsibility (OECD, 2018).

Finland’s primary education, from grades 1 to 6, is renowned for its flexible and student-centered approach. The curriculum promotes creativity, critical thinking, and life skills. Finnish schools often incorporate outdoor education, where students learn about nature, teamwork, and problem-solving through hands-on experiences. This approach enhances cognitive and social skills. Emphasis on personalized learning experiences and integration of practical life skills into everyday lessons are core principles (Sahlberg, 2015).

New Zealand employs a three-tier education model, encompassing primary, intermediate, and secondary schools, followed by tertiary

education at universities and polytechnics. Education is compulsory from ages 6 to 16. The New Zealand system is inclusive, integrating the indigenous Maori culture into the curriculum, thereby promoting cultural awareness and diversity. The curriculum covers essential academic subjects and incorporates key competencies such as thinking, using language, symbols, and texts, managing self, relating to others, and participating and contributing. Projects that require teamwork, problem-solving, and community involvement prepare students for real-life challenges (New Zealand Ministry of Education, 2020).

Comparative Analysis : Secondary Education

Japan's secondary education system, which includes junior high schools (grades 7-9) and senior high schools (grades 10-12), is characterized by a rigorous curriculum that emphasizes academic excellence, discipline, and holistic development. Students undergo intense preparation for high school and university entrance exams. The curriculum includes a wide range of subjects, including mathematics, science, social studies, and languages, as well as extracurricular activities to promote overall development. Moral education continues to play a significant role, fostering a sense of responsibility and community (OECD, 2018).

Finland's secondary education, divided into lower secondary (grades 7-9) and upper secondary (grades 10-12), continues the flexible and student-centered approach established in primary education. The curriculum allows for a high degree of personalization, enabling students to choose courses based on their interests and career aspirations. Vocational education is highly valued, and students can opt for vocational upper secondary schools, which provide practical skills and training for various professions. Finland's focus on well-being, individualized learning, and teacher autonomy ensures that secondary education remains engaging and effective (Sahlberg, 2015).

New Zealand's secondary education system, comprising junior secondary (years 7-10) and senior secondary (years 11-13), is designed to be inclusive and culturally responsive. The curriculum is broad and balanced, offering both academic and vocational pathways. New Zealand's National Certificate of Educational Achievement (NCEA) provides a flexible qualification system that recognizes a wide range of learning, including traditional academic subjects, vocational training, and skills developed through extracurricular activities. The integration of Maori culture and perspectives ensures that education is relevant and respectful of the country's indigenous heritage (New Zealand Ministry of Education, 2020).

Comparative Analysis : Tertiary Education

Japan's tertiary education system is well-developed, with a strong emphasis on research and innovation. Universities collaborate closely with industries, providing students with ample opportunities for practical experience and employment. Government policies support research funding and international collaboration, making Japan a hub for technological and scientific advancements. Strengths of Japan's system include substantial government and private sector funding, strong industry-academic collaboration, and a focus on lifelong learning. However, challenges such as high academic pressure and balancing traditional education methods with modern innovations persist (OECD, 2018).

Finland offers a robust tertiary education system characterized by high-quality research output and strong international collaboration. Finnish universities prioritize academic freedom, interdisciplinary studies, and practical application of knowledge. The education system supports lifelong learning and continuous professional development. Finland's strengths include high-quality research, international collaboration, and support for lifelong learning. Challenges involve ensuring equal access to education across regions and adapting to rapidly changing job market needs (Sahlberg, 2015).

New Zealand's tertiary education system is inclusive and internationally recognized, attracting students globally. The emphasis on research, innovation, and practical skills is evident in the wide range of master's and doctoral programs. Collaboration with industries and global research institutions provides valuable opportunities for internships, research projects, and employment. Integration of cultural competence and indigenous knowledge, particularly through partnerships with Maori communities, ensures graduates are well-rounded and culturally aware. Strengths of New Zealand's system include its inclusivity, strong focus on research and practical skills, and cultural integration. Challenges involve maintaining international student enrollment amid global competition and aligning education with evolving job market needs (New Zealand Ministry of Education, 2020).

Importance of Life Skills in Education

Life skills are essential for students to navigate the complexities of modern life. These skills include critical thinking, problem-solving, communication, collaboration, and emotional intelligence. Integrating life skills into the education curriculum helps students develop a well-rounded personality, preparing them for future academic and personal challenges. Students with strong life skills tend to perform better academically, improve social interactions, and are better prepared to handle real-world challenges effectively (Sahlberg, 2015).

Life Skills in Japan

In Japan, life skills education is embedded within the curriculum from primary to higher education. Activities such as cleaning the school environment, participating in community service, and collaborative projects are designed to instill responsibility, teamwork, and social awareness (OECD, 2018).

Life Skills in Finland

Finland’s education system places a significant emphasis on life skills, particularly through outdoor education and student-centered learning approaches. Students engage in activities that promote independence, creativity, and problem-solving, preparing them for the complexities of adult life (Sahlberg, 2015).

Life Skills in New Zealand

New Zealand integrates life skills education through its key competencies framework, focusing on thinking, using language, symbols, and texts, managing self, relating to others, and participating and contributing. These competencies are woven into the curriculum, ensuring that students develop the skills necessary for personal and professional success (New Zealand Ministry of Education, 2020).

Case Studies on Life Skills Integration

Japanese schools incorporate moral education to instill values such as respect, responsibility, and empathy. For instance, students participate in cleaning activities, fostering a sense of community and responsibility. This practice, known as “souji,” teaches students the importance of maintaining their environment and working collaboratively (OECD, 2018).

Finnish schools often incorporate outdoor education, where students learn about nature, teamwork, and problem-solving through hands-on experiences. This approach enhances cognitive and social skills. For example, students may engage in activities such as hiking, camping, and environmental conservation projects, which foster a deep connection with nature and practical life skills (Sahlberg, 2015).

New Zealand’s curriculum includes key competencies that are essential for students’ lifelong learning and well-being. For example, students engage in projects that require teamwork, problem-solving, and community involvement, pre-

paring them for real-life challenges. These projects may include organizing community events, participating in local government activities, and developing entrepreneurial skills through school-based businesses (New Zealand Ministry of Education, 2020).

The Interplay between Education,Cultural Identity, and Globalization

Education systems play a crucial role in shaping cultural identity. They transmit cultural values, traditions, and languages from one generation to the next. In Japan, cultural education is integrated into the curriculum through subjects like Japanese history, literature, and traditional arts. Similarly, Finland emphasizes cultural heritage and national identity in its education system, promoting respect for Finnish culture and traditions (OECD, 2018; Sahlberg, 2015).

Globalization and its Impact on Education

Globalization has brought about significant changes in education systems worldwide. It has facilitated the exchange of ideas, knowledge, and best practices across borders, leading to more diverse and inclusive curricula. However, globalization also poses challenges, such as the risk of cultural homogenization and the loss of local identities. Education systems must balance global competencies with the preservation of cultural identity (OECD, 2018; Sahlberg, 2015).

Balancing Cultural Identity and Global Competence

To navigate the complexities of globalization, education systems must strike a balance between fostering cultural identity and preparing students for a globalized world. This involves incorporating global competencies, such as critical thinking, intercultural communication, and digital literacy, into the curriculum while maintaining a strong emphasis on cultural education. Countries like New Zealand have successfully integrated Maori culture into their education system, ensuring that students develop a strong sense of cultural identity alongside global competencies (New Zealand Ministry of Education, 2020).

Recommendations for Improving Sri Lankan Education

To improve education in Sri Lanka, several recommendations are proposed:

Curriculum Reform: Integrate life skills and critical thinking into the curriculum to ensure students are prepared for real-world challenges.

Teacher Training: Enhance teacher training programs to focus on modern pedagogical methods and life skills education.

Infrastructure Improvement: Invest in better facilities and resources, especially in rural areas, to provide a conducive learning environment.

Community Involvement: Encourage community participation in schools to foster a supportive learning environment and bridge the gap between education and societal needs.

International Collaboration: Foster international partnerships and collaborations to enhance research opportunities, funding, and academic exchange programs.

Linking Education to Employment: Align the curriculum with job market needs and provide vocational training to ensure students have the skills required for employment.

Areas for Future Research

Impact of Decentralization on Educational Outcomes: Investigate how the devolution of education to provincial councils has affected the quality and accessibility of education across different regions in Sri Lanka.

Effectiveness of Life Skills Education: Conduct longitudinal studies to measure the long-term

impact of life skills education on students' academic performance, employability, and personal development.

Integration of Technology in Education: Explore the potential of digital tools and online learning platforms to enhance educational delivery and access, particularly in rural and underserved areas.

Teacher Professional Development: Assess the current state of teacher training programs and their effectiveness in improving teaching practices and student outcomes.

Comparative Studies on Vocational Training: Compare the vocational training systems in Sri Lanka with those in Japan, Finland, and New Zealand to identify best practices and areas for improvement.

Policy Implementation and Impact: Analyze the implementation and impact of recent educational policies and reforms to understand their effectiveness and identify areas for further improvement.

Conclusion

Sri Lanka's education system, with its rich historical legacy, has made substantial progress over the years. However, it faces significant challenges that need to be addressed to enhance its efficiency and effectiveness. By adopting best practices from the educational systems of Japan, Finland, and New Zealand, Sri Lanka can implement reforms that are aligned with its future aspirations, thereby fostering a more robust and dynamic educational framework.

Emphasizing life skills education across all levels of learning will prepare students for personal and professional success, ensuring they contribute positively to the nation's development.

References

Ministry of Education. (2020). Historical Development of the Education System in Sri Lanka. [Online] Available at: http://moe.gov.lk

OECD. (2018). Education Policy in Japan. [Online] Available at: https://www.oecd.org/education/policy-outlook/country-profile-Japan-2018.pdf

Sahlberg, P. (2015). Finnish Lessons 2.0: What Can the World Learn from Educational Change in Finland? Teachers College Press.

New Zealand Ministry of Education. (2020). Overview of the New Zealand Education System. [Online] Available at: https://www.education.govt.nz/our-work/our-role-and-our-people/education-in-nz/

Department of Census and Statistics. (2017). Computer Literacy Statistics. [Online] Available at: http://www.statistics.gov.lk

World Bank. (2020). Sri Lanka Education Sector Report. [Online] Available at: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/202361468187775882/sri-lanka-education-sector-report

UNDP. (2019). Education and Human Development in Sri Lanka. [Online] Available at: https://www.lk.undp.org/content/srilanka/en/home/library/human_development_reports/2019-national-human-development-report.html

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Moisture Management in Fabrics

Kuruppu, R.

Introduction

As you would realize one of the most important aspects of any clothing product is comfort. Generally, it is about absorbency of perspiration from human body. However, the clothing comfort can be divided into three groups, i.e. physiological, tactile and thermal comfort. Physiological comfort is about the fashion trend and the recognition in society. The tactile comfort has relationship with fabric surface and mechanical properties. The thermal comfort is about the ability to maintain the temperature of the skin through transfer of heat and perspiration generated within human body.

In other words, the heat and moisture transport is to help the clothing wearer to maintain the heat of the body during various levels of activity. This is moisture management property which decides the comfort level of that fabric. Every human being sweats during different kinds of activities. An important feature of any fabric is how it transports the water and heat out of the body, in order to make the wearer feel comfortable. So, moisture management can be defined as the controlled movement of water vapour (liquid water) and heat together the perspiration from the body to the atmosphere through the fabric.

When a person is subjected to some activity s/he sweats and as the body temperature gradually increases whilst in activity, more and more sweat is generated thus wets the fabric worn next to skin. The fabric should have two important properties. The initial and the foremost property is to evaporate the perspiration from the skin to atmosphere and the second property is to transfer the moisture to the atmosphere and make the wearer feel comfortable. Moisture management often refers to the transport of both moisture vapour and liquid away from the body.

This subject is important these days because of sports (e.g. cricket). Have you seen the shirt or the trouser wet of these cricketers? Probably not. That is because they are wearing moisture managed fabric. Of course, some shirts may show wet patches and others not. If you use the right raw material and the construction, you can avoid moisture remaining on the fabric. These days most of the textile manufacturers have mastered this technique and therefore, the fabrics of right quality, sans moisture patches.

The faster the fabric can wick, the rest of the moisture can evaporate faster through capillary action and keep the wearer dry and comfortable. Capillary action ceases when all parts of a garment are equally wet. The Garments worn next to the skin should have good sweat absorption and sweat releasing property to the atmosphere and fast drying property for getting more tactile comfort.

In the case of polyester worn next to the skin and Nylon at the outer surface will be a good combination in this regard. Polyester can wick the moisture and transport the moisture to the outer surface through capillary then it can get evaporated to the atmosphere. The polyester does not retain moisture because it does not absorb moisture but Nylon do absorb a little hence in the evaporation it can get slightly delayed and there can be wet surface for some time in the outer layer.

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Contribution of Micro Filaments in Moisture Management in Fabrics

Filaments in the textile industry is normally known as man-made filaments (MMF). Therefore, Micro filament is either polyester or nylon. It is very soft and has buttery feeling. It is very fine. It can be made finer. Anyway, staple fibre is not possible to maneuver in that way. Staple fibres being natural fibres, it cannot be modified like synthetics. The MMF is used for high quality men's' suits, t-shirts, dress shirts, sportswear etc. Since it is very fine filaments, it has large number of filaments in the yarn cross section of the filament yarn. So, it covers a large yarn surface area. This will enable to provide more pores. Micro filaments have superior capillary action (Senthikumar et al 2013) thus helps to transport moisture to the outer layer. Microfilaments have higher breathability and moisture transport properties because they are wind and water proof. These fabrics made out of micro filament yarns are widely used in active sportswear. Microfilaments converted into micro fibres (cut staple) can be used alone or blended with conventional man-made filaments as well as with natural fibers such as cotton, wool, and silk.

In textile structures, the spaces between fibres effectively form capillaries. The closer the fibers in yarns the smaller the apparent diameter due to yarns are very close to each other, the more readily wicking can occur. This means, when micro fibres packed densely it starts wicking (moisture molecules attract to the inner fabric surface) and quick capillary action. Thus enabling fabrics made from microfibers to pick up sweat more easily than those from conventional fibers, e.g. cotton, wool. As micro fibres are so fine, they form especially small gaps and have a big surface area. This leads to high capillary effect and that helps to transport of moisture and aids in rapid evaporation.

Produce a micro filament yarn which has densely packed micro filaments in it. This yarn is used to produce a fabric with highly dense and it is packed with such yarn. Manufacture a garment from such fabric and subject it to active wear sports activity. The moisture will get wicked and transport the moisture through tiny spaces in the fabric by capillary action to the surface of the fabric. It will then get evaporated to the atmosphere (Behera et al 2007 & 2009). If you use polyester (e.g. hydrophobic), it will wick the moisture but will not absorb moisture in to the filaments. Then it will transport to the surface of the outer fabric by capillary action and evaporate to the atmosphere. In the case of Nylon, it can retain moisture in the filament and then release moisture which will move to the surface by capillary action. The point here is that nylon fabric will be wet for a longer time than polyester because it retains moisture at the initial stage (Nylon absorbs little moisture). In that context polyester fabric can be better next to the skin for sportswear because it does not retain moisture in the filament.

The managing of Moisture properties of textiles during sports considered as major factor in the comfort performance. The comfort perceptions of clothing are influenced by the wetness or dryness of the fabric. For the garment that is worn next to skin should have good sweat absorption and sweat releasing property to the atmosphere, and fast drying property for getting more tactile comfort (Hill, 1985). Therefore, it means, the wet fabric, due to its clinging tendency, will give an additional stress to the wearer. When removing the liquid sweat from the skin, some claim that moisture absorbency of the fibre is important. Therefore, cotton or viscose is a necessary component worn next to the skin for sportswear. There is another school of thought that fibres in these garments should not absorb moisture, so that moisture is wicked away from the skin to outer layers of clothing into atmosphere. However, the synthetics should be preferred in clothing of active sports as they do not retain moisture and this has the advantage of keeping garments lighter than the cotton when it is wet. Further, polyester fibres have some added advantage of quick dry and good shape retention property. Most of the modern textile materials use the basic idea of capillary action for sweat absorption and for fast drying.

Moisture Management Using Waterproof Breathable Fabrics

Fabrics that can move water vapor from body perspiration then out through the material to external liquids such as rainwater without returning to the body are widely used in sportswear. Water-resistant but moisture-permeable materials may be divided into three main categories – tightly woven fabrics, resin-coated materials and film-laminated materials - which are selected by manufacturers according to the end use requirements in casual or outdoor apparel.

The tightly woven fabrics are known as waterproof breathable fabric (famous fabric is Ventile). VENTILE was manufactured by using long staple cotton e.g. sea island cotton with almost no space between the fibres (Anon. World's Sports). Sea Island cottons are so fine and very regular fibres. Such fires are spun into combed yarn and woven with no pores at all for water to penetrate. Very tightly woven. They can be called as water resistant but moisture permeable fabrics. That means water proof but breathable fabric. Since fibres are so fine they tend to demonstrate good capillary action.

Blends in form of layering of fibres are capable of offering the best properties of each. Bi-component knits such as polyester/wool or polypropylene/wool blends provide wicking and insulation properties in a single layer. Push-pull fabrics are bi-component materials composed of a non-absorbent hydrophobic material on the inside-worn next to the skin-and an absorbent hydrophilic material on the outside. Usually, the hydrophobic material is polyester, and the absorbent hydrophilic material nylon. Sportswool, a trade mark of The WoolMark Company, is an example of a fabric which has been engineered to manage moisture (Sanjay et al). Developed by scientists in 1994, it is a hybrid material composed of a fine Merino wool sub-layer for Insulation and a polyester exterior which draws moisture away from the wool layer to the surface. The wool fibre next to the skin attracts perspiration vapour molecules, before they have the chance to condense into liquid, and disperses them into the atmosphere. The fabric has attracted the attention of top athletes in the world e.g. the Manchester United soccer team. Its major drawback, however, is that it takes longer to dry because of its wool content.

These fabrics can be divided into three categories, i.e. very tightly woven; resin coated (chemically treated finish); film laminated fabric.

Very Tightly Woven Water Breathable Fabric

Very tightly woven fabric will have very high densities in warp and weft. It is known as high sett in weaving. The yarns are woven very close, almost touching each other and no space between yarns. Fully cramped. Ventile is one of the famous fabrics. This fabric can be produced by using long staple cotton or microfilament polyester (Anon, 1996).

When the fabric is wetted, if it has cotton, the warp and weft swell transversely (across) so that pores (tiny space between yarns) in the fabric becomes small and prohibits water penetrating the fabric. If you are using polyester microfilaments, then the diameter of the filaments must be less than 10 microns so there are no pores hence water cannot penetrate. Remember MMF do not normally absorb moisture. The waterproof is provided without the application of any water- repellent finishing treatment.

This fabric can absorb the moisture vapour by wicking and move the tiny moisture molecules by capillary action to the surface of the fabric. If any large water molecule falls onto the surface of the fabric it cannot penetrate the fabric. Therefore, it is water proof and breathable fabric.

A very Thin Layer of Laminated Waterproof Breathable Fabrics

Waterproof breathable fabrics are made out of membranes (a very thin layer) laminated into textile product. These are thin membrane made from polymeric materials. They offer high resistance to water penetration but allow water vapour at the same time.

The maximum thickness of the membrane is 10 microns. They are of two types: 1) Micro porous membranes 2) Hydrophilic membranes.

The micro porous membranes have tiny holes on their surface slightly larger than water vapour molecule. The hydrophilic membranes are thin films of chemically modified polyester or polyurethane (Lomax, 1991). These polymers are modified by the incorporation of the hydrophilic part of the membrane by forming amorphous region in the main polymer system. This amorphous region acts as intermolecular pores allowing water vapour molecules to pass through but preventing the penetration of liquid water due to the solid nature of the membrane.

Coated Waterproof Breathable Fabrics

It has two- layer structure. In this structure, the layer close to skin which is base fabric has wicking and comprised of synthetic fibers e.g. micro-filament polyester. Micro filament polyester is ideal for wicking moisture away from the skin. Further, helps to operate capillary action to bring the moisture to the outer surface which has cotton (Ishtiaque, 2000). The outer layer is usually cotton or rayon that absorbs and evaporates. Since it absorbs moisture, there will be a short delay in evaporating thus slower drying. Coated fabrics with waterproof breathable fabrics consist of polymeric material applied to one side of fabric which is closer to the skin which will wick the sweat (Little, 2002).

Micro filament polyester is ideal for wicking perspiration away from the skin. The use of superfine or microfibre yarn enables production of dense fabrics leading to capillary action that gives the best wicking properties. Sweat absorption and fast drying property cannot be given by one fabric.

When people play sports, they sweat and some sweat more. The sweat creates a moisture layer between the skin and fabric which is worn next to skin. This is most uncomfortable for those play sports. Therefore, to keep the players comfortable it is required to remove the sweat quickly and keep the body dry (Hill 1985). Also, the body temperature must be maintained during sports.

Whilst we discuss removing sweat from our body, there are two schools of thought; Some textile manufacturers believe that it is better to have cotton or merino wool fabric next to the skin so that it can readily absorb the sweat into the fabric whilst the other is that fibres in these garments should not absorb moisture, instead it should be wicked away from the skin to the outer layers of clothing from whence it can evaporate into atmosphere. If the sweat particles are absorbed into the fibres that will carry some weight until it is evaporated. Also, there will be a little delay in drying the fabric. If polyester micro filament is used, it will not absorb into the filament (hydrophobic). In this case it will be wicked and brought to the outer surface quickly and evaporated to the atmosphere. This seems a better option because keeping garments lighter than the cotton when it is wet. Also, synthetic fibres have some added advantage of quick dry and good shape retention property.

A few special fibres for moisture managed fabrics,

Hygra.

Unitika Limited has launched Hygra, which is a sheath-core type filament yarn composed of fibre made from water absorbing polymer and nylon. The water-absorbing polymer has a special network structure that absorbs 35 times its own weight of water and offers quick releasing properties that the conventional waterabsorbing polymer cannot do. On the other hand, nylon in the core gives tensile strength and dimensional stability. The main apparel applications include sportswear like athletic wear, golf etc. (Anon, 1998).

Lumiac

Lumiac is also a product from Unitika. It is a collection of polyester filaments having different fineness (0.5 - 2.0 denier per filament) and irregular cross sections. Hygra - Lumiace combination in knitted fabric is very popular (Anon, 2001).

Dryarn

Dryarn is the new fibre from Aquafil. It is a completely recyclable polypropylene micro-fibre. Fabric from Dryarn is very lightweight and comfortable and used in different sports. In addition, it has a soft handle and a high thermo regulatory capacity and also dries quickly (Rigby, 1996).

Triactor

Toyoba Co Ltd has developed Triactor, which is a perspiration absorbing/quick drying polyester filament as shown in fig.3. Polyester is hydrophobic and does not absorb moisture but by changing the filaments to Y shaped cross section Toyobo has realized quick perspiration absorbency by capillary action. The hydrophobic nature and large filament surface of polyester filaments realize quick drying and refreshing properties at the same time (Anon, 1999).

Roica and Leofeel

Roica is a polyether type spandex made by dry spinning method and Leofeel is a soft nylon-66 yarn developed by Asahi Chemical. The combination of Roica and Leofeel in mixed knitted tricot fabric gives a soft touch and excellent stretch. It is mainly used in swimwear (Asahi Chemical Industries, 1993).

There are many other fibres, which have good sweat absorption and fast drying property. Most of them are either nylon or polyester.

Liquid Moisture Transport

Liquid Moisture Transport in Cotton woven fabrics with different weft Yarns are significant and higher the linear density of the weft yarns lowers the rate of transport of moisture to the outer surface of the fabric (Kami & Matusiak. 2021). Measurement was done using the Moisture Management Tester MMT M290 of SDL. The obtained results confirmed that the linear density of weft yarn significantly influenced the values of all parameters characterizing liquid moisture transport in the investigated fabrics.

Testing on cotton fabrics were performed in standard testing atmosphere: 65 ± 5% RH and ambient temperature 20 ± 2 ◦C. The following parameters were determined as the results of measurement using the MMT testing machine (SDL Atlas,2017):

The wetting time for top (WTT) and bottom (WTB) surface in s;
The absorption rate for top (TAR) and bottom (BAR) surface in %/s;
The maximum wetted radius for top (MWR top) and bottom (MWR bottom) surface in mm;
The spreading speed for top (TSS) and bottom (BSS) surface in mm/s;
The accumulative one-way transport index R, -;
The overall moisture management capability (OMMC), -.
The results of measurements of the cotton woven fabrics by means of the MMT are presented in Table format below;

Weft yarn	Mean (SD)	WTT	WTB	TAR	BAR	MART	MWRB
30Text							
40Text							
50Text							
60Text							
100Text							

Source: SDL Atlas

The WTT and WTB are the time periods in which the top and bottom surfaces of the fabric started to become wet after the test commenced. They are defined as the time in second (s). The longer the wetting time was, the worse the performance of the fabric from the aspect of wettability. The shortest wetting time was for the fabric variant with the 30 tex weft yarn. For the top surface, the value of the WTT was 2.84 s, and for the bottom surface the WTB was 3.00 s. The longest wetting time for both sides occurred for the fabric variant with the 100 tex weft yarn: the WTT was 3.69 s, and the WTB 3.88 s. It was also found that the wetting time for fabric variants with the weft yarns 50 tex and 60 tex was at the same level. For the fabric variant with the 50 tex weft yarn, the WTT value was 3.23 s and the WTB was 3.26 s, whereas for the variant with the 60 tex weft yarn the WTT was 3.19 s and the WTB 3.24 s. For both surfaces, inner and outer, the tendencies were the same. The wetting time increased with an increase of the linear density of weft yarn. This means that when using coarse weft yarn, the wettability of fabrics becomes worse. Wettability is the potential of a surface to interact with liquids with specified characteristics (Patnaik,2006). According to Harnett and Mehta (Harnett, 1984), wettability is the initial behavior of the fabric, yarn or fiber when brought into contact with a liquid. It also describes the interaction between the liquid and the substrate prior to the wicking process (Matusiak & Kaminska., 2022).

These results show that for all fabric variants, the wetting time for the inner (upper) surface is shorter than for the outer (bottom) surface. This is understandable as it also takes some time for the fluid to pass from the top to the bottom surface.

The results of the wetting time tests were in agreement with the results of the spreading speed tests for both surfaces. The spreading speed is defined as the accumulative spreading speed from the center (the point of dosing the testing solution) to the maximum wetted radius [33]. The higher the spreading speed is, the better the spreading of the liquid on the fabric surface, and in consequence the better are conditions Materials (Patnaik, 2006) for liquid sweat evaporation. In both cases, the SST and the SSB, the lowest spreading speed was found for the fabric with the 100 tex weft yarn. For this fabric variant, the value of the SST was 3.80 mm/s, and the SSB 3.76 mm/s. The highest spreading speed was found for the fabric variant with the 30 tex weft yarn. The values of the spreading speed for this yarn were the same for both surfaces—5.83 mm/s. For both fabric surfaces, the spreading speed decreased with the increase of the linear density of the weft yarn applied in the investigated fabric. This means that using weft yarn of higher linear density when other structural parameters (warp linear density, warp density, weft density and weave) are the same causes a worsening of fabric performance from the aspect of liquid moisture transport.

The liquid is spread slower, and simultaneously it is evaporated slower too. A different tendency was observed in the case of the absorption rate. The TAR and the BAR are defined as the average speed of the liquid moisture absorption for the top and bottom surfaces of the specimen during the initial change of water content during a test (Matusiak 2019). They are expressed as a percentage per second. The parameters are determined from the "water content vs. time" graph available in the MMT M290 software as the slopes between where the specimen begins to wet and the maximum point on the graph [SDL Atlas]. The highest value of the absorption rate occurred for the fabric variant with the 30 tex weft yarn: the TAR was 65.62%/s and the BAR 58.83%/s. The lowest absorption rate was found for fabric with the 60 tex weft yarn: the TAR was 61.59%/s and the BAR 55.02%/s. In both cases, the TAR and the BAR values of parameters decreased with the increase of the linear density of the weft yarn. Such a situation was observed for fabrics with weft yarns in the range 30–60 tex. Next, the value of both parameters increased significantly

for the fabric variant with 100 tex weft yarn and had the following values: the TAR was 65.13%/s and the BAR 58.09%/s. The values of the absorption rate for the fabric variant with the 100 tex weft yarn were slightly lower than those for the fabric variant with the 30 tex weft yarn. It is difficult to explain this phenomenon. In our opinion, it resulted from an interaction between the linear density of the weft yarn and other structural parameters of fabrics. The fabric variant with the 100 tex weft yarn contained the largest amount of fibrous material—cotton. Cotton fibers are hydrophilic and they absorb liquid (water) well. At the same time, a higher absorption of liquid is in opposition to the transport of the liquid due to capillarity. On the other hand, for fabrics with weft yarns of lower linear density, liquid moisture may be transferred down by the interstitial spaces in the fabric due to gravity. The fabric variant with the 100 tex weft yarn contained the largest amount of fibrous material—cotton. Cotton fibers are hydrophilic and they absorb liquid (water) well. At the same time, a higher absorption of liquid is in opposition to the transport of the liquid due to capillarity. On the other hand, for fabrics with weft yarns of lower linear density, liquid moisture may be transferred down by the interstitial spaces in the fabric due to gravity.

The biggest maximum wetted radius was found for the fabric variant with the 30 tex weft yarn The values were the following: the MWRT was 25.0 mm and the MWRB 26.5 mm. The lowest values of the maximum wetted radius occurred for the fabric variants with the 100 tex and 60 tex weft yarns. For both fabric surfaces, the maximum wetted radius was 20.0 mm. On both surfaces, the maximum wetted radius decreased with the increase of the linear density of the weft yarn. This was according to our expectations. Coarser weft yarn means a larger share of fibrous material in the fabric structure. As was mentioned, the investigated fabrics were made of cotton, which is hydrophilic. A larger amount of cotton causes more intensive absorption of liquid and retention of liquid inside.

Matusiak and Kaminska (2022) have concluded on the liquid moisture transport that it determines the transport and evaporation of sweat produced by the human body and condensed on the human skin. The results influence the type of weft yarns used which influence the liquid moisture transport in cotton fabrics. It has been said that weft yarn significantly influences liquid moisture transport in cotton fabrics. The thinnest weft yarn e.g. 30 tex, demonstrated shortest wetting time and highest spreading speed for both fabric surfaces. The 30 tex weft yarn also had a bright wetted radius per both sides.

Sweat Drying Performance

Men and women in sports would always prefer dry fabric in their clothing. It is not an easy task. As they increase sports activities in the game, the sweating too increases. The task is to keep the wearer comfortable throughout the game by controlling the two parameters, sweat and drying. The mechanism applied here is, sweat on the skin is absorbed to the fabric and quickly brought to the surface of the outer layer of the fabric through capillary action. How quickly you can bring to the surface without making the wearer uncomfortable? There is a research gap in this context. Today, when sportswear has become popular world over, quick drying has become a driving force in textiles (Bruun et al. 2016).

Sweating starts when the skin temperature passes the body temperature, 37 degrees Celsius. The temperature rises as sports activities increases thus sweating increases (Guyton, 1977). At this stage it is required to transport the sweat particles to the fabric surface and to the ambient environment (Lin et al. 2015). The drying depends on fibre type. It has been confirmed that MMF performs better during exercise due to wicking property in these filaments (Emirhanova and Kavusturan. 2008). A synthetic yarn has been produced using micro-filaments, then it will be able to demonstrate very high wicking and capillary action. Further, the fabric

structure too can help in the movement of sweat to the atmosphere. Fabric structure is the way yarn has interlaced in the fabric. Some fabric structures can have more air space in the fabric which is known as open fabric and the other is closed structure. Air permeability high in open fabric. It is believed that high air permeability fabrics demonstrate breathability. This makes the wearer comfortable. Therefore, it is better to have MMF fabric with high air permeability for sportswear (Ogulata. 2010).

There is another area of interest i.e. yarn in fabrics. Yarn thickness known as yarn count, twist and number of fibres in the cross section contribute to air permeability of fabrics. Thicker yarn in the fabric can cover the air spaces in the fabric thus resist air passing through the fabric. Whilst thin yarn provides air spaces in the fabric which increase the air flow through the fabric. This helps the sweat particles to move to the surface of the fabric much easily than the fabric has low air permeability (Bhattacharya, 2014).

Fabric drying is considered the effect of breathability and wicking properties (Surya Nasrin. 2023). To provide a better performance, these two variables are not good enough. As such, there is a research gap in the fabric drying performance. It will be necessary to know the relationship between sweat volume and fabric properties. That is because the amount of sweat generates by an individual can vary according to the weight of the body per hour. Also, the number of hours that you are engaged in playing. Fabrics will be required to meet varying targets of sweat volumes.

Conclusion

This article summarized and synthesized the current state of research on the moisture management performance of fabrics. Moisture management in the fabric is, control movement of sweat from the body into fabric and then pass it all the way to the outer surface of the fabric and to the atmosphere, keeping the comfort level of the wearer. It means, the amount of perspiration generated and how quickly it has been transported to the surface of the fabric and evaporated to the environment, keeping body cool.

Micro filaments are very fine filaments. As such, there can have large number of filaments in the yarn cross section. As such, there will be hardly any space in the filament. A fabric made out of such micro filaments will have good capillary action. This will be enable to draw moisture particles on to the fabric and transport to the surface of the fabric and then evaporate it to the environment.

Moisture managed water proof breathable fabrics are popular in sports garments. Fabrics that can displace water vapor from body perspiration then out through the material to external liquids such as rainwater without returning to the body are widely used in sportswear. These fabrics are water-resistant but moisture-permeable. These fabrics may be divided into three main categories – tightly woven fabrics, resin-coated materials and film-laminated materials - which are selected by manufacturers according to the end use requirements in casual or outdoor apparel.

Another aspect of moisture management is Liquid Moisture Transport. Research has been carried out in Cotton woven fabrics with different weft Yarns. The results have been significant. It revealed that higher the linear density of the weft yarns lowers the rate of transport of moisture to the outer surface of the fabric.

Drying fabric after it has been subjected to lot of sweat is not an easy task. Fabrics have been developed to wick moisture from the skin and apply capillary mechanism to bring the moisture to the surface and then to evaporate to the environment. This behaviour has been successful. It is comparatively slow. But the relationship between amount of sweat and drying is not known. If there is someone who sweats a lot than a normal person then there is no fabric made to suit his desires. This gap needs to be closed.

References

Anon. (1996). World sports active wear. World Sports Active Wear, 8.

Anon. (1998). Active sportswear fabrics. Japan Textile News, (535), 39-42.

Anon. (2001). Active sportswear fabrics. Japan Textile News, (559), 34-35.

Rigby, D. (1996). Sportswear & leisurewear: Understanding the present & forecasting the future. Australian Textiles & Fashion, 19-22.

Kanebo Co. Ltd. (1993). Newly developed nylon hollow filament. Japan Textile News, (459), 44.

Anon. (1999). Toyobo pursuing comfortability. Japan Textile News, (536), 41.

Anon. (1990). Lycra – the fitness fiber. Textiles, 19(3),

Asahi Chemical Industry Co. Ltd. (1993). Expansion of Roica business. Japan Textile News, (459), 42.

Chaudhari, S. S., et al. Waterproof breathable active sports wear fabrics.

Bardhan, M. K., & Sule, A. D. (2001). Anatomy of sportswear & leisurewear: Scope for spandex fibre. Man Made Textiles in India.

Anon. (1996). World sports active wear. World Sports Active Wear, 8.

Gore Fabrics. (2024). Retrieved from www.gorefabrics.com.

Anon. (1988). Design news. Design News, 44(13), 48.

Lomax, G. R. (1991). Breathable, waterproof fabrics explained. Textiles, (4), 12-16.

Mayer, W., Mohr, U., & Schuierer. (1989). International Textile Bulletin, (2), 18.

.Hill, R. (1985). Fibers & fabrics in sports. Textiles, 14(2), 30-36.

Matusiak, M., & Kaminska, D. (2022). Liquid moisture transport in cotton woven fabrics with different weft yarns. Materials, 15, 6489.
18.Behera, B.K., & Singh, M.K. (2007). Breathable fabrics: Various aspects. Textile Asia, 38(11), 38-44.

Behera, B.K., & Arora, H. (2009). Surgical gown: A critical review. Journal of Industrial Textiles, 38(3), 205-231.

Senthikumar, M., et al. (2013). Moisture management in an active sportswear: Techniques and evaluation - A review article. Journal of The Institution of Engineers (India): Series E.

Little, T. (2000, November 29). Keynote address at NIFT seminar. Delhi.

Ishtiaque, S. M. (2000, November 29). Engineering comfort. In S. Gupta (Ed.), Proceedings Smart Textiles: Their Production & Marketing Strategies (pp. 58-64). National Institute of Fashion Technology, New Delhi.

SDL Atlas Ltd. (2017). SDL Atlas MMT M 290 Manual. Rock Hill, SC, USA.

Kamińska, D., & Matusiak, M. (2021). Does the weave matter? Analysis of moisture transport in cotton fabrics (in Polish). In I. Mołdoch-Mendoń & K. Skrzątek (Eds.), Modern Technologies-Strategies, Solutions and Development Prospects (Vol. 2, pp. 147-152). TYGIEL Scientific Publisher: Lublin, Poland.

Hill, R. (1985). Fibers & fabrics in sports. Textiles, 14(2), 30-36.

Akwatek. (2024). Retrieved from www.akwatek.com.

SDL Atlas Ltd. (2017). SDL Atlas MMT M 290 Manual. Rock Hill, SC, USA.

Patnaik, A., Rengasamy, R.S., Kothari, V.K., & Ghosh, A. (2006). Wetting and wicking in fibrous materials. Textile Progress, 38, 1-105.

Harnett, P.R., & Mehta, P.N. (1984). Survey and comparison of laboratory test methods for measuring wicking. Textile Research Journal, 54, 471-478.

Matusiak, M. (2019). Moisture management properties of seersucker woven fabrics of different structure. Fibres & Textiles in Eastern Europe, 27, 43-50.

Nasrin, S., Mandal, S., Islam, M.M., Petrova, A., Agnew, R. J., & Boorady, L. M. (2023). Factors affecting the sweat-drying performance of active sportswear—A review. Textiles. MDPI, Switzerland.

Bielefeldt Bruun, M., & Langkjær, M.A. (2016). Sportswear: Between fashion, innovation and sustainability. In Taylor & Francis (Vol. 8, pp. 181-188). Abingdon.

Guyton, A.C. (1977). Basic Human Physiology (pp. 615-618). W.B. Saunders Company: Philadelphia, PA, USA.

Lin, X., Li, Y., Zhou, J., Cao, X., Hu, J., Guo, Y., Sun, S., Lv, R., Lin, Y., Ye, Q., et al. (2015). Effects of fabrics with dynamic moisture transfer properties on skin temperature in females during exercise and recovery. Textile Research Journal, 85, 2030-2039.

Emirhanova, N., & Kavusturan, Y. (2008). Effects of knit structure on the dimensional and physical properties of winter outerwear knitted fabrics. Fibres & Textiles in Eastern Europe, 16, 67.

Ogulata, R.T., & Mavruz, S. (2010). Investigation of porosity and air permeability values of plain knitted fabrics. Fibres & Textiles in Eastern Europe, 18, 71-75.

Bhattacharya, S., & Ajmeri, J. (2014). Air permeability of knitted fabrics made from regenerated cellulosic fibres. International Journal of Engineering Research & Development, 10, 16-22.

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Knowledge and Practice on Self-Administration of Sublingual Nitro-Glycerin among Coronary Heart Disease Patients: A Single Centre Cross-Sectional Study

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Abstract

Sublingual glyceryl trinitrate (S/L GTN) is a widely used treatment to relieve angina in patients with Coronary Artery Disease (CAD). Therefore, understanding existing knowledge and practice is vital in addressing gaps to improve patients' treatment compliance and prevent potential adverse effects. A descriptive cross-sectional study was conducted among a cohort of CAD patients (n=215). A simple random sampling technique was utilized to select the sample. A content-validated, pre-tested, interviewer-administered questionnaire containing socio-demographic details, knowledge, and practice assessing closed-ended questions was used to collect data for the study. Data were analyzed descriptively using SPSS version 25. The sample was male predominant (68.8%) and aged 61-70 years (40%). Most CAD patients' knowledge of S/L GTN was less than average (34.28%) or average (29.04%). Patients had good knowledge regarding the appropriate body position for the administration of the drug. Knowledge is lacking regarding adverse effects, number of tablets, and time intervals of taking tablets during pain episodes. They have shown good knowledge and practice of storing and replacing the drug and used to carry GTN at all times. Notably, they regularly attended the clinic and followed instructions related to S/L GTN. In conclusion, patients with CAD knowledge of S/L GTN is sub-optimal though rather practice is good. Therefore, regular patient education is essential in improving the proper use of the drug and avoiding its potential adverse effects. Multicenter larger-scale studies are needed.

Keywords: Coronary artery disease, patients, sublingual GTN, knowledge, practice

Introduction

Angina is a chest pain and a common manifestation of Coronary Artery Disease (CAD) and it results from a regional imbalance between myocardial oxygen supply and demand (Pragani et al., 2017). Nitrates are used for symptom prophylaxis and to prevent symptomatic episodes of angina (Boden et al., 2012). Short-acting sublingual Glyceryl Trinitrate (GTN); also called Nitroglycerin, is recommended for the acute relief of angina and is accepted as a standard treatment and primary therapy for angina pain control (National Institute for Health and Care Excellence, 2011; Boden et al., 2015; Pragani et al., 2017). Nitrates aid in relieving angina symptoms by reducing myocardial oxygen demand and improving myocardial blood flow through dilatation of epicardial and collateral coronary arteries (Tarkin & Kaski, 2017).

Sublingual use of GTN differs from usual tablets. Therefore, proper instructions enhance patients' understanding and ensure the proper use (Gallagher et al., 2010). As reported in previous studies, moderate or poor knowledge (Azmi et al., 2019; Foong et al., 2023) and unsatisfactory practice (Azmi et al., 2019; Fan et al., 2009; Thanujah et al., 2021) of using SL/GTN were reported in several studies. As revealed, most patients were not properly aware of the mechanism of action, potential adverse effects (Azmi et al., 2019), and the correct method of drug administration (Azmi et al., 2019; Foong et al., 2023), and appropriately use (Fan et al., 2009).

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Though sufficient evidence of knowledge and use of S/L GTN is available in the global context, limited literature is available in the local context. Insufficient knowledge and improper practice consequently lead to therapeutic failure. Therefore, identification of those aspects is vital in improving patients' understanding and use of the drug. Thus, the present study aimed to assess knowledge and practice of self-administration of S/L GTN tablets among CAD patients attending the Cardiology Clinic at Teaching Hospital, Jaffna.

Methodology

This is a quantitative descriptive cross-sectional study conducted at the Cardiology clinic, at the Teaching Hospital, Jaffna. Patients attending Cardiology Clinic and receiving S/L GTN tablets as a treatment for cardiac disease condition for more than one year were invited to participate in the study. Sample size calculated according to the Daniel formula (n =Z2p (1-p)/ d2, Daniel, 1999) was 372. A simple random sampling technique was utilized to select the sample. Both male and female patients aged 30 years or above, and patients who can understand and speak Tamil language were included in the study, and patients with cognitive impairment and severely ill were excluded. An interviewer-administered questionnaire was used to collect data.

It was prepared by referring to previous literature developed in English and was translated into Tamil. The questionnaire consisted of three sections. Section A was designed to collect the socio-demographic data of the participants. Sections B and C were designed to collect data on the knowledge and practice of using GTN medication respectively. The content validity of the questionnaire was assured by clinical experts in the relevant field and pre-tested among 10 participants who were not included in the main study. When scoring, correct answers were given 1 point. Data were analyzed using SPSS version 25. Participants characteristics, knowledge, and practice scores were analyzed using descriptive statistics (frequencies and percentages). This study was approved by the Ethics Review Committee of the University of Jaffna. Informed written consent was obtained from all the participants who volunteered for the study and the right to withdraw from the study was permitted. The anonymity and confidentiality of participants were ensured.

Results

Of the 372 patients were invited, 215 were participated in the study (response rate-57.8%). Most of the study participants were males (68.8%) and aged between 61-70 years and married (100%). All participants were Sri Lankan Tamils and most of them were Hindus. (Tabel 1).

Table 1. Characteristics of the Participants (N=215)

Variables	Categor	Frequency (n)	Percentage (%)
Sex	Male	148	68.8
	Female	67	31.2
Age in years	≤ 40	1	0.5
	41-50	10	4.7
	51-60	50	23.5
	61-70	87	40.5
	>70	67	31.2
Marital status	Married	215	100
Ethnicity	Sri Lankan Tamil	215	100
Religion	Hindu	196	91.16
	Christians	19	8.84
Education	Up to GCE(O/L)	100	46.51
	Up to GCE(A/L)	105	48.84
Degree		10	4.65
Employment	Employed	60	27.9
	Retired	155	72.09

Table 3 shows individual correct response scores obtained from knowledge questions. Accordingly, more patients knew that there is a limitation to taking GTN tablets during an episode of chest pain (95.3%), sitting or lying as an appropriate body position for taking the drug (92.1%), and the proper place of keeping GTN container is dry and cool (83.7%). Also, a considerable segment of the sample is aware that replacing the tablets from the container first opened is 8 weeks (65.1%).

Table 2. Overall knowledge of self-administration of S/L GTN among coronary heart disease patients (N=210)

Percentage of knowledge	Frequency (n)	Percentage (%)
30%	20	9.52
40%	52	24.76
50%	61	29.04
60%	49	23.33
70%	24	11.42
80%	4	1.90

However, knowledge gaps were identified in some areas that needed to be filled. Considerably, less than one-fifth of the sample (18.7%) knew about the indication of S/L administration of GTN. The vast majority of the sample was not aware of headache, dizziness, and flushing as adverse effects of this drug (97.2%) are a major concern. Similarly, almost all patients did not know that the maximum number of S/L GTN tablets per episode was three (99.5%). Notably, only 34.9% of patients knew that the time interval between two tablets in a pain episode was five minutes. Also, a lower proportion of patients (18.6%) knew that the proper storage temperature of GTN is 15 – 30 OC.

Practices Regarding Self -Administration of S/L GTN

Table 4 shows practices on self-administration of S/L GTN among CAD patients. Accordingly, most of the sample (81.9%) in the present study used to carry GTN tablets with them. They have mentioned the various reasons for skipping GTN even if they experience chest pain. Surprisingly, almost all participants (99.5%, n=214) in the sample correctly administered the tablet by keeping it under the tongue and rushed to the hospital for persistent chest pain which does not respond to the medication (97.7%). All patients (100%, n=225) regularly visit the clinic. Most (99.5%) patients mentioned that they were stuck to the medical advice of the clinic.

Table 3. Participants' knowledge regarding self-administration of S/L GTN

	Correct responses	
	%	N
Indication for S/L GTN	40	18.6
Adverse effects	06	2.8
Maximum number of tablets per pain episode	01	0.5
Time interval between two tablets in a pain	75	34.9
Appropriate body position	198	92.1
Storage temperature	40	18.6
Storage place	180	83.7
Replacing of the tablets in a container	140	65.1

Table 4. Distribution of practices on self-administration of S/L GTN

Practices	Category of response	n	%
Do you carry your GTN tablets at all times?	Yes	176	81.9
If you were experiencing chest pain and skipped taking GTN, mention the reason.	The pain is not severe Pain in the right chest A short period of pain Pain is different from usual chest pain Unavailability of GTN I was in a public place Other reasons	36 9 24 8 5 3 130	16.7 4.2 11.2 3.7 2.3 1.4 60.0 2.3+1.4
How do you administer GTN?	Placing the tablet under the tongue Swallowing the tablet	214 1	99.5 0.5
What will you do if the chest pain persists even after taking the relevant number of GTN tablets?	Rush to hospital Lying down and resting at home Ignore the pain Others	210 1 1 3	97.7 0.5 0.5 1.3
How do you store GTN?	In amber color bottles In plastic bottles In envelops	213 1 1	99.1 0.5 0.5
Do you follow the medical advice regarding GTN?	Regularly follow Sometimes	214 1	99.5 0.5
Do you regularly visit the clinic?	Yes	215	100

Period of using GTN

More than 60% of the patients used GTN tablets for ≤ 5 years while around 25% of the patients used the medication for 6 to 10 years (Figure 1).

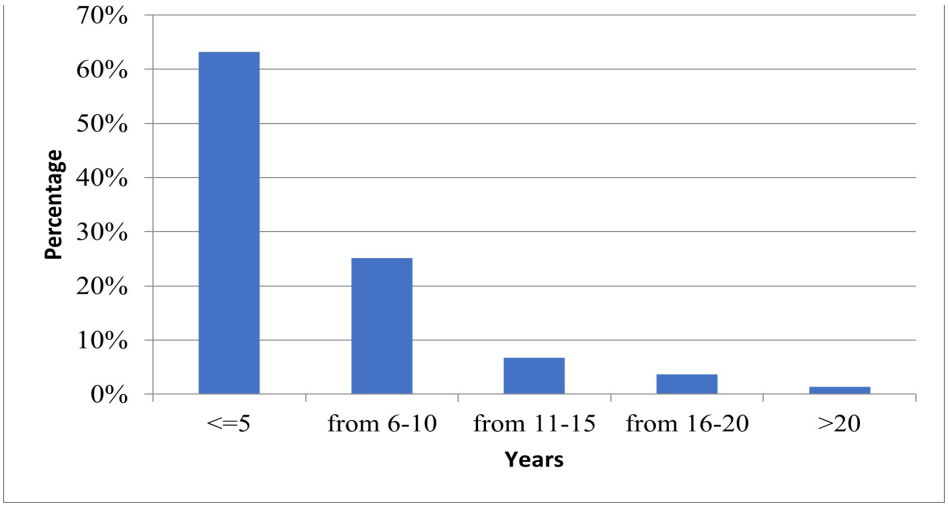

Figure 1. Period of using Nitro-Glycerin tablets

Discussion

The present study revealed important findings regarding knowledge of S/L GTN and its use among patients attending the Cardiology Clinic of Teaching Hospital, Jaffna. The sample was male-predominant (68.8%) similar to the studies elsewhere (Azmi et al., 2019; Thanujah et al., 2021; Foong et al., 2023) signifying the prevalence of CAD is higher among men than women. Many patients in the present study studied up to the ordinary level (46.51%) and advanced level (48.84%). In contrast, in a study in the same context in Sri Lanka, Thanujah et al. (2021) found more participants (88.7%) who had studied up to O/L. The COVID-19 pandemic perhaps influences clinic attendance in the present study. Data for the study were collected in the post-pandemic and a more educated group possibly attended the clinic while adhering to precautions.

The present study revealed important findings regarding knowledge and practice of self-administration of S/L GTN. A minority of patients (13.4%) demonstrated good knowledge (70-80%, n=28). This finding is comparable with several previous studies in several contexts. As revealed in two Malaysian studies good knowledge was seen among 2.9 % of the sample and the majority (70%) had moderate knowledge (Azmi et al., 2019). A recent Sri Lankan study reported similar results of good knowledge only among 22.7% of the sample (Thanujah et al., 2021) and considered knowledge to be good if the participants scored more than 50% of the total score.

Patients' knowledge of using S/L GTN is important to take preventive actions during episodes of chest pain. A notable fragment of the sample was not aware of the indications and adverse effects that could prevent its proper use. In contrast, the indication for S/L GTN was correctly mentioned as relief from chest pain in several studies (Azmi et al., 2019; Thanujah et al., 2021). Understanding the adverse effects of the drug is important in improving patients' compliance. In addition, the importance of aware of the mechanism of the S/L GTN is highlighted in other studies (Azmi et al., 2019; Foong et al., 2023; Thanujah et al., 2021). Lack of awareness can cause failure to use the drug during a decisive moment thus impeding treatment (Foong et al., 2023) and consequently, it negatively impacts patients' lives.

Unexpectedly, most participants in the present study were not identified dizziness, and flushing as potential adverse effects of this drug. However, participants had good knowledge of some of the important aspects. For instance, more than 92% of patients correctly mentioned the appropriate body position for taking the drug as sitting or lying down posture. Congruent findings were reported by Thanujah et al. (2021) by indicating the correct body position of taking the drug (92.6%). The onset of action of S/L GTN is 1–3 minutes, and the duration of action is 10–30 minutes (Tarkin & Kaski, 2016). Therefore, CAD patients are advised to take the drug while seated or lying posture since there is a risk of potential symptomatic postural hypertension that can occur after taking the drug (Burchum et al., 2016; Tarkin & Kaski, 2016).

Unsatisfactory knowledge was found in some key areas in the present study and it highlights the need to improve the knowledge of patients with CAD for saving their lives. Almost all patients in the present study are not aware of the maximum number of S/L GTN tablets per episode as three (99.5%) is a major concern. As previously reported the maximum number of tablets per episode was correctly mentioned in different studies was 75.4% (Azmi et al., 2019), 49.8% (Foong et al., 2013), and 47.2% (Thanujah et al. (2021). Consuming too many tablets in a shorter period can lead to serious side effects. Therefore, patients' understanding is vital to prevent adverse effects. However, a significant number of patients in the present study were not accurately aware the time interval between the first and second tablet in a pain episode is five minutes (65.1%). This is coherent with oth-

er studies. As found by Azmi et al/ (2019) only 70% of the sample was accurately aware of the time intervals of taking the drug, comparatively low knowledge was reported by Foonge et al. (2023) and only 156 out of 420 (37.1%) knew about time sequencing of S/L GTN.

Though some knowledge gaps were apparent in the present study, the practice of using GTN is relatively satisfactory. Remarkably, almost all participants (99.5%) in the sample correctly self-administered the drug by placing the tablet under the tongue. It shows that participants of the present study were properly advised that swallowing S/L GTN is not ineffective (Tarkin & Kaski. 2017). Another important practice of patients with CAD is the availability of GTN patients to use whenever they feel anginal pain. Hence, they are advised to carry the GTN container constantly and 81.9% of patients in the present study adhere to the instruction. In agreement, a study conducted at two cardiac wards of a small public metropolitan teaching hospital in Brisbane, Australia reported that 82.1% of the sample used carry SL GTN at all times (Fan et al., 2009).

Storage of drugs impacts the potency of drugs and GTN is heat sensitive. Further, more than 80% of the sample knew proper storage of GNT containers. They knew that GTN tablets should be stored in the original amber color bottles and cool and dark places. This is comparable with findings of several local and international settings (Azmi et al., 2019; Fan et al., 2009; Foong et al., 2023; Omar et al., 2015). According to Fan et al. (2009), male patients properly stored GTN than females (85.7% vs.78.6%). Almost all patients in the present study regularly attended the Cardiology Clinic and followed the clinic instructions. It is a positive observation regarding patients' compliance with the treatment regimen.

Limitations

Study was limited to a single setting and it lessened the generalizability of findings. A small sample size due to a low response rate is another limitation.

Conclusions

Knowledge regarding self-administration of S/L GTN among CAD patients is sub-optimal. Patients had good knowledge regarding taking GTN tablets during pain episodes, appropriate body position of taking the drug, drug storage, and replacing the drug in the container. However, poor knowledge is obvious regarding the indication of the drug, adverse effects, the maximum number of tablets that should be used in a pain episode its time interval, and drug storing temperature. The practice of using S/L GTN seems satisfactory. Knowledge gaps identified in the present study emphasize the need to implement regular awareness sessions in Cardiology clinic settings to prevent adverse effects and possible life-threatening events. Further, multi-centre larger studies are warranted.

Acknowledgment

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Conflicts of Interest

The authors declared that they do not have any conflict of interest.

References

Azmi, N. L., Azmi, A. A., Lian, C. W., Seman, S. M., & Sukri, I. M. (2019). Knowledge and use of sublingual glyceryl trinitrate: A single centre experience. International Research Journal of Pharmacy and Medical Sciences, 2 (4), 35-39.

Boden, W.E., Finn, A.V., Patel, D., Peacock, W.F., Thadani, U., & Zimmerman. F.H. (2012). Nitrates as an integral part of optimal medical therapy and cardiac rehabilitation for stable angina: review of current-concepts and therapeutics. International Research Journal of Pharmacy and Medical Sciences, 35(5), 263–271.

Boden, W. E., Padala, S. K., Cabral, K. P., Buschmann, I. R., & Sidhu, M. S. (2015). Role of short-acting nitroglycerin in the management of ischemic heart disease. Drug Design, Development, and Therapy, 9, 4793–4805. https://doi.org/10.2147/DDDT.S79116.

Burchum, J., Rosenthal, L., Jones, B., Neumiller, J., Lehne, R., (2016). Lehne's pharmacology for care [Internet]. St. Louis, Missouri: Elsevier/Saunders.

Daniel, W. W. (1999). Biostatistics: A foundation for analysis in the health sciences. (7th Ed.). New York: John Wiley & Sons.

Fan, Ming-I., Mitchell, M., Cooke, M. (2009). Cardiac patients' knowledge and use of sublingual glyceryl trinitrate (SLGTN). Australian Journal of Advanced Nursing, 26 (3), 31-38.

Foong, W.S., Looi, K.L., Lee, S.F., Ai, A.T.C., Yi-Ing, S.K., & Ravindra, A. K., & Jie, O. Y. Z. (2023). Assessment of knowledge and use of sublingual glyceryl trinitrate (S/L GTN) among cardiac patients in Penang government hospitals: A multicentre study. e-PMJ, 3(1), doi: https://doi.org/10.1111/e-pmj.v3i1.23149

Gallagher, R., J. Belshaw, A., Kirkness, K., Roach, L. S., & Warrington, D. (2010). Sublingual nitroglycerin practices in patients with coronary artery disease in Australia, J. Cardiovasc. Nurs., 25, (6), 480–486.

Omar, W,A., Jasudass, S.R., & Saad, S.R. (2015). Patient's knowledge and use of sublingual glyceryl trinitrate therapy in Taiping Hospital, Malaysia. International Journal of Pharmacological and Pharmaceutical Sciences. 8(10),758-761.

Murrell, W. (1879). Nitro-glycerine as a remedy for angina pectoris. Lancet Elsevier. 113, 225–7.

Pragani, M.A., Desai, K. P., Morrone, D., Sidhu, M.S., & Boden, W. E. (2017). The role of nitrates in the management of stable ischemic heart disease: A review of the current evidence and guideline. Rev Cardiovasc Med., 18(1),14-20.

Tarkin, J.M., & Kaski, J.C. (2016). Vasodilator therapy: Nitrates and Nicorandil, Cardiovasc Drugs Ther., 1-11. DOI 10.1007/s10557-016-6668-z

Thanujah, M., Thuvaragan, S., Coonghe, P.A.D., Guruparan, M. (2021). Knowledge and practice regarding the usage of sublingual glyceryl trinitrate. International Journal of Multidisciplinary Research. 7 (1), 28-02-202.

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Harnessing Global Trends and Digital Innovation for a Greener and a Prosperous Future

Wijayaratne, K.

Introduction

Sri Lanka stands at a critical juncture in its journey towards economic and environmental sustainability. Over the past decade, the island nation has weathered significant challenges, including a severe economic crisis in 2022, compounded by the global COVID-19 pandemic. However, amidst these trials, Sri Lanka has demonstrated resilience and a steadfast commitment to charting a course towards sustainable development.

As of 2024, Sri Lanka's economic landscape reflects a mixture of recovery and ongoing structural reforms aimed at fostering long-term sustainability. Following a period of contraction, the Sri Lankan economy exhibited signs of resurgence, with real GDP growth turning positive at 1.6 percent in the third quarter of 2023. This rebound marks a pivotal moment in Sri Lanka's economic trajectory, signaling a shift towards recovery from the adverse effects of the recent crisis. (The World Bank Group, 2024)

Moreover, key indicators suggest a positive outlook for the near future. The purchasing managers' indices for manufacturing and services sectors show steady signs of expansion, indicating a revival in economic activity. Notably, 2023 is projected to witness a rare occurrence in Sri Lanka's economic history—a "twin surpluses" scenario, characterized by a surplus in the primary balance of fiscal accounts and the external current account. This milestone underscores the efficacy of fiscal policies and debt restructuring efforts in stabilizing the economy.

Despite these encouraging developments, challenges persist on the path to economic sustainability. Sri Lanka faces significant debt servicing obligations, with total debt servicing projected to reach over 38 percent of GDP by 2026 in the absence of comprehensive debt restructuring measures. However, under the baseline scenario of debt restructuring, the country anticipates a notable reduction in debt servicing burdens, offering a glimmer of hope for fiscal stability and long-term sustainability. (The World Bank Group, 2024)

In parallel, Sri Lanka confronts environmental sustainability concerns, exacerbated by factors such as climate change, natural resource depletion, and pollution. Addressing these challenges requires a multifaceted approach that integrates economic policies with environmental conservation efforts. As the nation navigates this complex terrain, it must balance the imperatives of economic growth with the imperative of environmental stewardship to ensure a prosperous and sustainable future for generations to come.

The main goal of this article is to investigate how Sri Lanka can use worldwide sustainability trends to support its economic and environmental sustainability goals. By studying the impact of global movements such as the adoption of renewable energy, initiatives for achieving net zero emissions and increased corporate transparency, this study aims to pinpoint strategies that can steer Sri Lanka towards a more environmentally friendly future. The aims include examining the importance of digital literacy, Big Data and IoT in encouraging sustainable practices,

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as well as assessing the role of the banking and finance industry in promoting economic stability and backing sustainable investments. In essence, this write-up aims to offer a comprehensive framework for integrating global sustainability trends into Sri Lanka's development plans, strengthening resilience, fostering economic growth and positioning the country as a sustainability leader in its region.

Global Sustainability Movements

When we explore the current sustainability trends on a global scale, it becomes clear that these advancements have significant implications for both the present situation and future direction of Sri Lanka. As Sri Lanka navigates the challenges of economic recovery and environmental protection, lessons learned from international sustainability trends can offer valuable guidance. By studying the innovative strategies and successful practices implemented by other countries, Sri Lanka can gain important knowledge to shape its own sustainability efforts. Moreover, by staying informed about the changing global landscape of sustainability, Sri Lanka can discover opportunities for collaboration, sharing knowledge and forming strategic partnerships that can speed up progress towards its sustainability objectives. Therefore, examining emerging sustainability trends in a wider context not only enhances our understanding of global dynamics but also provides practical insights that can be utilized to promote sustainable development in Sri Lanka's distinct socio economic and environmental setting.

Renewable Energy Remains a Top Priority

Renewable energy remains a cornerstone of environmental sustainability efforts, despite the evolving global energy landscape. The recent geopolitical tensions between Russia and Ukraine have underscored the importance of reducing dependence on fossil fuels, prompting a renewed emphasis on renewable energy alternatives worldwide. As countries seek to insulate themselves against energy price volatility and mitigate the impact of inflation on consumers, renewable energy emerges as a compelling solution.

In the United States, the renewable energy sector experienced challenges in 2022, but signs of recovery and growth are on the horizon. The Inflation Reduction Act (IRA) presents promising incentives for renewable energy development, offering a potential catalyst for accelerated sectoral expansion in 2023. However, the sector continues to grapple with persistent obstacles, including supply chain disruptions and fluctuations in interest rates. (McClimon, 2023).

Despite these challenges, proactive measures to maximize the utilization of renewable energy sources hold the key to overcoming barriers and fostering sustained growth. Leveraging advancements in technology, such as artificial intelligence (AI), renewable energy stakeholders can enhance operational efficiency and optimize resource allocation. AI-driven predictive analytics enable more accurate forecasting of energy consumption patterns and facilitate proactive maintenance of renewable energy infrastructure, ensuring optimal performance and reliability.

Solar energy innovation represents a particularly promising avenue for advancing renewable energy adoption. Breakthroughs in solar technology, including the emergence of photovoltaics (FPV), are revolutionizing the solar power landscape and democratizing access to clean energy solutions. Photovoltaics, which involve installing solar panels on bodies of water, offer significant advantages, including increased energy generation efficiency and reduced land usage compared to traditional solar installations. (McClimon, 2023).

Overall, the convergence of technological innovation, policy support, and market dynamics positions renewable energy as a pivotal driver of sustainable development and energy transition initiatives. By embracing renewable energy solutions and harnessing the power of innovation, stakeholders can navigate existing challenges and pave the way for a more resilient, low-carbon future.

Pursuit of Net-Zero

In the realm of sustainability, the Race to Zero initiative stands out as a global call to action in response to the pressing threat of climate change. This initiative urges non-state actors worldwide to take decisive steps towards halving emissions by 2030, with the ultimate objective of achieving net-zero emissions over the long term. While Race to Zero has gained significant traction as a crucial trend in sustainability, its effectiveness hinges on addressing all facets of emissions, including Scope 3 emissions—indirect emissions generated by suppliers or customers associated with a given organization. (Global Destination Sustainability Movement, 2024)

Recent sustainability reports underscore the growing recognition of the importance of tackling Scope 3 emissions. In 2023, companies across various industries have intensified their focus on this challenge, signaling a shift towards more comprehensive approaches to reducing carbon footprints. While companies have traditionally relied on carbon offsetting as a strategy to mitigate emissions, it has become increasingly evident that carbon offsets alone are insufficient in achieving net-zero emissions targets.

To truly make meaningful progress towards net-zero emissions, there is a growing emphasis on holistic manufacturing sustainability trends aimed at reducing emissions at the source. Rather than solely relying on carbon offsetting measures, organizations are prioritizing efforts to minimize emissions throughout their supply chains and operational processes. This entails implementing innovative solutions and technologies to enhance energy efficiency, optimize resource utilization, and minimize waste generation.

Furthermore, companies are exploring a range of strategies to address residual emissions that cannot be eliminated through emission reduction efforts alone. These strategies may include initiatives such as reforestation projects, ecosystem restoration efforts, and investments in carbon capture and storage technologies. By adopting a multifaceted approach that combines emission reduction with carbon offsetting measures, organizations can significantly contribute to the global transition towards a low-carbon economy. (EDITORIAL, 2022)

In essence, while the Race to Zero initiative serves as a rallying cry for climate action, achieving meaningful emissions reductions requires a comprehensive and integrated approach that encompasses both emission reduction efforts and carbon offsetting measures. By prioritizing sustainability and embracing innovative solutions, companies can play a pivotal role in driving collective efforts towards a more sustainable and resilient future.

Corporate Sustainability Continues to Harvest Attention in Boardrooms

The integration of sustainability into business operations is no longer just a matter of ethical responsibility; it has become a strategic imperative with tangible financial benefits. Across various industries, companies are embracing sustainability trends that encompass everything from eco-friendly products to sustainable business practices. This shift towards sustainability is driven by factors beyond altruism, with companies recognizing the economic advantages it brings.

One prominent area within this broader trend is Environmental, Social, and Governance (ESG) criteria. ESG encompasses the environmental, social, and governance factors that businesses consider in their decision-making processes. Not only does adherence to ESG principles enhance a company's reputation among investors, but it also contributes to improved financial performance. As ESG investing gains traction, companies are increasingly under pressure to align their operations with ESG goals to attract investment and mitigate risks. (Global Destination Sustainability Movement, 2024).

Another significant trend is the focus on supply chain sustainability. Companies are reevaluating their supply chains to reduce environmental impact and promote sustainability. This includes initiatives such as eliminating single-use plastics, transitioning to renewable energy sources, and embracing circular economy models. By optimizing their supply chains for sustainability, businesses not only reduce energy consumption and enhance efficiency but also realize cost savings by utilizing existing materials and mitigating risks associated with supply chain disruptions.

Furthermore, the adoption of sustainable packaging practices is gaining momentum. Businesses are actively seeking alternatives to conventional packaging materials, aiming to minimize environmental harm and reduce reliance on non-renewable resources. Initiatives such as using recycled or plant-based materials and implementing innovative packaging designs are becoming increasingly prevalent. These efforts not only align with consumer preferences for eco-friendly products but also contribute to reducing waste and pollution.

Real-world examples highlight the commitment of businesses to sustainability in action. For instance, Costco's initiative to divert 600,000 tons of packaging waste annually demonstrates a proactive approach to waste reduction and environmental stewardship. Similarly, Innocent Drinks' pledge to eliminate 2,500 tons of plastic bottles by 2023 underscores the growing momentum towards sustainable packaging solutions. (EDITORIAL, 2022)

In summary, sustainability trends in business are driving transformative change, offering companies not only reputational benefits but also tangible financial advantages. By embracing ESG principles, enhancing supply chain sustainability, and adopting sustainable packaging practices, businesses can position themselves for long-term success while contributing to a more sustainable future.

End of the Era of 'Greenwashing'

The phenomenon of "greenwashing" has become increasingly prevalent in recent years as companies attempt to capitalize on growing consumer demand for eco-friendly products and practices. Greenwashing refers to the deceptive practice of making exaggerated or false claims about a company's environmental sustainability efforts without providing adequate evidence to support those claims. Unfortunately, research indicates that a significant portion of businesses engage in greenwashing, with over 40% of randomly selected websites found to make false eco-friendly claims.

In today's consumer landscape, where sustainability is a key consideration for many individuals, it is understandable why companies may be tempted to engage in greenwashing. However, such practices not only mislead consumers but also undermine the credibility of genuine sustainability efforts.

Consumers are becoming increasingly discerning and are demanding greater transparency from companies regarding their environmental impact and sustainability practices. As a result, brands that engage in greenwashing risk losing consumer trust and facing potential legal repercussions.

To address this issue, there is a growing call for greater transparency and accountability in corporate sustainability reporting. Governments, particularly in regions like Europe, are enacting legislation that mandates comprehensive sustainability reporting from businesses. For example, the sustainable finance disclosure regulation (SFDR) requires financial market participants to publicly disclose climate-related financial information. (McClimon, 2023)

Moving forward, environmental trends in marketing are likely to evolve towards more honest and transparent communication of sustainability efforts. Brands will be expected to demonstrate genuine commitment to sustainability through concrete actions and measurable results, rather than simply relying on green marketing tactics.

Ultimately, the era of greenwashing is coming to an end as consumers, regulators, and investors demand greater authenticity and accountability in corporate sustainability practices. For companies, the imperative is clear: genuine and meaningful sustainability efforts must be prioritized to build trust, loyalty, and long-term success.

The Future is Undoubtedly in Sustainable Smart Cities

Cities worldwide are embracing technology to usher in a smarter and more sustainable future, giving rise to the concept of 'smart cities.' These urban hubs are at the forefront of eco-friendly practices, incorporating everything from sustainable building materials to innovative transportation solutions and the transition to circular economies.

The intersection of smart cities and sustainability is multifaceted, with a primary focus on resource efficiency and consumption reduction. According to Rob Hopkins, author of "From What Is To What If," the future of sustainability hinges on cities' ability to reimagine their infrastructure, economy, and societal engagement. Hopkins envisions a landscape where cities compete to achieve zero carbon emissions and pioneer imaginative strategies to address pressing environmental challenges.

However, while the vision for radical urban transformation is clear, tangible progress has been slower than anticipated. Despite discussions about vehicle-free cities and the implementation of smart technologies like intelligent lighting and traffic management systems, practical challenges and cost constraints have hindered widespread adoption.

Nevertheless, the dream of smart cities remains very much alive. The imperative for radical innovation persists, driven by the projected urbanization trend, with an estimated 68% of the global population expected to reside in urban areas by 2050. As urbanization accelerates, the demand for adaptive, forward-thinking smart cities intensifies, highlighting the crucial role of innovation in shaping a sustainable and prosperous future for society.

Working from Home' is Sticking Around

Since the onset of the global pandemic, remote work has emerged as the new standard for many businesses, transforming the traditional workplace landscape. While 2020 marked the inception of this trend, the prevalence of remote work in 2023 signifies just the beginning of its sustainability impact.

Forecasts indicate a substantial surge in remote workers, with experts projecting that by 2025, over 36 million Americans will be working remotely—a staggering 417% increase compared to pre-2020 levels. The allure of remote work extends beyond enhanced productivity and work-life balance; it also offers tangible environmental benefits. (McClimon, 2023)

As remote work becomes more commonplace, there is a noticeable reduction in traffic congestion and emissions from vehicles, including both personal cars and public transportation. Consequently, there is a significant decrease in greenhouse gas emissions, contributing to environmental conservation efforts.

According to a report by Owl Labs & Global Workplace Analytics, remote work has already led to emissions reductions equivalent to removing 600,000 cars from US roads. As more companies embrace a remote-first approach, these environmental gains are expected to multiply further.

Moreover, technological advancements enable businesses to save energy by facilitating remote work. With fewer employees occupying office spaces, there is reduced demand for heating, lighting, and other energy-intensive resources, resulting in additional energy conservation.

The shift towards remote work represents a sustainable, low-carbon trend that is poised to en-

dure well beyond the pandemic era. As remote work continues to redefine traditional work practices, it will increasingly become the norm rather than the exception, further reinforcing its role in fostering a greener and more environmentally-conscious future.

Get Ready for Eco-friendly Travel Vibes

Eco-friendly travel, transport, and tourism are consumer sustainability trends with far-reaching implications for the macro environment, signifying a growing global consciousness towards greener practices.

Consumers are increasingly opting for greener travel options, signaling their demand for sustainable alternatives by selecting eco-conscious airports and reducing the number of flights taken. This shift in consumer behavior compels businesses to respond accordingly, as consumer preferences wield significant influence in shaping market trends. (Global Destination Sustainability Movement, 2024)

The evolution of sustainable transport options, including increased bicycle use, low-carbon public transport, and the proliferation of electric cars, reflects ongoing efforts to prioritize environmental considerations in transportation infrastructure. While the adoption of energy-efficient electric vehicles varies among countries, their prevalence on roads worldwide underscores the growing acceptance of greener transportation solutions.

Addressing the over-reliance on car transport is a prominent focus of current sustainability trends in transportation. Countries like Malta, Luxembourg, and Spain are at the forefront of promoting public transport and bicycle usage by offering free or subsidized transportation options—a testament to their commitment to fostering sustainable mobility solutions.

Similarly, the tourism industry is embracing ecological trends to mitigate its environmental impact. Measures such as limiting visitor capacity at popular attractions and implementing carbon offset initiatives, exemplified by initiatives like Ghibli Park and Blenheim Palace, respectively, demonstrate a concerted effort to promote sustainable tourism practices.

It is evident that greener travel and tourism options are pivotal sustainability trends that are poised for continued growth and adoption in the foreseeable future. As stakeholders across industries prioritize environmental sustainability, the proliferation of eco-friendly travel solutions will play a crucial role in shaping a more sustainable global landscape. (Global Destination Sustainability Movement, 2024)

Sri Lanka has a lot to gain from the worldwide push for sustainability, given its stunning natural beauty and rich cultural heritage. By embracing eco friendly approaches in travel, transportation and tourism, the country can protect its beautiful landscapes and become an attractive destination for sustainable travel. Encouraging the use of greener transport options like electric vehicles and improving public transportation, as well as promoting eco friendly tourism initiatives, can help lower both residents and tourists' impact on the environment. By following these global trends, Sri Lanka could establish itself as a frontrunner in sustainable tourism within South Asia, drawing in travelers who prioritize environmental consciousness while nurturing a stronger and more resilient economy.

Realizing Sustainable Development: Leveraging Global Sustainability Trends for Sri Lanka's Prosperity

Adopting global sustainability trends offers Sri Lanka countless benefits across various dimensions, ranging from economic prosperity to environmental resilience and enhanced international standing. By embracing these concepts seamlessly into its socio-economic fabric, Sri Lanka can unlock opportunities for businesses, generate tax revenue, improve the quality of life for its citizens, promote environmental stability, bolster its global reputation, reduce carbon footprint, and secure foreign relations and export markets.

First and foremost, integrating sustainability practices into business operations can catalyze economic growth and innovation in Sri Lanka. Businesses that prioritize sustainability are often more resilient, adaptable, and competitive in the global marketplace. They attract investment, stimulate job creation, and contribute to GDP growth. Moreover, sustainable businesses are better equipped to navigate regulatory changes, market disruptions, and shifting consumer preferences, thus fostering long-term viability and profitability.

From a fiscal perspective, embracing sustainability can bolster tax income for the Sri Lankan government. Sustainable businesses contribute to economic activity and generate tax revenue through corporate taxes, value-added taxes, and other levies. Additionally, investments in renewable energy, eco-tourism, and sustainable infrastructure projects can attract foreign investment and development assistance, further augmenting government revenue streams.

The adoption of sustainable practices also has tangible benefits for the lifestyle and well-being of Sri Lankan citizens. Sustainable urban planning initiatives, such as green spaces, pedestrian-friendly infrastructure, and efficient public transportation systems, enhance livability and promote physical and mental health. Furthermore, sustainable agriculture and food production methods ensure food security, improve nutrition, and support rural livelihoods, benefiting both urban and rural populations.

Environmental stability is paramount for Sri Lanka's ecological health and resilience. By embracing sustainability trends, such as renewable energy adoption, waste reduction, and conservation efforts, Sri Lanka can mitigate the impacts of climate change, natural disasters, and environmental degradation. Protecting natural habitats, preserving biodiversity, and ensuring access to clean air and water are essential for the long-term sustainability of Sri Lanka's ecosystems and the well-being of its inhabitants.

Furthermore, integrating sustainability into national policies and practices enhances Sri Lanka's global image and reputation. As a responsible steward of the environment and a champion of sustainable development, Sri Lanka can attract positive attention from international organizations, investors, tourists, and trading partners. This positive perception can open doors to new trade opportunities, foreign investment, and development partnerships, strengthening Sri Lanka's economic ties and geopolitical influence on the world stage.

Reducing carbon footprint is a crucial aspect of Sri Lanka's commitment to sustainability. By transitioning to renewable energy sources, improving energy efficiency, and adopting eco-friendly transportation options, Sri Lanka can significantly reduce its greenhouse gas emissions and contribute to global efforts to combat climate change. This not only mitigates the adverse impacts of climate change on Sri Lanka's environment and economy but also demonstrates leadership and responsibility in addressing a pressing global challenge.

Finally, embracing sustainability trends can help Sri Lanka secure foreign relations and export markets. As the global demand for sustainable products and services continues to grow, Sri Lankan businesses that prioritize sustainability can access lucrative international markets and forge partnerships with environmentally conscious consumers and businesses abroad. By aligning with global sustainability standards and certifications, Sri Lanka can enhance its competitiveness and credibility in the global marketplace, paving the way for sustainable economic growth and prosperity.

To make the most of the current global sustainability trends, Sri Lanka needs to not just embrace eco friendly practices but also make use of modern technological advancements. Digital literacy and technology are essential for promoting sustainable development by improving resource management, increasing efficiency and encouraging innovation. As the country aims to

incorporate sustainability across all aspects of its socio-economic structure, the use of digital tools, Big Data and the Internet of Things (IoT) becomes more and more important. These technologies can support well informed decision making, simplify processes and offer intelligent solutions that push Sri Lanka towards a brighter future built on sustainability and prosperity.

Digital Literacy and Technology for Sustainable Development in Sri Lanka

In Sri Lanka's pursuit of sustainability, digital literacy and the utilization of digital concepts such as Big Data and the Internet of Things (IoT) play a crucial role in enabling effective adoption and implementation of sustainability trends. By harnessing digital technologies, Sri Lanka can overcome challenges, optimize resource utilization, and drive sustainable development across various sectors. (Buchholz, 2023)

Digital Literacy for Sustainable Practices

Digital literacy empowers individuals and organizations to embrace sustainable practices by providing access to information, tools, and resources necessary for informed decision-making. In Sri Lanka, promoting digital literacy initiatives that focus on sustainability education can raise awareness about environmental conservation, resource management, and eco-friendly practices among citizens and businesses.

For instance, digital literacy programs can educate individuals on the importance of recycling, energy conservation, and sustainable transportation options. By fostering a culture of environmental awareness and responsibility through digital channels, Sri Lanka can encourage widespread adoption of sustainable behaviors and lifestyles.

Moreover, digital literacy enables businesses to implement sustainable practices by leveraging digital tools and platforms for eco-friendly operations. From implementing energy-efficient technologies to optimizing supply chain logistics, digital literacy empowers businesses to reduce their environmental footprint and contribute to overall sustainability efforts. (Buchholz, 2023)

Harnessing Big Data for Environmental Insights

Big Data analytics offers unparalleled capabilities for generating insights into environmental trends, patterns, and dynamics. In Sri Lanka, leveraging Big Data analytics can provide valuable information for monitoring and managing environmental resources, predicting environmental risks, and designing targeted interventions for sustainable development.

For example, by analyzing data on weather patterns, water quality, and biodiversity, policymakers and environmental agencies can develop evidence-based strategies for natural resource management, conservation, and disaster resilience. Big Data analytics can also facilitate early warning systems for natural disasters, enabling proactive measures to mitigate environmental risks and protect vulnerable communities.

Furthermore, in sectors such as agriculture and urban planning, Big Data analytics can optimize resource allocation, improve productivity, and minimize environmental impact. By analyzing data on soil health, crop performance, and urban infrastructure, stakeholders can make informed decisions to enhance sustainability outcomes and promote resilient, eco-friendly development. (Ott, 2024)

IoT for Smart and Sustainable Solutions

The Internet of Things (IoT) presents opportunities for deploying smart, connected devices and sensors to monitor, manage, and optimize environmental systems and processes. In Sri Lanka, IoT technologies can support the implementation of sustainable solutions across various domains, including energy, transportation, and waste management.

For instance, IoT-enabled smart energy meters and sensors can track energy consumption patterns, identify inefficiencies, and promote energy conservation practices among households and businesses. By providing real-time data on energy usage and performance, IoT solutions empower individuals and organizations to make informed choices that reduce energy waste and promote sustainability.

Similarly, in transportation, IoT sensors can enable smart traffic management systems, optimize public transit routes, and promote eco-friendly modes of transportation such as cycling and electric vehicles. By integrating IoT technologies into transportation infrastructure, Sri Lanka can alleviate traffic congestion, reduce emissions, and enhance mobility options for citizens while promoting sustainable urban development. (Buchholz, 2023)

As we implement IoT technologies to promote sustainable development, the role of banking and finance become more and more important in supporting those advancements. Financial institutions play a crucial part in boosting the economy and fostering long term growth by investing in smart technologies, financing eco friendly innovations and backing businesses that prioritize sustainability objectives. Incorporating sustainability into financial strategies enables banks and financial organizations to strengthen technological advancements that support a more robust and environmentally conscious economy.

Role of Banking and Finance on Economic Revival and Long- Term Growth

In the face of current economic challenges, the banking and financial sector plays a crucial role in ensuring stability, encouraging growth and supporting efforts that prioritize sustainability.

Economic Stability and Revival

Following the economic turmoil of 2022 and the repercussions of the COVID 19 pandemic, Sri Lanka's economy has encountered notable difficulties. The banking and financial sector is tasked with stabilizing the economy through sound monetary policies, maintaining financial liquidity and aiding businesses and individuals impacted by these crises. Through offering credit access, providing solutions for debt restructuring and facilitating investment inflows, banks and financial entities can bolster economic recovery efforts and rebuild trust in the financial framework. (Central Bank of Sri Lanka, 2024)

Advancing Sustainable Funding

With an increasing global emphasis on sustainability, Sri Lanka's banking and finance industry plays a pivotal role in advocating for sustainable financing practices. By incorporating environmental, social and governance (ESG) considerations into lending decisions as well as investment strategies, banks can direct funds towards projects that align with sustainable development objectives. (Central Bank of Sri Lanka, 2024)

Banks have the opportunity to make a positive impact on the environment and sustainability by financing renewable energy projects, supporting eco friendly businesses and encouraging sustainable agricultural practices.

Aiding and Guiding Financial Inclusion

In Sri Lanka, ensuring financial inclusion remains a significant challenge, as many people do not have access to formal banking services. Banks can contribute to sustainable development by increasing access to financial services, especially in underserved communities and rural areas. By introducing innovative digital banking options, mobile banking services and microfinance programs, banks can empower individuals and small businesses, foster entrepreneurship and promote inclusive economic growth. (Bank of Canada, 2022)

Supporting Green Investments and Innovations

Promoting green investments and innovation is essential for Sri Lanka's shift towards a low carbon economy. The banking sector can play a

vital role in this transition by providing funding and assistance to green companies, renewable energy startups and research projects focusing on sustainability. By creating a supportive environment for green investments and innovation, banks can hasten the progress of sustainable development while helping combat climate change and environmental harm. (Central Bank of Sri Lanka, 2024)

Closing Thoughts.....

In wrapping up, Sri Lanka finds itself at a transformative crossroads, where the pursuit of economic vitality intertwines with the imperative of environmental stewardship. Through resilience and a forward-looking approach, the island nation is not merely weathering storms but hoisting the sails towards a brighter, more sustainable future.

In this unfolding narrative, Sri Lanka is not alone. It draws inspiration from global sustainability movements, where nations are not just embracing change but sculpting it into opportunities for growth and innovation. From renewable energy revolutions to the race towards net-zero emissions, the world is a stage for Sri Lanka to glean insights and strategies, transforming challenges into triumphs.

Yet, in this grand symphony of progress, technology emerges as a conductor of change. Digital literacy becomes the melody that empowers individuals and businesses to compose a harmonious blend of sustainability and innovation. Through the virtuosity of Big Data and the Internet of Things (IoT), Sri Lanka orchestrates a symphony of smart solutions, optimizing resources, and enhancing resilience in the face of environmental challenges.

However, the score of sustainable development is not solely composed in boardrooms and laboratories; it resonates in the hearts and minds of every citizen. It is a collaborative endeavor, where governments, businesses, civil society, and individuals each play a part in the ensemble of progress.

As Sri Lanka embraces this crescendo of sustainability, it not only charts a course for its own prosperity but also becomes a beacon of inspiration for the region and beyond. With creativity, collaboration, and commitment, Sri Lanka dances towards a future where economic vitality harmonizes with environmental resilience, creating a symphony of progress that resonates for generations to come.

References

Bank of Canada. (2022, June 7). Financial System Review—2022. Retrieved from Bank of Canada: https://www.bankofcanada.ca/2022/06/financial-system-review-2022/ Buchholz, L. (2023, September 1).

Sustainability & digital skills: Education can change world. Retrieved from Sustainability Magazine: https://sustainabilitymag.com/articles/sustainability-and-digital-skills-how-education-can-change

Central Bank of Sri Lanka. (2024). Annual Economic Review 2023. Colombo: Central Bank of Sri Lanka.

EDITORIAL. (2022, June 1). The sustainability movement is 50. Why are world leaders ignoring it? Retrieved from Nature: https://www.nature.com/articles/d41586-022-01508

2Global Destination Sustainability Movement. (2024, July 19). Design a thriving future for people and place. Retrieved from Global Destination Sustainability Movement: https://www.gds.earth/

McClimon, T. J. (2023, April 15). 7 Global Trends Impacting The Sustainability Movement. Retrieved from Forbes: https://www.forbes.com/sites/timothyjmcclimon/2019/04/15/7-global-trends-impacting-the-sustainability-movement/Ott, B. L. (2024).

Communicating for Sustainability in the Digital Age: Toward a New Paradigm of Literacy. MDPI, 9.

The World Bank Group. (2024, April 2). Sri Lanka Development Update 2024. Retrieved from https://www.worldbank.org/en/country/srilanka/publication/sri-lanka-development-update-2024#:~:text=The%20economy%20contracted%20by%202.3,following%20six%20quarters%20of%20contraction.

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