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Editor's note

We are delighted to present Vallis Aurea (Journal of Sustainable Development and Innovation) due to successful cooperation between the School of Industrial Fisheries, Cochin University of Science and Technology and the Faculty of Tourism and Rural Development. The Journal **Vallis Aurea** (*Journal of Sustainable Development and Innovation*) is devoted to multidisciplinary research in the fields of management, economics, entrepreneurship, tourism, sustainable development, gastronomy, food safety, quality control and innovation, addressing complex issues that are closely intertwined with other disciplines such as information and communication sciences, law, sociology, psychology, and other relevant fields.

The journal aims to foster an integrative approach to understanding the dynamic and interconnected nature of economic and entrepreneurial activities, the evolving trends in tourism, the principles and practices of sustainable development, and the role of innovation in driving societal progress.

The journal focuses on a wide range of topics, including but not limited to economic theories and models, entrepreneurship and its impact on society, sustainable and responsible tourism development, innovative practices in business and management, the role of technology and information systems in economic and social development, the legal and regulatory environment of business, societal and psychological aspects of entrepreneurship and economic behaviour, the impact of innovation on competitiveness and growth, sustainable business practices, and the integration of environmental and social considerations into economic and business strategies.

By emphasising a multidisciplinary perspective, the journal aims to contribute to the development of knowledge and understanding that supports the advancement of sustainable and innovative economic and business practices, the promotion of entrepreneurship, the enhancement of tourism, and the achievement of a more sustainable and prosperous society.

Vallis Aurea (Journal of Sustainable Development and Innovation) is a biannual journal that affirms an integral, holistic view of interdisciplinary research. It aims to unite academic methodology and sincerity with professional focus and practices.

We are dedicated to achieving and maintaining this journal's high standards. All articles submitted for publication in this journal are subjected to a double-blind review process performed by at least two academics from the Editor‘s Board. Reviewers stay anonymous.

With all our hearts and sincerity, we express our deepest gratitude to all the authors, reviewers, and editorial board members for their valuable contribution to this journal. We look forward to successful cooperation.

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REVITALISING FRESHWATER PONDS: ASSESSING PHYSICAL STRUCTURES BIO-RECHARGING STRATEGIES THROUGH COMMUNITY ENGAGEMENT

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ABSTRACT

Purpose*: The purpose of this study is to revitalize the freshwater ponds by assessing physical structures, water quality parameters and sustainable bio-recharging strategies through community engagement.*

Research Design*:The study employs a combination of exploratory and descriptive research approaches. Sampling was conducted among the individuals who are in direct access with the freshwater ponds.*

Methodology*: Data collection was carried out through direct surveys using a structured questionnaire, and water samples were gathered from the designated areas for water quality analysis.*

Results*: The results reveal that there are ponds that need immediate restoration and rejuvenation in order to sustainably take up the matter of a balanced ecosystem for the better survival and coexistence of individual species along with mankind by proper maintenance of the water body for a better tomorrow. The water quality analysis shows significant causes of deterioration due to ecological instability and overuse of the resources by improper management strategies which resulted in loss of biodiversity and habitat loss.*

Originality of Research*: This study records the revitalization of freshwater ponds by assessing physical structures, water quality parameters, and sustainable bio- recharging strategies through community engagement.*

Keywords*: Revitalization, Biodiversity, Bio- recharging, Water quality*

1. INTRODUCTION

Attractive ecosystems that add to the diversity of our natural environment are freshwater ponds. These tiny, still freshwater ponds provide special insights into the delicate balance of aquatic ecosystems

while also supporting a wide variety of plant and animal life. Freshwater ponds, from their origin to the rich web of life they support, are dynamic microcosms that capture the wonder and intricacy of nature. The preservation and restoration of freshwater ponds are greatly aided by conservation initiatives. This entails controlling human activity near pond habitats, putting sustainable land use strategies into place, and keeping an eye on water quality. Freshwater pond health and biodiversity are preserved through the establishment of buffer zones, rehabilitation initiatives, and the preservation of natural habitats. Freshwater ponds are vibrant, complex ecosystems that offer important ecological services and are brimming with life. Ponds serve as prime examples of the delicate balance found in natural ecosystems, from their origin through the seasonal variations and the wide variety of flora and animals they sustain. It is crucial to comprehend and value freshwater ponds in order to support conservation initiatives that guarantee the long-term health and vitality of these fascinating aquatic ecosystems.
The objective of this study is to identify and map the freshwater ponds of Thrikkakara region of the state of Kerala in India that needs restoration and conduct biodiversity study of flora and fauna of the selected ponds, to conduct surveys among the people residing the area about their dependency on the pond and regarding the need for restoration, also to assess the water quality of the selected ponds and analyse the chemical and biological parameters responsible for deterioration ,to understand the source of deterioration and to impart the relevance of restoration that helps recreation and community groups to cherish the pond for the future

2. REVIEW OF LITERATURE

The creation and maintenance of habitat for biodiversity, water purification, flood mitigation, and cultural benefits (such as recreational opportunities) are just a few of the many ways that ponds and "pondscapes," or networks of ponds, are essential habitats for biodiversity and for providing numerous benefits to humans, often known as "Nature's Contribution to People." Ponds do not, however, usually qualify as nature-based solutions that offer all of these advantages. Furthermore, there is a dearth of information regarding the optimal management and restoration of ponds to enhance their capacity to fortify ecosystems and society against the effects of climate change. To enhance the application of ponds as Nature-based Solutions for providing a diverse range of Nature Contributions to Humans, it is imperative to produce and include ecosystems, biodiversity, sociological, economic, and policy dimensions (Cambronero, et.al 2023)
Zainulabdeen and Nagaraj (2022) review the material that has been published on the effects of human activity on Kerala's wetlands and conservation efforts. Wetlands are an essential component of the state and provide several ecosystem services to humans, including food production, flood control, erosion control, biodiversity support, and subsurface water recharge. Wetlands are currently in danger due to population pressure, accelerated urbanization, and careless land use patterns. Kerala's wetlands have been divided, contaminated, and restored for different uses. Man is putting not just humans but also other species at peril if this trend keeps up. Realizing the value of wetlands, scientists and environmental conservationists have investigated the detrimental effects of human activity on wetlands.
Chidi and Aryal (2022) analyzed the current purposes of ponds in Nepal's Lumbini Province's Nawalparasi West district. Ponds are essential to many facets of both human and natural existence. Its significance ranges from a marvel of nature to religion, culture, and economy. Ponds can be used for a variety of purposes, depending on factors including accessibility, topography, society, and climate. It is essential to understand how the pond is used and valued by the community to plan development more effectively and ensure long-term sustainability. Data for this report came from fieldwork conducted in the Tarai plain areas, where locals use multiple ponds, as well as from maps. The study found that

the ponds serve a variety of purposes. Fishing is the primary usage of the majority of privately held ponds, and household income is directly correlated with this activity. Community fishing at many public ponds was found economically significant. Furthermore, the indigenous inhabitants of the area have historically associated numerous public ponds with their cultural traditions and religion. In terms of ecology, a few ponds are significant at the research location.

Manikandan and Bhuvanesvari (2022) focus on their study of how farm ponds improve rural livelihood in India. Their paper examines a case study of farm ponds that support agricultural activities and raise people's standards of living, particularly in rural areas. Farm ponds also help to recharge groundwater levels, control soil erosion, and increase crop production for financial gain. Irrigation from farm ponds preserves agriculture. India experiences short spells of intense rainfall these days, but throughout the summer, the country experiences extreme drought. As a result, people depend on water for both their cattle and everyday needs. People's resilience to the climate cost them dearly. Agricultural ponds are among the greatest remedies in this case. A case study undertaken as a part of the Asian Development Bank (ADB) special evaluation study on small-scale freshwater rural aquaculture development. Small-scale fisheries and aquaculture development within the irrigation command regions in the Meghna-Dhonagoda irrigation system (MDIS) in Chandpur District, Bangladesh. The study documented the human, social, natural, physical, and financial capital available to impoverished people involved in the production and consumption of freshwater-farmed fish using primary and secondary data as well as published information. It also identified channels through which the poor can benefit, such as through access to livelihood assets, markets and prices, services and facilities, and important institutions and processes. The study focuses on small-scale freshwater aquaculture, mainly in tiny ponds, for the impoverished through extension services, organizational and management development support, and credit inputs.

Karim E. et al. (2023) assessed the primary productivity and phytoplankton abundance in Dingapota Haor, which is a wetland ecosystem in the northeastern part of Bangladesh. Phytoplankton is one of the primary producers in aquatic environments. It is essential to the diversification of aquatic species and the production of oxygen via photosynthesis. There were 41 phytoplankton genera identified, with the most prevalent being Bacillariaophyceae (37.02%), followed by Chlorophyceae (15), Cyanophyceae (8), and Euglenophyceae (4). Pre-monsoon had the highest cell density ever measured. Pre-monsoon diversity indices were likewise much higher. The five species that contributed the most to the seasonal fluctuation were Euglena (2.88%), Bacillaria (3.13%), Volvox (2.95%), Spirulina (2.92%), and Cyclotella (3.60%). The most fruitful time was before the monsoon. This investigation yielded significant baseline data that will facilitate the development of conservation and management plans for wetlands. The impact on phytoplankton abundance, which in turn affects fish growth. To assess a body of water's potential for fish production and, consequently, to create effective fishery management plans, researchers have focused a great deal of attention on its primary productivity.

Smith. P et al. (2022) evaluated that the quantity of freshwater ponds has been steadily declining due to changing land management methods in the UK's Severn Vale catchment since 1900 was calculated in their study. Changing forms of land use, and freshwater ponds' long-overlooked role as stores of biodiversity. Identifying important places for conservation action begins with determining the regional extent of pond loss. A comparison of the total number, density, and distance between modern and historic ponds was made possible by the identification of the location of the ponds and the surrounding land use on historical and modern maps. Between 1900 and 2019, the number of ponds decreased from 7.3 to 4.5 ponds km−2, accounting for 57.7% of the total ponds that were present. As a result, the average distance between modern ponds increased by 24.6 meters. Their findings show how much of a pond has been lost in Severn Vale since 1900 and offer a useful starting

point for landscape restoration. The techniques outlined have broad applicability to other areas that have historically had ponds or that have an environment suitable for supporting them.
In a study, different financing options for municipal projects with social significance are discussed. The article examines the pros and cons of financing through in-house funds, bank loans, bond issuance, pooling, and revolving schemes, while keeping in mind the opportunities and constraints associated with municipal budgets using the municipality of Burgas as an example. The focus of the study is on the variables that affect the decision of which financing option to choose: funding costs, financial infrastructure level, regulatory framework, debt risk, degree of decentralisation, and revenue-generating potential. The difficulties involved in implementing socially relevant municipal initiatives are explained through the use of specific diagnostic indicators (Dancho 2015).

3. RESEARCH METHODOLOGY

The study focused on residents of the Thrikkakara region, specifically those living near freshwater resources slated for restoration. Participants were chosen from ward numbers 4, 7, 17, 24, 26, 27, 28, 31, and 35. These individuals, living close to public freshwater ponds, were the main participants in the data collection process. The purposive sampling method ensured the study targeted individuals directly connected to the ponds.Surveys were conducted among residents near selected public freshwater ponds within the Thrikkakara municipality. The aim was to gather local community insights and opinions regarding the condition and restoration needs of these ponds. The survey responses were crucial in identifying which ponds required urgent restoration.Based on the survey results, three out of nine ponds were identified for immediate restoration, as the others had been restored within the past two years. The primary data collection tools were prepared paper questionnaires, which were manually analyzed to draw meaningful conclusions.To assess the water quality of the ponds identified for restoration, water samples were meticulously collected. Sterilized 500ml bottles were used for the samples, which were gathered early in the morning, between 6 and 7 am, to ensure consistency and prevent contamination. One sample from each of the three ponds was taken. For dissolved oxygen analysis, the samples were fixed on-site using laboratory-provided reagents, ensuring the integrity of the measurements. Additionally, water temperature and pH levels were measured directly at the sites using a mercury thermometer and a pH meter, respectively.The study aimed to involve the local community in restoration efforts by leveraging their proximity and firsthand knowledge of the ponds. The purposive sampling method ensured that the data collected was relevant to the ponds under consideration. Manual analysis of the questionnaires provided a clear understanding of the ponds' current state and necessary actions.
In conclusion, the study focused on restoring and maintaining the health of public freshwater ponds in Thrikkakara by involving local residents. The use of prepared questionnaires and meticulous water sampling processes ensured reliable and actionable insights. These findings are intended to guide future restoration efforts, ensuring the long-term sustainability of these vital freshwater resources.

3.1 AREA OF STUDY

Nine public school ponds located in nine different wards of Thrikkakkara Municipality were selected for the study. The public pond named Varikoy Chira (latitude and longitude - 10.00810376, 76.32348295) with an area of 0.32 acres situated at Ward no. 31 Snehanilayam, Chembumukku, Pulikillam West Road near V Square IT Hub was the first studied pond. The next site Chinnampilli Chira (latitude and longitude -10.01152237,76.33492492) having an area of 0.03 acres was exactly 1.3 kilometres distant from Varikorichira and was located at Ward no.26 Padamugal, Chinnampilli Chira Road, Kakkanad West. Third pond Poyyachira (latitude and longitude - 10.01419674,76.33975993)

with an area of 2 acres situated in Ward no.24 TV Centre, Justice Anna Chandy Road, Kakkanad. And it is half a kilometre away from Chinnampillichira. The former two ponds were in densely populated residential areas. The latter one was quietly isolated and surrounded by few households and automobile workshops. Pond named Methakulam (latitude and longitude - 10.02532553,76.33087512) of area 0.2 acres at Ward no.28 Kunnepuram East, NPOL Karimakkad Road, Thrikkakkara near Heritage Villa. Another pond named Valiyakulam (latitude and longitude - 10.01883557,76.33251529) comprises 0.12 acres and is situated at Ward no.35 Housing Board Colony, Mythripuram Cross Road, Vazhakkala. Erumakulam (latitude and longitude -10.01953320,76.33872527) of area 0.05 acres at Ward no.27 NGO Quarters, Ambadimoola, near MIR Jade Heights. The remaining three ponds are Kuzhipillimoola pond (latitude and longitude 10.03506897,76.33797425) comprises 0.43 acres at Ward no.4 Thrikkakkara, Vallathol Padi, Vidhya Nagar Colony, Muthirachira (latitude and longitude -10.03348030,76.36855479) of area 0.19 acres at Ward no.7 Valyattu Mugal, Vyavasaya Kendra Road, Thrikkakkara North and Chittethukara Kulam (latitude and longitude - 9.994841056,76.35450672) having 0.24 acres of area at Ward no.17 Chittethukara, Rajagiri Valley Road, Kakkanad. Most of these wards are located in the urbanized region of Thrikkakkara Municipality.

Map showing the 9 selected geographical places for data

Source: Google maps

4. DATA ANALYSIS:

4.1 Survey of the Respondents:

The majority of respondents felt that the pond's presence had no bearing on them. Since the majority of them had only recently moved close to the pond, the ponds were obviously in bad shape when they first learned about them. The ponds were initially in good shape, but their quality was determined throughout time, according to an analysis of the subjective ratings given for their opinions, where 1 represents good and 3 stands for Excellent. Furthermore, because the majority of the ponds showed signs of recent poor quality, the immigrants were already unaware of the pond's good condition.

The Kerala State Agriculture Department, has begun to turn fallow areas into farms as part of the government's "*Subhiksha Keralam*" Project, which aims to fight food scarcity in the state. Approximately 25,000 hectares of fallow land are the goal for the government to turn into farms. Under the Subhiksha Keralam Padhathi program, all departments are coming together to form one. In order to decrease costs and increase revenue, the government is working to develop effective integrated agricultural models. As a part of the "Subhiksha Keralam" Project, Poyyachira actively engages in cage aquaculture, small-scale agriculture, and cattle husbandry, all of which contribute significantly to the best possible maintenance of the pond. The rehabilitation of Methakulam Pond started in February 2024 and is centred on making the most of the pond's active use by hosting swimming lessons and other small-scale aquaculture operations.

4.1.1 Effect of construction activities

Construction activities have no influence on ponds like Varikorichira, Chittethukara, and Erumakulam, but they do have an impact on ponds like Poyyachira, Muthirachira, Kuzhipillimoola, Valiyakulam, and Methakulam. The pond's area has been reduced due to the houses nearby for the pond Varikorichira. A road is close to the Chittethukara Pond. Additionally, it includes the adjacent properties of some houses. As a consequence, the pond's water quality declined and the surrounding walls collapsed, bringing trees down into the water body. In contrast, Erumakulam is located in the middle of a residential complex. It was once a sizable pond, but as of November 2023, it had undergone reconstruction. But this reconstruction hasn't helped much, though, as the pond's natural ecology has been disrupted and none of its plant or animal species remain. It remains there solely as a recreational area.

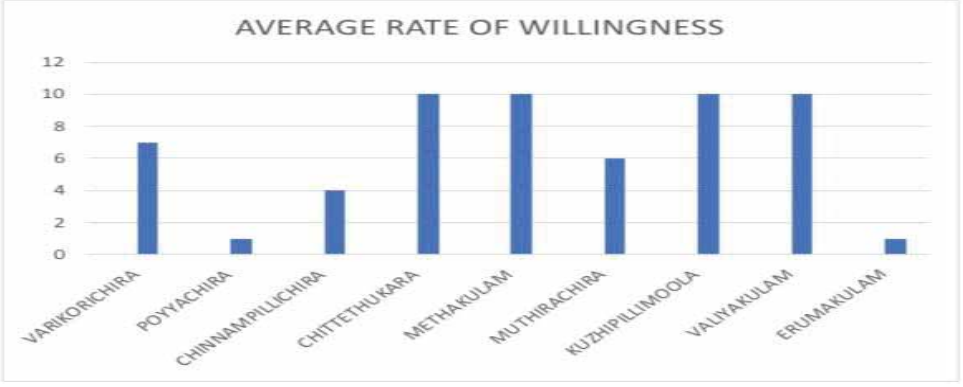
4.1.2 Pollution:

The survey concluded that passengers, sewage, local communities and other natural pollutants are the main sources of pollution in the ponds. The main contaminants observed from the ponds are listed as sewage (30%), glass bottles (10%), and plastics (60%).

4.1.3 Willingness for restoration:

This refers to the readiness, interest, or commitment of individuals and communities living near the ponds to engage in efforts aimed at rehabilitating and revitalizing ponds. On a scale of 1 representing not at all willing and 10 representing fully willing, the average rate of willingness for restoration was plotted. The results suggest that people are interested in restoring the pond. Overall, the concept encompasses the broad spectrum of support and active involvement required to successfully restore ponds to a healthier state, ensuring their ecological, social, and economic benefits are sustained and considerable.

Graph 1: Average rate of willingness for restoration



Source: Data analysis

4.2 Water Quality Analysis:

Table 1: Showing analysed water quality parameters (obtained values)

SL NO	PARAMETERS	AREA-1 KUZHIPILLIMOOLA	AREA-2 CHITTETHUKARA	AREA-3 VARIKORICHIRA	IDEAL LEVEL
1	TEMPERATURE	23°C	22°C	22°C	20°C -30°C
2	PH	6.73	6.76	6.56	6.5-8.5
3	SALINITY	6ppt	8ppt	8ppt	1.3ppt-2.5ppt
4	PHOSPHATE	0.002 mg/L	0.020 mg/L	0.085 mg/L	0 mg/L -0.5 mg/L
5	BICARBONATES	100 mg/L	100 mg/L	150 mg/L	50 mg/L -200 mg/L
6	NITRITE	0.004 mg/L	0.001 mg/L	0.001 mg/L	0 mg/L -0.5 mg/L
7	NITRATE	0.095 mg/L	0.018 mg/L	0.002 mg/L	0 mg/L -10 mg/L
8	AMMONIA	0.055 mg/L	0.118 mg/L	0.151 mg/L	0 mg/L -0.02 mg/L
9	TDS	0.2134 mg/L	0.1814 mg/L	0.1859 mg/L	0 mg/L -500 mg/L
10	TSS	0.023 mg/L	0.0053 mg/L	0.0251 mg/L	0 mg/L -50 mg/L
11	TOTAL HARDNESS	150 mg/L	200 mg/L	150 mg/L	50 mg/L -150 mg/L
12	CALCIUM HARDNESS	40 mg/L	60 mg/L	160 mg/L	20 mg/L -100 mg/L
13	DISSOLVED OXYGEN	2mg/L	4mg/L	2 mg/L	6 mg/L -8 mg/L
14	BIOLOGICAL OXYGEN DEMAND	2mg/L	6mg/L	10mg/L	3 mg/L -5 mg/L
15	TOTAL COLIFORMS	1100 MPN/100 ml	1100+ MPN/100 ml	43MPN/100 ml	0 MPN/100ml

Source: Data Analysis

The pH values of all ponds (6.73, 6.76, 6.53) fell within the ideal range (6.5-8.5), making them suitable for species survival. The recorded temperatures (22°C, 22°C, 23°C) also fell within the ideal range (20-30°C), indicating favourable conditions for aquatic life. However, the salinity values (6 ppm, 8 ppm, 6 ppm) exceeded the ideal range (1.3-2.5 ppm), suggesting stress on organisms not adapted to higher salinity, potentially due to factors like freshwater input deficiency, human activities, and evaporation. Phosphate levels were 0.002 ppm in Kuzhipillimoola, 0.02 ppm in Chittethukara, and 0.085 ppm in Varikorichira. The value for Varikorichira exceeded the ideal range (0-0.02 ppm), indicating eutrophication and algal blooms, which deplete oxygen and disrupt the ecosystem. All ponds had bicarbonate levels (100 ppm, 100 ppm, 150 ppm) within the ideal range (50-200 ppm), supporting aquatic plant growth.

Nitrite concentrations (0.095 ppm, 0.018 ppm, 0.002 ppm) were within the ideal range (0-10 ppm), indicating good water quality, and nitrate levels (0.095 ppm, 0.018 ppm, 0.002 ppm) also fell within the ideal range (0-10 ppm), supporting plant growth without causing eutrophication. Ammonia concentrations (0.055 ppm, 0.118 ppm, 0.15 ppm) exceeded the ideal range (0-0.02 ppm) in Chittethukara and Varikorichira, posing a risk to aquatic life due to potential gill damage and stress. The TDS values (0.213 ppm, 0.118 ppm, 0.15 ppm) were within the ideal range (0-500 ppm), indicating appropriate mineral and organic matter levels, and TSS values (0.0023 ppm, 0.0053 ppm, 0.0251 ppm) were within the ideal range (0-50 ppm), ensuring water clarity and light penetration.

The total hardness values (150 ppm, 200 ppm, 150 ppm) were within the ideal range (50-150 ppm) except for Chittethukara, which was slightly higher, affecting osmotic balance.
Calcium hardness values (40 ppm, 60 ppm, 60 ppm) were within the ideal range (20-100 ppm), supporting aquatic health and osmotic balance. Dissolved oxygen (DO) levels (2 ppm, 4 ppm, 2 ppm) were below the ideal range (6-8 ppm), indicating poor oxygen levels that could lead to reduced biodiversity and aquatic life stress. BOD values (2 ppm, 6 ppm, 10 ppm) indicated that Kuzhipillimoola had minimal organic pollution, whereas Chittethukara and Varikorichira had high organic pollution, leading to hypoxic conditions. Finally, all ponds had coliform bacteria counts (1100 MPN, >1100 MPN, 43 MPN), indicating faecal contamination and potential health risks from sewage or runoff.

5. RESULT AND OBSERVATIONS

5.1 SOCIAL IMPACTS OF THE POND

Thrikkakara municipality, with a population of approximately 71,319 and a density of about 1820 people per square kilometer, is densely populated. Ponds play a crucial role in such communities by replenishing surrounding water bodies and maintaining the groundwater table. The ponds in Thrikkakara municipality are vital for preserving water sources and addressing the community's water shortage issues.However, the impact of these ponds varies across different locations. The desire for pond restoration is particularly strong among residents who have lived in the area for over 30 years and are older than 50. These long-term residents view the ponds as essential for future generations. In contrast, children have recently begun using the ponds primarily for fishing.Despite these differences, many residents are enthusiastic about contributing to the maintenance of public ponds. They recognize the benefits of utilizing these water bodies for small-scale farming, aquaculture, and recreational activities. Overall, there is significant community support for preserving and enhancing the ponds to ensure they continue to serve the needs of the population..

5.2 ECOLOGICAL IMPACTS

5.2.1 Species diversity

The pond and the area show medium diversity when coming to the species diversity. However, the majority of the ponds are covered with heavy, dense vegetation cover, mainly algae. The surroundings of the pond include vegetation covers all over with both invasive and indigenous species.
Table 2 Showing the Flora of the selected regions:

SL.No	COMMON NAME	SCIENTIFIC NAME
1	Water velvet	Azolla pinnata
2	Common duckweed	Lemna minor
3	Water lettuce	Pistia stratiotes
4	Water thyme	Hydrilla verticillata
5	Butterfly fern	Salvinia auriculata
6	Cupid's shaving brush	Emilia sonchifolia
7	Alligator Weed	Alternanthera philoxeroides
8	Barnyard grass	Echinochloa crus-galli
9	Great manna grass	Glyceria maxima
10	Touch-me-not	Mimosa pudica

SL.No	COMMON NAME	SCIENTIFIC NAME
11	Coconut tree	Cocos nucifera
12	Chandada	Macaranga peltata
13	Cherry tree	Muntingia calabura
14	Mango	Mangifera indica
15	French plantain	Musa paradisiaca
16	Tomato plant	Solanum lycopersicum
17	Green chilli	Capsicum annuum
18	Eggplant	Solanum melongena
19	Elephant ear plant	Colocasia esculenta
20	Bitter gourd	Momordica charantia
21	Betel palm	Areca catechu
22	Cassava	Manihot esculenta
23	Sedge	Cyperus rotundus
24	Parthenium	Parthenium hysterophorus
25	Lantana	Lantana camara
26	Devil weed	Chromolaena odorata
27	Sessile joy weed	Alternanthera sessilis
28	Bengal dayflower	Commelina benghalensis
29	Yellow nutsedge	Cyperus esculentus
30	Water primrose	Ludwigia spp.
31	Billy goat weed	Ageratum conyzoides
32	Par grass	Urochola mutica

Source: Survey

Table 3 Showing the Fauna of the selected regions:

SPECIES	SL.NO	COMMON NAME	SCIENTIFIC NAMES
FISHES	1	Barramundi	Lates calcarifer
	2	Climbing perch	Anabas testudineus
	3	Indian mottles eel	Anguilla bengalensis
	4	Panchax	Aplocheilus lineatus
	5	Stripped snakehead	Channa striata
	6	Stinging catfish	Heteropneustes fossilis
	7	Tilapia	Oreochromis spp
	8	Pearl spot	Etroplus suratensis
	9	Valencienne'c clarid	Clarias batrachus
BIRDS	1	Little Egret	Egretta garzetta
	2	Indian Pond Heron	Ardeola grayii
	3	White-breasted Waterhen	Amaurornis phoenicurus
	4	Indian Cormorant	Phalacrocorax fuscicollis

SPECIES	SL.NO	COMMON NAME	SCIENTIFIC NAMES
INSECTS	1	Dragonflies	Sympetrum vulgatum
	2	Common Skimmer	Orthetrum sabina
	3	Crimson Marsh Glider	Trithemis aurora
	4	Pied Paddy Skimmer	Neurothemis tullia
	5	Water Striders	Aquarius remigis
	6	Water Boatmen	Sigara striata
REPTILES	1	Checkered Keelback	Xenochrophis piscator
	2	Banded Racer	Argyrogena fasciolata
	3	Common Water Snake	Enhydris enhydris
	4	Indian Black Turtle	Melanochelys trijuga
AMPHIBIAN	1	Indian Bullfrog	Hoplobatrachus tigerinus
	2	Marsh Frog	Pelophylax ridibundus
DOMESTIC ANIMALS	1	Cattle	Bos taurus
	2	Buffalo	Bubalus bubalis

Source: Survey

5.2.2 Water quality

Water quality analysis was conducted for the ponds at Kuzhipillimoola, Chittethukara, and Varikorichira, identified as needing immediate restoration based on respondent feedback and their poor condition compared to other ponds. The analysis assessed the current water composition and its potential for rejuvenation. It revealed that poor maintenance and neglect had severely degraded these freshwater sources. The tests indicated a high oxygen demand in these ponds, signifying poor aquatic life conditions. Additionally, the biological oxygen demand was elevated, confirming the same poor status. The Varikorichira pond exhibited significant eutrophication, exacerbated by ongoing legal disputes over its name, contributing to its deterioration.Despite these issues, the community's strong willingness to restore these ponds offers a positive outlook for their rejuvenation. Effective maintenance could significantly improve water quality and enhance survival rates for aquatic life, ensuring these freshwater resources serve as valuable assets for future generations.

6. DISCUSSION

The market demand for ornamental flowers, such as water lilies and lotuses, presents a lucrative opportunity for small-scale farming. Cultivating these flowers can generate a significant source of income for local farmers.Local self-governments also have a crucial role to play. They can identify and clean abandoned ponds, then lease these ponds to small-scale farmers for pisciculture and aquaculture. This arrangement benefits both the self-government and the farmers, as it revitalizes neglected water bodies and provides farmers with new business opportunities. This approach promotes sustainable use of water resources and supports the local economy.A creative and collaborative approach to increasing pond usage is essential. By involving local communities, utilizing smart technologies, and supporting small-scale farming and aquaculture, we can ensure the better survival of organisms in and around the pond, enhance biodiversity, and contribute to sustainable water management practices. The leadership should adopt and promote these strategies to maximize the ecological and economic benefits of pond rejuvenation.

7. CONCLUSION

The study concludes the current condition of the public ponds of the selected geography which is the heart core part of Ernakulam district of Kerala in India that accounts for 43 wards with a population density of 1820 per sqkm and an overall population of around 71,319. The sampling was done from 3 among the 9 public ponds of ward numbers 4,7,17,24,26,27,28,31 and 35. Three ponds were selected based on the survey that insisted immediate need for restoration from the respondents. This study helped in understanding and evaluating the dependency of the people on freshwater resources. The survey benefitted in interacting with the local people, understanding their perception, and letting them express their perspective about further development in the pond for the future which came back with a highly positive response. The qualitative analysis helped in the improvement of the experimental side where the parameter's variation showed the reasonable condition of the pond currently. The experimentation helped in a better understanding of the water quality status and the parameters that needed improvement in raising the value of restoration. Through the survey, the social status of the people, their social behaviour, and their responding attitude were also imbibed. The study helped us know more about the process of restoration and the current restoration work going on in the Valiyakulam at Kunnumpuram under the local self-government. Similar activities like 'Subhiksha Keralam' were also undertaken by the local self-government for the pond of Poyyachira and recent restoration works were done for the ponds Erumakulam and Muthirachira ponds under their plan to conserve the resource.

With proper management strategies and skilled farmers, the ponds could be used for aquaculture recreation. Other small-scale farming is water lily for ornamental flower production, and Azolla as animal feed. With a good developmental plan and project idea, one can utilize the pond to its fullest and thus hope for a better tomorrow.

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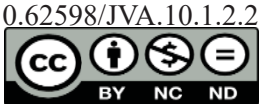

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THE SOCIO-ECONOMIC AND ECOLOGICAL IMPACTS OF WATER HYACINTH PROLIFERATION IN WATER BODIES: A CASE FROM GREATER KOCHI AREA IN SOUTH INDIA

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ABSTRACT

Purpose*: The purpose of this study is to critically analyse the socio-ecological impact of water hyacinths on the water bodies passing through 7 wards of the Thrippunithura Municipality in the Ernakulam district of the state of Kerala, India, by checking the quality of water and conducting surveys among the people.*

Research Design*: The study employs a combination of exploratory and descriptive research approaches. Purposive sampling targets individuals directly impacted by water hyacinth proliferation.*

Methodology*: Data collection involved direct surveys using a structured questionnaire, with analysis conducted using Excel and SPSS software. Water samples from selected regions of Thrippunithura Municipality in the Ernakulam district of the state of Kerala, India, were tested for various water quality parameters.*

Results*: The results reveal significant socio-economic ramifications of water hyacinth proliferation, particularly impacting fishing communities. Challenges include job losses, diminished access to fishing grounds, navigational hindrances, reduced catches, and fish scarcity. Ecologically, water quality parameters show notable disparities between heavily-infested and less-infested areas, highlighting the weed's impact on aquatic ecosystems. The phytoremediation potential of water hyacinth was also explored, revealing its ability to accumulate heavy metals such as chromium, cadmium, copper, zinc, lead, iron, and arsenic.*

Originality of Research*: This study records the socio-ecological impact of water hyacinth on the communities and environment, particularly the water bodies, of Greater Cochin. The interest in participating in applications for alternative uses of the otherwise disruptive water hyacinth has also been noted. This research provides valuable insights into managing water hyacinth's negative effects while exploring its potential benefits.*

Keywords: *Water hyacinth, social and ecological effects, alternative uses, heavy metal*

1. INTRODUCTION

The aquatic plant weed known as water hyacinth (*Eichhornia crassipes*) belongs to the family Pontederiaceae, which has been included in the order Commelinales. Eichhornia has eight species that originated in the Amazon basin of South America (DiTomasa et al., 2018). Water hyacinth is often referred to as the "noxious beauty" due to its beautiful purple flower. It is a perennial, free-floating plant in water but rooted in moist mud along the banks of rivers, lakes and impoundments where it can live and produce. It can be considered as the most toxic aquatic weed that is growing in temperate, tropical, and subtropical regions.

The International Union for Conservation of Nature (IUCN) identified water hyacinth as one of the most destructive species in the world due to its capacity for growth and significant socio-economic effect. Water hyacinth has grown to be a serious hazard to rivers around the world. It is considered as the world's worst aquatic weed. Ever since the introduction of water hyacinth outside the Amazon Basin, it has created innumerable problems for communities. The dense mats of water hyacinth interfere with navigation, recreation, irrigation, and power generation (Epstein, 1998). Water hyacinth is characterized by its reproductive capabilities, rapid dispersal and growth which leads to several environmental and socio-economic problems. The weed causes disastrous impact on the economy, health and well-being of communities which depend on water for their livelihood.

The objective of this study is to assess, how the proliferation of water hyacinth affects the livelihood of people residing near water hyacinth-infested water bodies, to examine the impact of water hyacinth on water quality, detect the heavy metal content in water hyacinth for elucidating its bioremediation properties, establish local awareness of the issue as well as to understand the socio-ecological impacts of water hyacinth in the selected wards of Thrippunithura Municipality, Ernakulam district, Kerala.

2. REVIEW OF LITERATURE

Water hyacinth (*Eichhornia crassipes*) is widely recognized for its invasive nature, significantly impacting freshwater ecosystems. Dersseh et al. (2022) highlighted the profound influence of this plant on Lake Tana in Ethiopia, noting a substantial increase in total phosphorus concentrations due to agricultural runoff. This nutrient influx facilitated the rapid proliferation of water hyacinth, exacerbating eutrophication and disrupting local aquatic ecosystems. Considering its environmental and health implications, the pervasive spread of water hyacinth not only affects biodiversity but also poses serious health risks. Endgaw (2021) emphasized that the dense mats of water hyacinth in Lake Tana create breeding grounds for disease vectors such as mosquitoes and snails, leading to increased incidences of malaria and schistosomiasis. The physical obstruction caused by these mats also impedes fishing and transportation, further stressing the socioeconomic stability of local communities.

Maulidyna et al. (2020) explored the economic potential of water hyacinth by documenting its use in crafting various handicrafts in Rawapening Lake, Indonesia. This utilization not only generates economic value but also provides a means of managing the invasive species. Similarly, Ekong et al. (2023) investigated the production of biogas from water hyacinth, highlighting its dual benefits in energy production and invasive species management. Additionally, water hyacinth can be utilized in bioplastic production, handicrafts, and biogas generation, offering alternative economic opportunities (Maulidyna et al., 2020; Pratama et al., 2020).

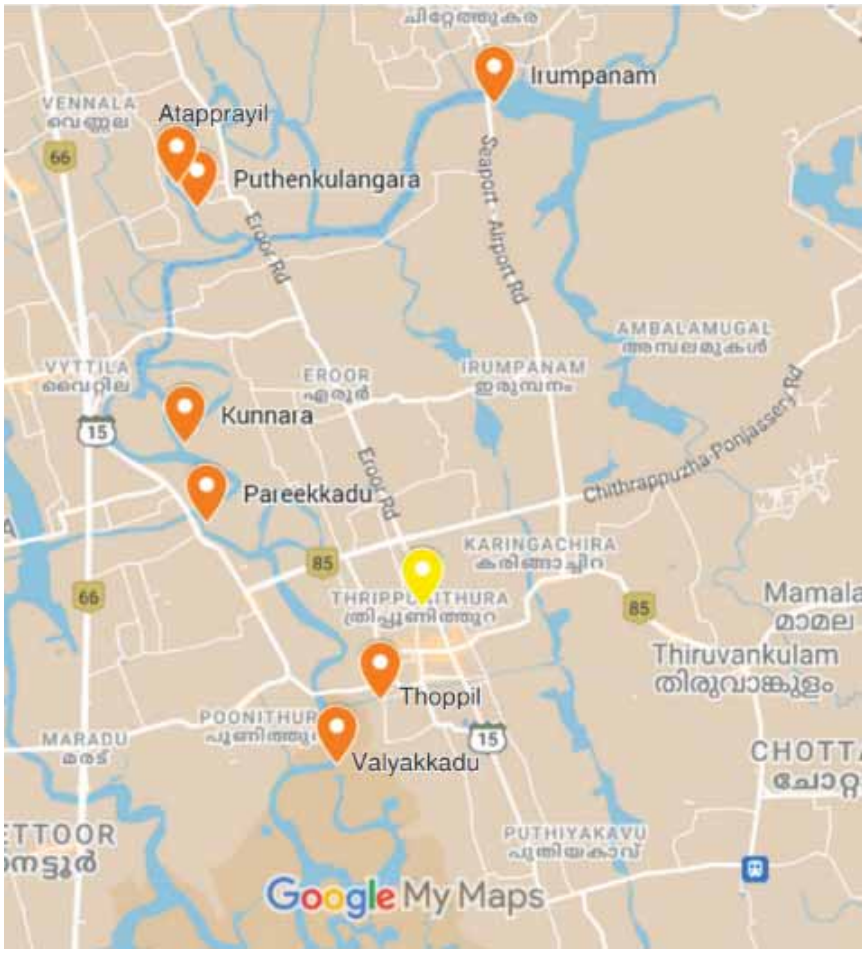
Effective management of water hyacinth involves a combination of mechanical, chemical, and biological approaches. Gupta and Yadav (2020) argued that manual removal is effective for small areas, despite its labor-intensive nature. They also highlighted the environmental risks associated

with chemical herbicides. Biological control, involving the use of weevils and other insects, has shown promise in reducing water hyacinth populations without adverse environmental impacts.
One of the promising applications of water hyacinth is its ability to absorb heavy metals from contaminated water. PN and Madhu demonstrated the plant's efficacy in removing chromium and copper from wastewater, underscoring its potential in phytoremediation. The ability of water hyacinth to accumulate significant amounts of heavy metals in its tissues makes it an effective, low-cost solution for mitigating water pollution.
Water hyacinth represents a complex ecological challenge with significant socioeconomic implications. Addressing its proliferation requires interdisciplinary approaches that balance environmental conservation with sustainable resource management and economic development.

3. RESEARCH METHODOLOGY

The methodology employed in this study comprised a combination of exploratory and descriptive research approaches. Purposive sampling was utilized to target individuals directly impacted by water hyacinth proliferation, particularly in communities residing near Vembanad Lake in Thrippunithura Municipality, Kerala, India. Vembanad Lake occupies the top position on rankings for longest lakes in India as well as one the largest in the state of Kerala spanning over a maximum length of 96.5 km and an area of 230 square kilometers. It is a part of the Vembanad-Kol wetland system which extends from Alappuzha in the south to Azhikode in the north and is approximately 14 kilometers wide at its widest point with a depth of 12m (39 feet). The lake is situated at sea level and is bordered majorly by the Kerala districts of Alappuzha, Kottayam and Ernakulam. The lake is linked to other coastal lakes in the north and south regions by various canals and is fed by 10 rivers flowing into it including the six major rivers of central Kerala. The total area drained by the lake is 15,770 km², which accounts for 40% of the area of Kerala. Its annual surface runoff of 21,900 Mm accounts for almost 30% of the total surface water resource of the state. The 1,252-meter (4,108-foot) long Thanneermukkom saltwater barrier, which was built as part of the Kuttanad Development Scheme to stop tidal action and saltwater intrusion into the Kuttanad lowlands, is one of the lake's distinctive features. The annual recurrence of Eichhornia crassipes infestation in the Cochin backwater, Kerala, India, can be attributed to the opening of Thanneermukkom saltwater barriers during the monsoon season. Because of tidal action, the plants are exposed to different salinities during the process.
The population of the study was confined to people living on the banks of the river in the greater Kochi area. Greater Cochin is the area defined by Greater Cochin Development Authority for town planning. This area consists of the Kochi UA region and its suburbs. The sampling was done from this population in the selected regions. The study employed purposive sampling to select seven wards within the geographical area identified for the study. Water samples were collected from water bodies in these selected wards. Additionally, a survey was conducted among individuals most likely to provide valuable information relevant to the study's objectives. This was done with a sample size comprising of a total of 50 individuals.
Data collection involved a direct survey using a structured questionnaire, with subsequent analysis conducted using Excel and SPSS software. Additionally, water samples were collected from both highly infested and low-infested regions from the area sampled. These samples were analyzed for various parameters, including heavy metals, to assess the extent of water contamination and its implications for the affected communities.

Map showing the 7 selected wards of Thrippunithura Municipality, Kerala, India



Source : Google - My Maps

4. DATA ANALYSIS

The objective of the survey was to assess the impact of water hyacinths on livelihoods and water quality in selected locations. Data was collected from residents using Google Forms and through direct interviews with water metro drivers. SPSS software was used for data analysis. Water and water hyacinth samples were tested in external laboratories for 15 water quality parameters and the presence of heavy metals. The interpretation of this data is provided below :

4.1 Education :

71.7% lack matriculation, limiting adaptability during events like water hyacinth proliferation. Limited higher education reflects historical constraints and ongoing financial challenges.

4.2 Occupation :

56.5% engage in fishing and transportation, facing disruptions from water hyacinth. Younger generations seek alternatives due to unpredictable fishing incomes.

4.3 Major Source Of Income :

46.6% rely on fishing, with limited job options near water bodies. Water hyacinth exacerbates economic strain, disrupting fishing activities and livelihoods.

4.4 Alternative Uses :

Water Hyacinth, typically seen as a nuisance, holds potential for alternative uses. Survey data reveals significant interest (45.7%) among respondents in exploring these options, with some (19.6%) already experimenting, primarily as fertilizer. However, a notable portion (26.1%) remains unaware of such possibilities, suggesting a need for increased awareness efforts. Despite some expressing disinterest (8.7%), there is the promise for utilizing Water Hyacinth in biofuel production, wastewater treatment, and handicrafts, offering economic benefits and aiding environmental conservation.

4.5 Weed management:

The significant spread of water hyacinth in water bodies necessitates weed management. This inquiry aids in determining whether weed management is practiced in the areas under study. 58.7 % people among the respondents said that there was prior weed management in these wards. Irrigation departments, Corporation and Municipality are generally responsible for removal of water hyacinth. However, the execution of this process lacks regularity, as these entities only address the issue upon receiving requests from local residents. Water hyacinth is being removed using JCB and the labor force. It is customary for fishermen to remove water hyacinth themselves when the water bodies fill up with it, otherwise they will not do fishing there.

4.6 Percentage of spread during monsoon :

All the 46 people surveyed said that the presence of water hyacinth is more than 75% during Monsoon season. Increased water level in rivers, lakes and other water bodies due to heavy rainfall facilitates rapid growth of water hyacinth. Water hyacinths thrive in environments that are particularly nutrient-rich, which is created when heavy rainfall dissolves nutrients into the water. Therefore when rain water comes, people find the situation where the water hyacinth spreads vastly.

4.7 Percentage of spread during post-monsoon:

The river influx declines during the Post-Southwest Monsoon and the saline water intrusions from the adjacent Arabian Sea through the Kochi inlet increase salinity downstream of the VLS (Arumpandi et al., 2022). Studies have shown that water hyacinth appears to weaken and reduce their growth at a salinity of oligosaline range (0.5 - 5 ppt). As our study was during the post monsoon period, the proliferation of water hyacinth could not be observed in abundance except in Thoppil. The weed starts to decay as per the salt intrusion into different water bodies.

4.8 Impact of water hyacinth on transportation and fishing activities:

The impact was measured on a 10-point scale, where 1 stands for less impact and 10 stands for extreme impact. Analyzing the impact of water hyacinth on fishing activities in the regions under study during the monsoon season rated a mean of 8.72 ± 1.440, signifying that fishing will be impossible due to the growth of this weed. During the post-monsoon period, the mean value was 4.61 ± 2.362, indicating the possibility of fishing activities as the spread of water hyacinth is reduced.

Analyzing the impact of water hyacinth proliferation on transportation during the monsoon season reveals that dense mats of water hyacinth make transportation very difficult in all wards under study. The impact rating on transportation had a mean of 8.35 ± 1.609, signifying a high impact. With the onset of the post-monsoon period, transportation becomes more manageable as water hyacinth levels decrease in the water, and the mean value was 4.83 ± 2.369.

4.9 Major Challenges Faced by people :

Table 1: Weighted score ranking method

SL. NO.	FACTORS	FREQUENCY					WEIGHTED SCORE					WEIGHTED TOTAL	RANK
		1	2	3	4	5							
1	Stagnation	0	0	0	0	1	0	0	0	0	1	1	10
2	Dereliction of Water Quality	0	1	0	2	6	0	4	0	4	6	14	8
3	Health Hazard	5	0	0	0	3	25	0	0	0	3	28	6
4	Low Tide Inundation	0	0	0	1	1	0	0	0	2	1	3	9
5	Low Water Flow	0	0	0	0	1	0	0	0	0	1	1	10
6	Increased sedimentation	3	3	5	8	18	15	12	15	16	18	76	5
7	Navigational difficulty	2	9	15	9	1	10	36	45	18	1	110	3
8	Loss of jobs related to farming	4	10	13	5	4	20	40	39	10	4	113	1
9	Less fish availability	0	3	0	2	1	0	12	0	4	1	17	7
10	Reduced catch	3	9	8	11	2	15	36	24	22	2	99	4
11	Loss of access to fishing areas	24	7	1	3	4	70	28	3	6	4	111	2
	TOTAL						155	168	126	82	42	573	

Source: Survey data

Weighted ranking method was used to identify the major challenges faced by people living on the banks of the river. Loss of farming and fishing jobs ranked highest, signaling significant socioeconomic impacts. This is followed by loss of access to fishing areas, indicating constraints on fishing activities and potential income reduction. Navigational difficulty emerged as the third-ranked challenge, hindering waterway transportation. Reduced catches ranked fourth, reflecting declining fish availability and economic pressures on fishing communities. Increased sedimentation ranked fifth, highlighting environmental consequences such as water quality degradation. These findings emphasize the complex impacts of water hyacinth, necessitating comprehensive management strategies to address them effectively.

4.10 Water quality analysis: A total of 12 parameters were analyzed to understand the quality of water in weed infested and non infested areas. Physical parameters like Temperature, Total Dissolved Solids and Total Suspended Solids and chemical parameters like Salinity, pH, Alkalinity, Total Hardness, Ammonia, Nitrite, BOD, Dissolved oxygen, Nitrate and Phosphate were tested. The water samples were collected during Post-Monsoon period from seven locations such as Valyakkad, Thoppil, Pareekad, Kunnara, Attapprayil, Irumpanam, Puthenkulangara where water hyacinth was found and one sample from a water hyacinth free area. All the parameters were analyzed using SPSS software. Water hyacinth was highly infested in Thoppil compared to other locations. Due to the salt intrusion in all locations except Thoppil the infestation seemed to be less. So the data were analyzed using a One-sample t-test where the test value of Thoppil was taken. The following tables shows the result:

Table 2: One-Sample Statistics for water quality parameters

Parameters	N	Mean	Std. Deviation	Std. Error Mean	Test Value
Temperature	7	28.1429	1.34519	0.50843	26
pH	7	7.1571	0.09759	0.03689	7.3
Salinity	7	7.5714	4.19750	1.58651	3
Alkalinity	7	83.5714	19.30334	7.29598	160
Total hardness	7	1471.4286	787.32519	297.58095	650
Ammonia	7	0.01343	0.035529	0.013429	0
Nitrite	7	0.07229	0.073920	0.027939	0.472
BOD	7	2.9543	1.03985	0.39303	1.5
Dissolved Oxygen	7	5.5257	2.53200	0.95701	0.35
Phosphate	7	0.12000	0.070666	0.026709	0.089
TDS	7	10.2071	7.05515	2.66660	5.51
TSS	7	0.39829	0.264125	0.099830	0.515

Source: Survey Data

Table 3: One-Sample Test for water quality parameters

	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Temperature	4.215	6	0.006	2.14286	0.8988	3.3869
pH	-3.873	6	0.008	-0.14286	-0.2331	-.0526
Salinity	2.881	6	0.028	4.57143	0.6894	8.4535
Alkalinity	-10.475	6	0.000	-76.42857	-94.2812	-58.5760
Total hardness	2.760	6	0.033	821.42857	93.2742	1549.5829
Ammonia	1.000	6	0.356	0.013429	-0.01943	0.04629
Nitrite	-14.307	6	0.000	-0.399714	-0.46808	-0.33135
BOD	3.700	6	0.010	1.45429	0.4926	2.4160
Dissolved Oxygen	5.408	6	0.002	5.17571	2.8340	7.5174
Phosphate	1.161	6	0.290	0.031000	-0.03436	0.09636
TDS	1.761	6	0.129	4.69714	-1.8278	11.2221
TSS	-1.169	6	0.287	-0.116714	-0.36099	0.12756

Source: Data analysis of water samples

The water quality parameters like pH, Salinity, Alkalinity, Total Hardness, Nitrite, BOD, DO, and TDS significantly varied in between the highly infested area and less infested area. The water temperature was recorded from 26 °C to 31 °C. Salinity comes between 2 to 13 ppt, which indicates the entry of salt water into the water bodies. The levels of ammonia, nitrate and sulphate in the water of study areas were found to be below the detectable limit, and the nitrite and phosphate concentration were also minimal. Total hardness recorded in the Thoppil was 650 mg/l which is less than that of the mean total hardness of the less infested areas (1471.42 mg/l). Total hardness is the parameter of water quality used to describe the effect of dissolved minerals like calcium, magnesium etc.

In this study, the highly weed-infested area recorded a DO (Dissolved Oxygen) concentration of 0.35 mg/l, which falls below the desired limit of 4-6 mg/l and the mean tested DO value in the non-

infested area was 5.5 mg/l, which is within the desired limit. The least BOD (1.5 mg/l) was reported in the highly infested area, Thoppil and the mean BOD of all other locations was slightly higher (2.95mg/l). Biological Oxygen Demand (BOD) is a measure of the biological activities of a water body. It is an indication of the organic load and it is a pollution index especially for water bodies receiving organic effluent. In our study the BOD level was only slightly higher in the low infested area than that of weed highly infested area.Within the comparison areas, the values of TSS and TDS show no significant difference and the concentration of both TDS and TSS were less in all locations.

4.11 Analysis Of Heavy Metals In Water Hyacinth :

The water hyacinth collected from Chithrapuzha river near Irumpanam region was tested for heavy metals: Iron, Copper, Arsenic, Chromium, Zinc, Cadmium, Lead, and Mercury. Different parts of the plant were dried, digested using Concentrated Nitric acid, and analyzed with Inductively Coupled Plasma Mass Spectrometry (ICP-MS) System. Except for Mercury, all heavy metals were detected. Iron was represented in percentage, while others were in ppm. The results indicated bioaccumulation and phytoremediation ability, with heavy metal presence: Iron (0.4 %), Copper (60.89 ppm), Arsenic (0.88 ppm), Zinc (74.41 ppm), Cadmium (1.45 ppm), Lead (10.01 ppm), with no Mercury detected.

Table 4: Heavy metals in water hyacinth

SL. No.	SAMPLE NAME	56Fe	63Cu	75As	53Cr	66Zn	114Cd	208Pb	200Hg
1	C3	0.4	60.89	0.88	6.25	74.41	1.45	10.01	NA
UNIT		%	ppm	ppm	ppm	ppm	ppm	ppm	
Detection Limit in ppm		0.10	0.01	0.01	0.01	0.01	0.01	0.01	

Source: Heavy Metal Analysis

5. RESULT AND OBSERVATIONS

5.1 Social Impacts Of Water Hyacinth :

People are directly impacted by the negative consequences of water hyacinth proliferation, particularly during the post-monsoon season, where dense growth obstructs activities like fishing and transportation, reducing water quality and hindering navigation. This adversely affects livelihoods reliant on water-based activities, leading to economic strain and limiting access to fishing grounds. The majority of respondents, primarily fishermen, report adverse effects on their livelihoods due to water hyacinth proliferation, with fishing, transportation, and other water-related activities severely affected, leading to a decline in income by over 50%. Traditional practices like clam harvesting have become unfeasible, with rising living costs exacerbating financial strain. The proliferation of water hyacinths has resulted in significant job losses in farming and fishing. Traditional crafts without advanced technologies are particularly affected due to increased expenses from net breakage, fuel utilization, and boat maintenance. The infestation also clogs boat motors, necessitating frequent repairs and maintenance, which further increases operational costs. Consequently, fishermen lose valuable working days, as time spent fixing nets and motors directly translates to lost income. These problems collectively result in increased financial burdens and reduced productivity for the fishing community. Water hyacinth mats block high fish population regions, especially during the monsoon season, leading to reduced fishing activities and income for fishermen. Local fishermen have also reported decreased fish populations in infested areas, exacerbating employment challenges.

The dense mats prevent easy movement, further restricting access. Waterway transportation is severely impeded, posing hazards for boat operators. Fishermen often have to manually remove water hyacinth mats, resulting in increased physical exertion, loss of time, and reduced catches. Reduced catches are a major issue as well which directly impacts the economic status of local fishing communities. Water hyacinth mats reduce dissolved oxygen and sunlight which are essential for aquatic life. This results in decreased fish populations and hinders fishing activities, especially during and after the monsoon season. Historically abundant species like Pearl Spot, Red Snapper, and Big-sized prawn are notably absent, while Tilapia remains prevalent due to government initiatives. Fishermen report a drastic reduction in income, with earnings plummeting by 50 - 70%, and increased costs for boat maintenance and repairs further strain finances, with daily earnings dropping from ₹1000 (€11.09) to ₹300-₹600 (€3.33-€6.66). Eutrophication and sedimentation, compounded by the 2018 Kerala flood, have reduced water depth, limiting fishing activities and hindering navigation, necessitating dredging and waterway maintenance. Water hyacinth proliferation also promotes mosquito breeding, increasing the risk of diseases like dengue and malaria, with residents reporting itchiness, rashes, allergies, and encounters with dangerous pests like snakes and monitor lizards. Water quality deterioration renders water bodies unsuitable for consumption and domestic use, impacting residents who have relied on them for generations, while hindering Kochi Water Metro operations through blockages, leading to increased maintenance costs and operational challenges. Addressing water hyacinth proliferation requires comprehensive measures to mitigate its impact on livelihoods, health, and transportation infrastructure, ensuring sustainable development in affected regions.

5.2 Ecological impacts of water hyacinth:

The water quality parameters like pH, Salinity, Alkalinity, Calcium, Magnesium, Total Hardness, Nitrite, BOD, DO, and TDS have differences in between the highly infested area and less infested area. Salinity shows a difference due to the salt water intrusion into the water. At the end of North-West Monsoon (October-December) the salt water intrusion begins. Since our study was in the Post-Monsoon period, the water hyacinth started to dry and only patches of mats of water hyacinth can be seen in water bodies. But there is an exceptional case in ward number 35, Thoppil where dense mats of water hyacinth were observed. The water hyacinth starts to dry when salt water gets into the water bodies.

The very low concentration of parameters such as ammonia, nitrite, nitrate and phosphate could be due to the phytoremediation property of water hyacinth. But it is also affected by the nature of water, due to the dynamic nature it possesses. Studies have shown that water hyacinths have excellent capacities in removing N and P from water. Water hyacinth was also effective in significantly lowering the TAN and nitrite of water (Reyes et al., 2019). Total hardness is the parameter of water quality used to describe the effect of dissolved minerals like calcium, magnesium etc. A difference in total hardness was shown by less infested area and Thoppil which is the highly infested area. A study held by Mikhil, 2022 found that the water hyacinth can reduce the hardness of water and he concluded that water hyacinth has phytoremediation properties.

Dissolved Oxygen (DO) concentrations were notably lower in highly infested areas, indicating the impact of dense water hyacinth mats on oxygen transfer. In our study the BOD level was only slightly higher in the low infested area than that of weed highly infested area. The reason for the lack of increase in the BOD level of water in the less infested areas could be the continuous flow of water hyacinth throughout the water. If the weed sinks into the water upon decomposition, it will potentially contribute organic matter to the water. However, since the water hyacinth was continuously flowing, there was minimal organic matter presence, consequently leading to low BOD levels throughout. Total suspended solids (TSS) and total dissolved solids (TDS) showed no significant differences

within comparison areas, with concentrations generally lower across all locations. A study conducted by Elizabeth et al., 2020 proved that water hyacinth can be used as a bioaccumulator because it has the ability to absorb substances in the water and makes the water become clearer.

5.3 Heavy Metals :

Water hyacinth, known for its rapid growth and adaptability, offers promise in treating wastewater and purifying polluted water. While it thrives in contaminated environments, it effectively removes organic materials and metals, particularly through its roots, making it a valuable tool for assessing metal pollution levels and phytoremediation. However, heavy metal concentrations vary across its parts, with roots showing the highest accumulation. Notably, metals like copper, chromium, and zinc are detected at concerning levels, emphasizing the need for monitoring and remediation to safeguard the environment and human health in Kerala. Analyzed through Inductively Coupled Plasma Mass Spectrometry (ICPMS), the results highlight diverse heavy metal presence, underscoring water hyacinth's potential as a phytoremediation agent. Continued analysis and adherence to regulatory standards are vital to mitigate associated risks effectively.

6. DISCUSSION

The rapid and uncontrollable proliferation of water hyacinth in the Thrippunithura Municipality significantly affects the local residents, particularly during the monsoon and post-monsoon seasons. During the monsoon, the challenges are heightened, but post-monsoon conditions remain unfavorable for normal activities. The dense growth of water hyacinth forms thick mats on the water surface, severely hampering local activities such as fishing, transportation, and aquaculture. These mats obstruct navigation channels and degrade water quality. Water quality can be affected by water hyacinth. This invasive aquatic plant can impact various parameters such as dissolved oxygen levels, nutrient concentrations (like nitrogen and phosphorus), pH, alkalinity, hardness, TSS, TDS etc. The presence of the weed limits oxygen exchange, creating unfavorable ecological conditions for native aquatic species, which in turn impacts aquatic biodiversity. This reduction in biodiversity directly affects the livelihoods of local fishermen by decreasing the catch rates. Additionally, the proliferation of water hyacinth reduces access to fishing grounds and increases maintenance costs for boats, fuel, and fishing equipment, further exacerbating the economic strain on fishermen. Overall, the infestation leads to significant socio-economic and ecological disruptions, necessitating effective management and remediation strategies to mitigate its adverse impacts.

Education emerges as crucial, with most residents lacking higher education, limiting their adaptability and livelihood options during events like water hyacinth proliferation. To address this, education and training programs are recommended to enhance fishing skills, promote sustainable practices, and diversify employment opportunities. Economically, the spread of water hyacinth poses substantial challenges for communities reliant on water-based activities. The decline in earnings potential, particularly during off-seasons, underscores the vulnerability of these communities, necessitating targeted support measures. Overall, addressing water hyacinth challenges requires comprehensive strategies that prioritize education, infrastructure development, and sustainable resource management. In addition, the analysis reveals that 45.7% of respondents express interest in exploring alternative uses for water hyacinth, with 19.6% having previously utilized it for purposes like fertilizer. However, 26.1% remain unaware of alternative uses, emphasizing the need for education and outreach. Moreover, heavy metal analysis proved that water hyacinth has the ability to absorb different heavy metals, which indicates its phytoremediation property. This underscores the importance of timely

removal of water hyacinth to prevent persistent heavy metal accumulation in the environment to avoid reintroduction of pollutants .

7. CONCLUSION

Water hyacinth, known scientifically as *Eichhornia crassipes*, is an invasive aquatic weed causing ecological and socio-economic challenges globally, including in Kerala. Its rapid spread obstructs water flow, disrupts irrigation channels, and reduces sunlight and oxygen levels. Communities near water bodies suffer economic hardships due to decreased access to fishing grounds, especially among those with limited education. Education and training programs are recommended to enhance fishing skills and promote sustainable practices, thereby addressing economic and environmental concerns. While weed management efforts have been made, inconsistent execution highlights the need for coordinated actions by relevant authorities and local communities.

Water hyacinth proliferation peaks during Kerala's monsoon seasons, affecting fishing activities and navigation. Heavy metal contamination in water hyacinth poses risks to the environment and human health, necessitating timely removal to prevent further deterioration of natural conditions. The local communities have expressed their interest in participating in activities of alternative utilisation of the otherwise destructive water hyacinth. Exploring alternative uses for water hyacinth could bring new revenue streams and environmental benefits, but community engagement and capacity-building efforts are essential for success.

The socio-economic impact of water hyacinth infestation is evident in reduced job opportunities, navigational difficulties, and diminished catches, posing significant challenges for affected communities. Breaking the vicious cycle of water hyacinth proliferation requires collaborative actions involving government agencies, local authorities, and community organizations to restore aquatic ecosystems and support impacted communities' resilience and prosperity.

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DETERMINANTS OF SUCCESSFUL VIRTUAL TEAMS WITH SPECIAL REFERENCE TO THE INFORMATION TECHNOLOGY SECTOR IN SRI LANKA

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Abstract

Purpose*: Technological advancements, globalization, and crisis situations have compelled society to adopt a virtual platform. In light of this scenario, the purpose of this study was to ascertain the determinants that influence the success of virtual teams in the Sri Lankan context in order to enhance the benefits of the virtual platform.*

Design and approach: *Research study was based on quantitative approach and focused on the actual data that received from the respondents.*

Methodology: *This was a cross-sectional study involving employees in the Information Technology (IT) sector. The data collection technique used was a structured questionnaire combined with a simple random sampling technique. Correlation and simple linear regression analysis were used to analyze the data.*

Findings: *The research reveals that trust, leadership, and communication all have a significant positive impact on successful virtual teamwork independently, while also ensuring a positive relationship between the variables.*

Originality of the research: *The uniqueness of this study is demonstrating how those factors contribute to the conversion of traditional teams to modern teams, thereby increasing the likelihood of the final outcome in a fruitful manner.*

Keywords: *Virtual Teams, Globalization, Trust, Leadership, Communication*

1. Introduction

A virtual team can be defined as a group of individuals who work together from different geographic locations and rely on communication technology such as emails, FAX and video or voice conferencing services to collaborate and achieve a common target. Furthermore, virtual teams are geographically dispersed and depend directly on communication technology. Virtual Teams are culturally varied and dynamic in their structures. The contribution of virtual teams is becoming increasingly important and has gained more significance due to the increasing of globalization, distributed work, reliance of computer-mediated communication (CMC) over the past few decades (Gibbs et al., 2017).

Virtual teams can be mentioned as the in charge of which is allowed to enroll key specialist, regardless the physical location. These virtual teams reduce the need for travelling and it helps to reduce the

cost. To obtain the above-mentioned advantages, it is necessary to identify factors that contribute to an effective virtual teamwork (Smith & Ruize, 2020).

When it comes to the comparison of virtual platform with remote working, in virtual teams it is limited to viewing one another for short period of times such as Zoom, Microsoft Teams and participants rely on tones, voices, facial expressions and second-hand information pass from other participants. Due to these issues, it is normal to increase misunderstandings and misinterpretations in a virtual setting. Therefore, in order to have an effective outcome from virtual teams; social cohesion, perceived supervisory support, information sharing, vision and clarity, external communication and trust should be managed in a virtual team (Mawson, 2020)

Geographic dispersion, electronic dependence, cultural and functional diversity, dynamic structure can be identified as a set of key dimensions of virtuality that emerged through the reviews of research. (Gibson & Gibbs, 2006). On the other hand, according to latest reviews, scholar's emphasis; Subgroups and faultiness, power and status differences, leadership, and communication processes as key areas or the major dimensions in virtual teams. (Gibbs et al., 2017). Not only those factors, interdependence, ICT (Information Communication Technology) utilization, geographic dispersion, working across different time zones, dissolvable nature and resources pooling and knowledge sharing can be mentioned as characteristics of virtuality (Gunasekara & Ajantha, 2019). Although the virtual teams have existed before, a developing country like Sri Lanka paid more attention towards virtual teamworking after the COVID-19 outbreak. The Corona pandemic caused each an everyone across the world to work remotely from home and now number of people engage in full-time virtual teamwork. COVID crisis urged many companies around the world to ask employees to work from home and it was caused to the sudden increase of virtual teams. (Mysirlaki & Paraskeva, 2020). Therefore, this unprecedented occurrence "has made it more critical than ever before to face the challenges that come-up with being a part of a virtual team" and Skype, Microsoft Teams, Slack and Zoom can be mentioned as mostly using virtual meeting platforms around the world (Working in a virtual team: Using technology to communicate and colloborate, 2020). And the installing of the Zoom app by the people around the world, the Zoom company generated $671 million as the profit and $2.6 billion as the revenue for the financial year 2020 (Iqbal, 2021)

Furthermore, due to the vast improvements of using virtual platform caused to the increasing of issues related to the effectiveness of outcome of virtual teams. Even before the Corona pandemic, experts emphasized that more than half of the transitions to virtual teams fail and do not meet their strategic objectives (Winter, 2020).

In 2019 approximately 34.11% of the population had access to the internet. But when it comes to 2021 the number of internet users increased by 800,000 (+7.9%). (Digital in Sri Lanka, 2021). This increase in the use of using internet caused lots of network related issues not only in rural areas but in urban areas as well.

When it comes to the Sri Lankan context it is questionable the successfulness of a virtual teams due to some issues such as lack of infrastructure, lack of networking signals and cultural issues. However, it is the responsibility of all the members of the team to work towards the achieving team's objectives. There are no more studies regarding the success factors of a virtual team in related to Sri Lankan context. Therefore, this study will be another foundation for further research in Sri Lanka and this study will be helpful to identify the determinants of a successful virtual teamwork which is contribute to enhancement of effective participation of virtual teams in Sri Lanka. By considering all the above information as the researcher of this current study and by referring to previous literatures it is easier to identify the importance of carrying out the current study.

2. Statement of the Problem

After Covid-19 pandemic whole world shifted to virtual platform except manufacturing industries like apparel industry rather than having physical engagements. Increasing virtual teams depicts various advantages like cost reduction, ability to work internationally, greater degree of freedom among people (Szewc, 2013). Surveys clearly mention the rapid growing importance of global collaboration, which translates into virtual teamwork, and it depicts the key areas in virtual teams representing unique challenges to the outcome of organizations and individuals. The findings of previous studies have identified that virtual teams need specific training and tactics. Furthermore, these virtual teams should be monitored and adhered to the rules and be aware of the culture and work style among members. Thus, the statement of the problem of this study is "What are the determinants of a successful virtual teamwork?" which leads to the objective of the study as to identify the determinants of successful virtual teamwork.

3. Literature Review

The review of the literature shows the factors that impact on the effectiveness, or the success of virtual teams are still ambiguous (Lin et al., 2008). Not only that, but there is also no commonly used definition of virtual teams and authors vary in their interpretation of this phenomenon. Although virtual teamwork is a leading topic in literature on international organizations and it has been problematic to define what 'virtual' means across multiple institutional context (Chudoba, 2005).

The idea of a 'team' is mentioned as "a small number of people with complementary skills who are equally committed to a common purpose, goals, and working approach for which they hold themselves mutually accountable" (Zenun et al., 2007) According to Gassmann and Von Zetwitz, (2003) they defined "virtual teams as a group of people and sub-teams who interact through interdependent tasks guided by common purpose and work across linked strengthened by information, communication and transport technology" (Gassmann & Zedtwitz, 2003). Other than these definitions Leenders (2003), stated that virtual teams as; The groups of individual collaborating in the execution of a specific project while geographically and often temporally distributed, possibly anywhere within (and beyond) their parent organization (Leenders, 2003). Furthermore, according to Lurey and Raisinghani (2000), virtual teams can be defined as groups of people who work together although they are often dispersed across space, time, and/or organizational boundaries (Lurey, 2000). Among several definitions of virtual teams, we can identify following definition as one of the most widely accepted definitions: "we define virtual teams as groups of geographically, organizationally and/or time dispersed workers brought together by information technologies to accomplish one or more organization tasks" (Powell, 2004). Furthermore, the word virtual team can be defined as an individual collaboration in geographically dispersed work teams who may located in different zones and countries (Horwitz, Bravington, & Silvis, 2006). There are various definitions of virtual teams can be seen as follow. According to Lin, Standing and Liu (2008) virtual teams are referred as "an interdependent group working on a project across and space relying on information technology and communication technology" (Lin, Standing, & Liu, 2008). Above definition is similar up to some extend of the definition provided by the Horwitz, Bravington, & Silvis' (2006). Few decades ago, it could not be foreseen that people would work together on the same activity while being scattered around different geographic locations. Due to the advancements in technology and corporate globalization, these virtual teams are redesigning the way organizations conduct business (Zofi, 2011).

Virtual teams have several advantages including speed of execution, reducing cost and adaptability. On the other hand, disadvantages to the virtual team environment include, cultural nuances of operating globally, role ambiguity and the difficulty in the interpretation of decisions via virtual means. Previous

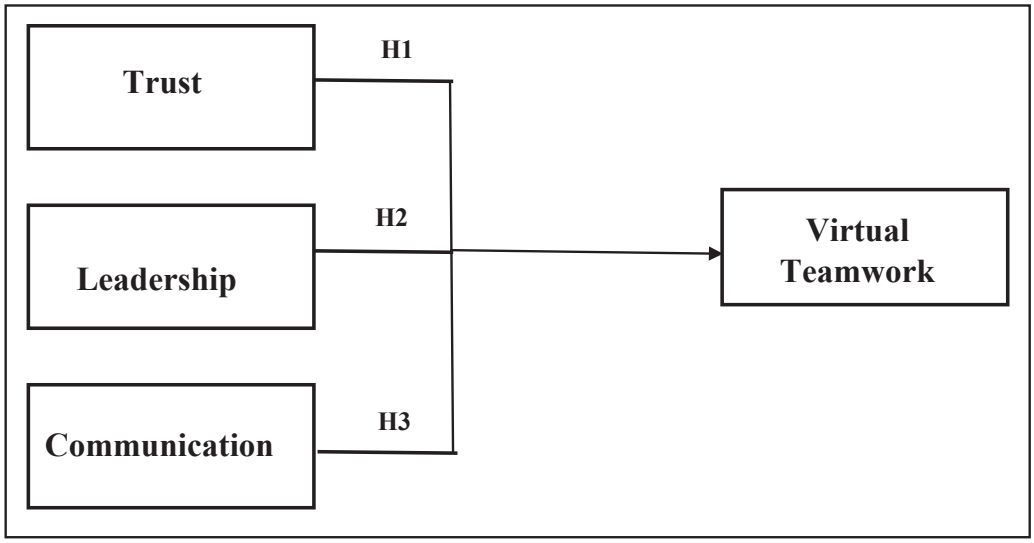
researchers have identified many factors affecting collaboration in general. Mattessich and Monsey identified nineteen factors required for successful collaboration, including the ability to compromise, mutual respect and trust and flexibility. Moreover, Patel et al., (2012) developed a framework based on the categorization of seven factors related to collaboration such as context, support, task, interaction for use in collaborative engineering projects in various sectors (Earnhardt, 2009).

When it comes to the trust, according to literature key definition or the accepted definition of trust is: "the willingness of a party to be vulnerable to the action of another party based on the expectations that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that the other party" (Mayer et al, 2005).

Trust is one of the social norms and it is developed with the improvement of teamwork. Trust helps to enhance information flow, improve cooperation, assisting to overcome problems and conflicts as well as reach team goals (Prati et al., 2003). To enhance trust, managers or the team leaders must communicate the responsibilities, conducting often feedback sessions and promote team-related rewards and there is a finding that the best way to assist team members is developing mutual trust (Szewc, 2013).

Furthermore, "leadership is defined as the process of influencing the activities of an organized group towards goal achievement". And according to the recent studies of Mysirlaki et al. (2020) showed that leadership mediates the relationship between leader's emotional intelligence and team effectiveness in a virtual team (Liao, 2017). Moreover, in the same way researchers agree that effective leadership is one of the key factors in the success of virtual teams and an important component in overcoming the challenges of virtual teams and realizing their potential benefits (Gremiel et al., 2023). Literature shows that providing effective functioning of a group in all of the aspects discussed above requires an appropriate leadership style. In virtual teams, direct leadership is less used and team members are managed by empowerment and allow them to engage in managerial functioning (Ebrahim et al., 2009). Lilian, (2014) stated that the virtual teams are presented more challenges, and the success of virtual teams relies on leadership (Lilian, 2014). According to interviews of Thorn, (2012) he stated that coping with the speed of interrelated international events and crises, managing and leading in the growing complexity of a society, managing the instability and gap in the process, becoming more adaptable and flexible in creating, accepting and adapting to change, maintaining a vision that incorporates peoples from different cultures as the challenges are as several opportunities for team leaders in virtual teams and on the other hand, these are the challenges for team leaders in virtual teams (Thorn, 2012). It is stated that, to achieve the effectiveness of virtual teamwork, it is necessary to select electronic collaboration and communication technology that meet the outcome. One of the main reasons why virtual teams are different from conventional team is the interference of technology to communicate (Bordia, 2017). According to Keith Davis, communication is a process of passing information and understanding from one person to another. There are number of different communication technologies available to manage and coordinate the virtual teamwork and different communication technologies suit to different requirements of the teams. (Norman, 2020). Researchers of Swiss Institute of Technology stated that the most common problems when working virtually are not connected only with the technology, but with the interaction between people, specifically with way of communication (Szewc, 2013)

Conceptual Framework work and Hypotheses



Source: Author, 2022

Relationship between trust and virtual teams.

The level of failures of virtual teams can be astounding. With the higher number of virtual teams' failures, organizations may become numb to the failures and obtain the targets without much consideration. Literatures depicts that it may be trust is a factor in most of the failures of virtual teams (Kanawattanachai & Yoo, 2002). Furthermore, according to (Meiner, 2018) trust was defined as strongly intercorrelated with virtual team success after applying spearman correlation analysis. Therefore, researchers constructed the first hypothesis as below.

H1 - There is a significant relationship between trust and the success of a virtual team.

Relationship between leadership and virtual teams.

Literatures argue that leadership may be more important to the performance of virtual teams, because activities of virtual teams are unique than the physically engaged groups (Kirkman et al., 2004). Leadership has a vital role on team members and team activities in order to achieve team objectives (He, 2008). Therefore, researchers have developed second hypotheses of the study as below.

H2 - There is a significant relationship between leadership and success of a virtual team.

Relationship between communication and virtual teams.

Due to geographical dispersion, virtual team members communicate with one another by utilizing different type of technological tools. According to previous literatures, ineffectiveness of communication within virtual teams caused task or the relationship among members negatively impacted to the success of virtual teams (He, 2008). Therefore, researchers have developed following hypothesis.

H3 - There is a significant relationship between communication and the success of a virtual team

4. Methodology

This research followed the quantitative method which led to identify the determinants that affect to the success of virtual teams and this study is a cross-sectional study which was collect data of the variable as a whole at a single point in order to examine the variables focused on the actual data that received from the respondents by considering employees as the unit of analysis of the study.

The population size of this study is known and Information Technology (IT) sector employees in a reputed organization with 130 employees has selected for the population. A further 97 employees were considered as the sample size of the study according to Morgan's table under the confidence interval of 95%. The reason for selecting the IT company is that, even before the pandemic period IT employees were using the virtual platform for their day-to-day business activities and they were having good understanding about the virtual team works. Therefore, the researcher identified that it would be assisted to ensure the reliability and the validity of the data collection in order to obtain an accurate statistic in the data analysis part. The questionnaire consisted of two parts; Part-A consisted of demographic information of the respondents and part-B consisted with questions that covered dependent and independent variables. All the questionnaires distributed by using simple random sampling technique which were created as a google form. As the measurement scale, five-point Likert scale was used which provided five possible answers to a statement that allow respondents to indicate negative to positive agreements or strength of feeling regarding the statements depicted in the questionnaire. Statistical Package for Social Sciences (SPSS) version 23.0 was used to analyze the collected data.

5. Findings

The respondents are classified according to gender. The majority were female employees 54.6% from all the respondents and 45.4% were male employees. In terms of monthly income, most of the employees are in the range of Rs.50,000 and Rs.75,000 (26.8%). When it comes to the age of respondents 41.2% of employees were within the range of 20 – 25 years. On the other hand, 3.1% of respondents were employees who are 41 and above ages. When it comes to the department that the respondents are working, 51.54% respondents were working in the department of technical. Furthermore, there were 9.27% respondents from the department of administration and 39.17% respondents from the department of Consulting.

When it comes to the reliability and validity statistics, reliability of the data was ensured by using both Cronbach's alpha and Split-halt coefficient. And validity statistics (Sampling adequacy) were ensured through Kaiser-Mayer-Olkin (KMO) measures.

Table 1: Reliability and Validity Statistics

Construct	Number of Items	Cronbach's Alpha	Split-half Coefficient	KMO Measures
Successful Virtual Teamwork	5	0.916	0.883	0.864
Trust	8	0.930	0.906	0.910
Leadership	9	0.948	0.894	0.925
Communication	8	0.965	0.973	0.925

Source: Analyzed Data, 2022

As the above table depicts, internal consistency of the dependent and independent variable was higher than 0.7. Further KMO coefficient depicted that the values are greater than 0.7. Therefore, reliability and validity were ensured of the current study.

Testing Hypotheses

Pearson Correlation Coefficient was used to assess the strength of association among dependent variable and the independent variables and Linear Regression analysis was conducted to test the hypotheses. Through linear regression analysis researcher analyzed the impact of independent variables (trust, leadership, communication) on the dependent variable (successful virtual teamwork).

Trust

Sig. (2-tailed) test was applied to test the significance of the correlation as the advanced hypothesis was non directional. As shown in table 2 a strong positive correlation is found between the trust and the successful virtual teamwork (r=0.658) which is statistically significant as Sig. 2-tailed (0.000) is less than the level of significance (0.001). Hence, it is proven that trust is significantly correlated with successful virtual teamwork.

Table 2: Correlation Analysis-Successful Virtual Teamwork and Trust

		Successful Virtual Teamwork	Trust
Successful Virtual Teamwork	Pearson Correlation	1	.658**
	Sig. (2-tailed)		.000
	N	97	97
Trust	Pearson Correlation	.658**	1
	Sig. (2-tailed)	.000	
	N	97	97

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Analyzed Data,2022

According to the regression results, R Square = 0.443 (43%) of the variation success of virtual team could be significantly (Sig. = 0.000 which is less than 0.05) explained by the independent construct in the research study which is trust. Furthermore, as given in the table 4, the marginal contribution of trust (0.654) in determining the effect on the successful virtual teamwork is to be considered statistically significant (Sig. = 0.000) in the regression equation. According to the regression results, it was statistically claiming that, there is a significant impact of trust on successful virtual teamwork. Therefore, H1 was accepted; There is a significant relationship between trust and the successful virtual teamwork.

Table 3: Regression Statistics-Impact of Trust on Successful Virtual Teamwork

Multiple R	0.658
R Square	0.433 (44.3%)
Adjusted R square	0.427
Standard Error	0.55683
Observations (N)	97
F	72.669
Sig.	0.000
Regression	Linear
Method	Enter

Source: Analyzed Data, 2022

Table 4: Coefficient-Impact of Trust on Successful Virtual Teamwork

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
B		Std. Error	Beta			
1	(Constant)	1.375	.303		4.534	.000
	Trust	.654	.077	.658	8.525	.000

a. Dependent Variable: Successful Virtual Teamwork

Source: Analyzed Data, 2022

Leadership

Pearson Correlation Coefficient was used to assess the strength of association among leadership and the successful virtual teamwork. Further, Sig. (2-tailed) test was applied to test the significance of the correlation as the advanced hypothesis was non directional. Table 5 shows the results of correlation analysis. As shown in the table 4.8, a strong positive correlation was found between the leadership and the successful virtual teamwork (r=0.779) which is statistically significant as Sig. 2 tailed test (0.000) is lower than the level of significance (0.01). Therefore, it is proven that the leadership is significantly correlated with the successful virtual teamwork.

Table 5: Correlation Analysis-Successful Virtual Teamwork and Leadership

		Successful Virtual Teamwork	**Leadership**
Successful Virtual Teamwork	Pearson Correlation	1	.779**
	Sig. (2-tailed)		.000
	N	97	97
Leadership	Pearson Correlation	.779**	1
	Sig. (2-tailed)	.000	
	N	97	97

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Analyzed Data, 2022

Further, results of the regression analysis test are given in table 6 and 7. According the results depicted in table 6, R Square = 0.607 (60.7%) of the variation successful virtual teamwork could be significantly (Sig. = 0.000 which is less than 0.05) explained by the independent variable in the research study which is leadership. As given in the table 7, the marginal contribution of leadership (0.708) in determining the effect on successful virtual teamwork is to be considered statistically significant (Sig. = 0.000) in the regression equation. According to the regression results, it was statistically depicted that, there is a significant impact of leadership on successful virtual teamwork. By considering above statistics, researcher analyzed that, H2 was accepted; There is a significant relationship between leadership and successful virtual teamwork.

Table 6: Regression Statistics-Impact of Leadership on Successful Virtual Teamwork

Multiple R	0.779
R Square	0.607 (60.7%)
Adjusted R square	0.603
Standard Error	0.46355
Observations (N)	97
F	146.938
Sig.	0.000
Regression	Linear
Method	Enter

Source: Analyzed Data, 2022

Table 7: Coefficients-Impact of Leadership on Successful Virtual Teamwork

Coefficients[a]						
Model B		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		Std. Error	Beta			
1	(Constant)	1.128	.235		4.806	.000
	Leadership	.708	.058	.779	12.122	.000

a. Dependent Variable: Successful Virtual Teamwork

Source: Analyzed Data, 2022

Communication

Furthermore, researcher has calculated the correlation between communication and the successful virtual teamwork was tested. Sig. (2-tailed) test was applied to test the significance of the correlation as the advanced hypothesis was non directional. Table 8 depicts the results of correlation analysis. As shown in table 8 a strong positive correlation can be seen between communication and successful virtual teamwork (r=0.843) which is statistically significant as Sig. 2 tailed (0.000) is less than the level of significance (0.001). Hence, it is proven that communication is significantly correlated with the success of virtual teamwork.

Table 8: Correlation Analysis-Successful Virtual Teamwork and Communication

		Successful Virtual Teamwork	Communication
Successful Virtual Teamwork	Pearson Correlation	1	.843**
	Sig. (2-tailed)		.000
	N	97	97
Communication	Pearson Correlation	.843**	1
	Sig. (2-tailed)	.000	
	N	97	97

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Analyzed Data, 2022

Finally, linear regression analysis was done to test third hypothesis (H3). Results of the test are given in table 9 and 10. According to the results depicted in table 9, R Square = 0.711 (71.1%) of the variation of successful virtual teamwork reflected that it is significantly (Sig. = 0.000 which is less than 0.05) explained by the independent construct which is communication. Further, as given in table 10, the marginal contribution of communication (0.809) in determining the effect on successful virtual teamwork is to be considered statistically significant (Sig. 0.000) in the regression equation. Further, according to the results of regression, it was accepted statistically calming that, there is a significant impact of communication on successful virtual teamwork. Thus, H3 hypothesis was accepted; There is a significant relationship between communication and successful virtual teamwork.

Table 9: Regression Statistics: Impact of Communication on Successful Virtual Teamwork

Multiple R	0.843
R Square	0.711 (71.1%)
Adjusted R square	0.708
Standard Error	0.39766
Observations (N)	97
F	233.746
Sig.	0.000
Regression	Linear
Method	Enter

Source: Analyzed Data, 2022

Table 10: Coefficients-Impact of Communication on Successful Virtual Teamwork

Coefficients[a]						
Model B		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		Std. Error	**Beta**			
1	(Constant)	.737	.212		3.478	.001
	Communication	.809	.053	.843	15.289	.000

a. Dependent Variable: Successful Virtual Teamwork

Source: Analyzed Data, 2022

6. Conclusion and Recommendations

According to the findings of primary data analysis, it is clear that there is a relationship and the impact between dependent and independent variables. Therefore, it can be mentioned as; there is a significant positive impact on successful virtual teamwork from trust, leadership and communication separately. When it comes to the implication, the findings and the conclusion of this study present the determinants of a successful virtual teamwork with certain implications for IT and the rest of the industries. That is a move from traditional teams to modern virtual teams in order to enhance the effectiveness of virtual teams. Although, there are so many studies regarding the factors that lead virtual teams to a success in international context, it is difficult to find studies relating to current research area in Sri Lankan context. Thus, the findings of current study provide contribution to existing body of knowledge to fill the gap in current research area. Due to the Covid-19 global pandemic the uses of virtual teams have increased. Some have suggested that this pandemic could be the basis for increasing virtual teams within different sectors. Therefore, the current study provides insight to corporate sector and the educational sector and the health sector as well. Furthermore, this study provides insight to policy makers, to ensure the technological requirements of business sector within the country and it is better to introduce work from home arrangements not only for the IT sector employees, but for the employees who are over age of forty as well.

Further, it has declared that there is a strong positive correlation between the trust and the successful virtual teamwork and moreover a significant impact was found between mentioned two variables. This will be a foundation to enhance the trust in virtual teams. According to the findings, it was found that there is a strong positive correlation between leadership and the successful virtual teamwork. In addition to that it declared the positive significant impact of leadership on the success of virtual teams. The previous findings of the current research areas depicted that to build the team trust a proper leadership has a significant value. By comparing the previous findings, it is shown that there

is a significant impact of leadership on virtual team success and analyzed that, there is a strong positive correlation between communication and successful virtual teamwork. Communication in virtual teams lead to confusion among team members and to cope with these confusions there should be a proper team communication which helps to create an effective team outcome.

On the other hand, researcher has identified limitations that need to be taken into serious consideration. The researcher's main objective was to identify the determinants that affect successful virtual teamwork considering only on the employees in IT sector. Therefore, the first limitation is the current study is only relevant to one industry, which is the IT industry. This reason has resulted in the study is to be a more subjective one into a particular industry. Due to this reason sample is bounded by the industry. On the other hand, it is difficult to collect data from production sector who are always working in physically. Furthermore, during the study, researchers considered all the other factors remain constant. Thus, results of the study may be influenced by environmental factors.

However, it can be concluding the trust, leadership and the communication as the determinants which affect the success of a virtual teamwork. As a developing country, it is necessary to identify the success factors of a virtual team. In addition to that this study is a move from traditional teams to modern virtual teams in order to enhance the effectiveness of virtual teams and this study provides insight to policy makers, to ensure the technological requirements of business sector within the country and it is better to introduce work from home arrangements not only for the IT sector employees but for the employees who are over age of forty as well. Finally, it is better to strengthen trust, leadership and communication within virtual teams to accomplish teams' objectives effectively and efficiently. Moreover, researcher presents the directions for future researchers as follows; It is more beneficial and effective for all decision makers if a study is considered as a whole without merely focusing on one particular industry. This can be helped in a wider and balanced study. Furthermore, researcher suggests to future researchers to expand the independent variables by including dimension (if there are any) based on previous literatures in order to enhance the capacity of identifying the success factors of virtual teams which have become an essential requirement within this new normal situation. Finally, researcher suggests conducting studies relevant to current study area in order to fill the theoretical gap in Sri Lankan context.

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FACTORS INFLUENCING THE UTILIZATION OF CLOUD OPTIMIZATION TOOLS AMONG DEVOPS ENGINEERS: INSIGHT FROM A SOFTWARE DEVELOPMENT COMPANY IN SRI LANKA

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Abstract

This study investigates the reasons why DevOps engineers utilize cloud optimization technologies, aiming to aid decision-makers in enhancing cloud technology use, ensuring cost-effectiveness, and simplifying management within organizations. A quantitative research approach was employed, with two hundred individuals randomly selected from a pool of eight hundred DevOps experts, prioritizing ethical considerations throughout the study process. Rigorous regression and correlation studies were conducted with a 95% confidence level to explore significant correlations between independent factors and a company's cloud optimization. The research focused on key goals such as reducing maintenance costs, improving scalability, and efficient resource utilization, with participants highlighting the importance of cost savings, scalability, and simplified management. The findings revealed significant correlations between these independent factors and the effectiveness of cloud optimization in companies. Consequently, the study suggests that decision-makers prioritize reducing maintenance costs, enhancing scalability, and optimizing resource utilization to enable their DevOps teams to effectively leverage cloud optimization technologies. This study provides practical recommendations for organizational strategies that promote the efficient use of cloud technologies and sheds light on the specific preferences of DevOps engineers regarding cloud optimization technologies.

Keywords*: DevOps, Cloud Optimization Tools, Cloud Computing, Cloud Optimization Technologies*

1. Introduction

Cloud computing has revolutionized IT due to its scalability, affordability, and agility. The US National Institute of Standards and Technology (NIST) recognizes essential characteristics of cloud computing: self-help, quantifiable services, rapid elasticity, resource pooling, and extensive network access. Typically, cloud resources are organized using Software as a Service (SaaS), Infrastructure as a Service (IaaS), and Platform as a Service (PaaS). Given its cost-effectiveness and ease of access

compared to specialized clusters or high-performance machines, businesses are leveraging cloud computing to enhance productivity. In Sri Lanka's rapidly evolving IT sector, cloud optimization by DevOps engineers has gained popularity (Mishra, 2018) .

Cloud computing has fundamentally altered how firms utilize and manage IT resources. Its scalability, cost-effectiveness, and agility make it indispensable for modern enterprises. The US National Institute of Standards and Technology (NIST) defines cloud computing by its on-demand self-service, measurable service, rapid flexibility, resource pooling, and broad network access. These capabilities collectively enhance technology efficiency and adaptability, allowing organizations to scale resources as needed and pay only for what they use (Attaran, 2018).

The primary methods for organizing cloud resources are SaaS, IaaS, and PaaS. SaaS delivers software applications online, eliminating the need for installation and maintenance. IaaS provides virtualized computing resources over the internet, allowing flexibility in processor, storage, and networking resources. PaaS offers a framework for developers to build and manage applications without dealing with underlying infrastructure (Jindal, A. a. G. M., 2021).

Companies are increasingly turning to cloud computing to boost productivity and efficiency. Its cost-effectiveness and ease of use make it a viable alternative to high-performance computing systems and specialized clusters, which are often expensive and complex to manage. Cloud optimization is particularly appealing to DevOps engineers in Sri Lanka's dynamic IT sector. Continuous efforts are underway to develop cloud computing solutions that maximize resource use for business purposes. This evolution underscores the critical role of cloud computing in driving technological innovation and business growth (Mohammad, S., 2018).

To maintain privacy, this study uses the pseudonym "ABC" for the company in question. The study focuses on the adoption decisions regarding cloud optimization technology by ABC's DevOps engineers. By examining these dynamics, the paper aims to illustrate how ABC leverages advanced technology to maintain a competitive edge and enhance its IT operations (Pawar, 2017).

ABC is a major IT company known for its innovative approach to technology. Founded over a decade ago, ABC has rapidly grown into a global leader in cloud computing solutions. In the face of a fast-changing technological landscape, this research investigates how ABC's DevOps teams use cloud optimization tools to improve operational efficiency and agility.

Cloud optimization aims to enhance the performance, scalability, and cost-efficiency of computing, storage, and networking resources. DevOps plays a pivotal role in a company's cloud optimization efforts. At ABC, many DevOps engineers struggle to allocate the appropriate instance sizes for their workloads. Overprovisioning wastes resources, while under provisioning hampers performance and usability. This misallocation has resulted in a 10% decrease in delivery efficiency and a 25% drop in customer satisfaction. Unused cloud resources also lead to higher costs. ABC's DevOps engineers strive to monitor resource consumption to minimize waste. Auto-scaling in cloud computing allows organizations to add resources as needed (Viegas, E., Santin., 2021).

Inefficient resource allocation at ABC hampers cloud optimization, indicating under- or over-utilization of CPU, memory, and storage. Monitoring the cloud infrastructure can reveal bottlenecks and inefficiencies, but poor monitoring hinders optimization. Inadequate resource consumption, over-provisioning, and underutilization of reserved instances increased 2022 expenditures by 30% due to insufficient cloud optimization monitoring. Additionally, ABC lacks proper cloud optimization planning, often ignoring the organization's specific needs and cloud workload. Without this understanding, resources may be over- or under-supplied. Architectural issues, such as a non-scalable, non-redundant cloud design, also increased costs and impaired performance (Tan., 2019).

This research aims to answer the question: "What factors affect DevOps engineers' adoption of cloud optimization tools at ABC?" The study has several goals, primarily to help ABC better understand

and utilize cloud optimization technologies. The main objective is to identify the factors influencing cloud optimization at ABC. This involves examining the technical, operational, and strategic aspects that contribute to effective cloud optimization practices. The study will also assess the significance of these factors by identifying patterns that indicate which elements most impact cloud optimization efforts. Finally, the research will offer specific recommendations to the organization's decision-makers based on the findings. These suggestions are intended to guide strategic planning and operational adjustments to enhance cloud optimization outcomes, ultimately improving ABC's performance and maintaining its technological edge.

Using cloud optimization tools can significantly enhance the productivity of DevOps engineers by automating the identification and resolution of cloud optimization issues, saving time and effort. Increased efficiency allows DevOps engineers to focus on other critical tasks. Cloud optimization tools can identify underutilized resources, optimize instance sizes, and improve networking, leading to cost savings for the company. By optimizing the cloud environment, DevOps engineers can maximize the return on the company's cloud investment.

These tools can also detect and resolve performance issues such as network latency and computing resource shortages, enhancing application performance and user experience. Additionally, cloud optimization tools help DevOps engineers develop effective auto-scaling strategies to scale resources in response to demand fluctuations. They also standardize cloud optimization across the organization's cloud infrastructure, eliminating human error. Cloud optimization tools provide DevOps engineers with a comprehensive view of the organization's cloud infrastructure, enabling them to identify and address issues more effectively. In conclusion, DevOps engineers should use cloud optimization tools to enhance productivity, cost savings, performance, scalability, consistency, and cloud visibility. These tools enable DevOps engineers to optimize the cloud environment, helping the company achieve its objectives.

In the context of cloud optimization tools utilized by DevOps engineers in the Indian IT industry, it has been found that most respondents focus on cost-saving mechanisms in their day-to-day operations. Additionally, research indicates that Indian DevOps engineers prioritize resource utilization and maintenance as key elements in their operational activities (Mohammad, 2018).

However, research studies face several limitations in data collection. The present study may have a sample size too small to be representative of the population due to respondent unavailability and inaccessibility. The probability sampling technique may also lead to sampling bias. Participants may provide socially desirable responses instead of their true feelings or behaviors, leading to data inaccuracies. The data collection instrument, such as a questionnaire, may not accurately measure the concept being studied, and the results may not be generalizable to other populations or contexts. Additionally, resource constraints like time or funding may limit data collection. In conclusion, sampling bias, social desirability bias, recollection bias, instrumentation bias, lack of generalizability, ethical issues, and resource limitations may affect data collection. Researchers should consider these limitations and use appropriate methods to minimize them, ensuring the validity and reliability of research findings.

2. Literature Review

Cloud optimisation technologies revolutionise DevOps operations, according to extensive study. These tools are linked to cost reductions, resource optimisation, scalability, and simpler maintenance. Automation and monitoring reduced expenditures by 25% in six months. (Khan, 2021). The findings showed that successful cloud optimization solutions saved 20–50%. Resource utilization studies, such as those conducted by Singh (2021), demonstrated a substantial increase due to cloud

optimization tools, emphasizing unlimited scalability and resource efficiency via automation. These technologies improved infrastructure management, aligning with the focus on balancing optimization and maintenance. (Singh, 2021).

These findings confirm and broaden paradigms, making them theoretically relevant. They also stress the importance of cost-effectiveness, scalability, and resource optimisation in cloud optimisation. This work contributes to the theoretical understanding of how automation and monitoring technology may foster these consequences. It also aligns with technology adoption, which emphasises how cloud optimisation tools affect DevOps. Empirical validation of the theoretical framework by gives a full knowledge of the related aspects that impact DevOps engineers' cloud optimisation tool selections. This research enhances theoretical perspectives on the mutually beneficial interplay between cloud optimisation tools and critical operational features in DevOps frameworks.

Cloud computing has revolutionised IT deployment, and cloud optimisation tools improve DevOps operations. Numerous studies support these technologies' revolutionary impacts, notably in cost reduction, resource optimisation, scalability, and maintenance. This literature review summarises the most significant study findings to provide readers an overview of where the subject is at. It's apparent that cloud optimisation technologies save expenses. The breakthrough Smith and Johnson (2020) study found that automation and monitoring technologies cut operational expenditures by 25% in six months. According to (Patel., e.,, 2020) ,cloud optimisation may save expenditures by 20–50%. All these research suggest that cloud optimisation benefits the economy and may save firms money (Patel, R., et al., 2021).

Cloud optimisation technologies may boost resource consumption. According to Thompson and (Lee, e.,, 2020), these technologies may enhance resource utilisation efficiency by 20-30%, with some situations reporting 50% savings. Increased efficiency is essential to maximise cloud resources and get more done with less. Researchers have studied scalability, particularly automation-based limitless scaling. Cloud optimisation helps organisations increase resources efficiently and adapt to changing demands without raising costs (Green, F., & Malik, S., 2018). One of the most essential characteristics of cloud computing is dynamic resource expansion. This allows organisations to adapt to a changing technology environment (Thompson, H., & Li, F., 2019).

Another benefit of cloud optimisation tools is reduced maintenance complexity. Brown and Gupta showed how these technologies enhance infrastructure management, reduce downtime, and simplify maintenance in their 2022 paper. (Fisher, D., & Kumar, S.,, 2020) found that balancing optimisation and maintenance is essential for operational efficiency. Effects theoretically: This research's empirical findings have major theoretical implications. Cloud computing and DevOps confirm and expand concepts. This research fills gaps in our theoretical understanding of how automation and monitoring systems enable cloud optimisation tools' cost savings, resource optimisation, scalability, and maintenance benefits.

3. Methodology

3.1 Introduction

This study aims to investigate the factors influencing cloud optimization for ABC, with attention to conceptual framework, operationalization, and research design. It explores research philosophy, discussing positivism, interpretivism, and critical theory, highlighting the importance of empirical observation and subjective experiences. The research approach encompasses both quantitative and qualitative methods, focusing on survey research to gather data from a representative sample, aligning with the researcher's positivism-oriented philosophy.

3.2 Data Collection

The data collection method for gathering information on cost savings determinants involved the use of online surveys distributed through digital platforms. This approach was chosen for its cost-effectiveness and efficiency in reaching a targeted group of respondents who are knowledgeable about or directly involved in cost-saving measures within their respective organizations or sectors.

3.2.1 Target Group of Respondents:

The surveys were likely directed towards professionals, managers, or decision-makers in various industries who are responsible for financial decisions and cost management within their organizations. This target group would provide insights into the factors influencing cost savings strategies.

3.2.2 Expected Number of Collected Data:

The researcher aimed to collect a substantial amount of data to ensure robust statistical analysis and generalizability of findings. The expected number of responses could range from several hundred to several thousand, depending on the reach and scope of the survey distribution.

3.2.3 Data Collection Process:

- Online Surveys: Surveys were administered via online platforms, which are cost-effective and efficient for reaching a large and diverse audience.
- Survey Distribution: The surveys were distributed widely through professional networks, industry associations, and possibly through targeted email campaigns to reach the intended respondents.
- Data Collection Period: The survey was likely open for a specified period to allow respondents enough time to participate, typically ranging from a few weeks to a couple of months.

3.3 Conceptual Framework

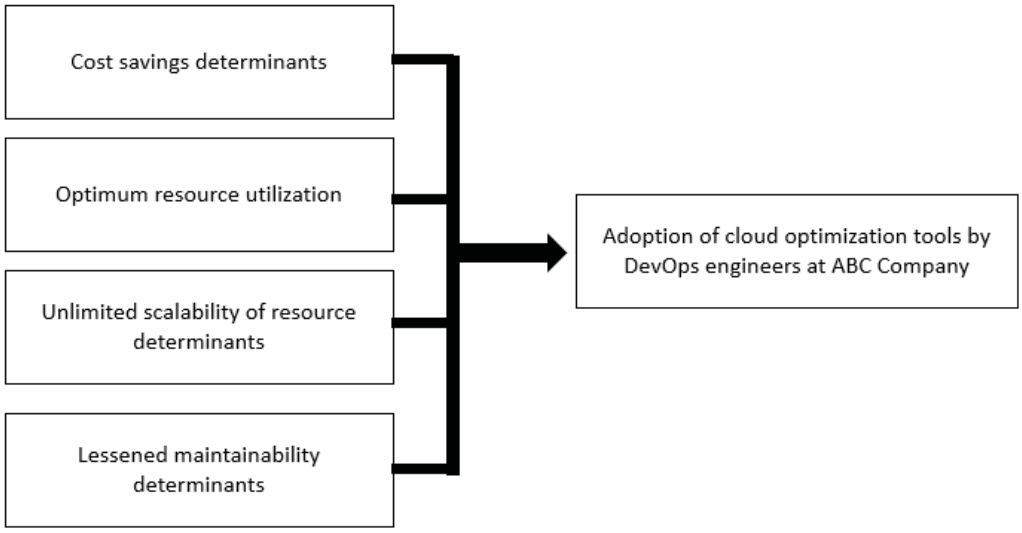

Figure 1 : Conceptual framework

3.3.1 Hypotheses of the study

The hypotheses of this research are as follows:

$H1_1$: There is a relationship between cost saving and adoption of cloud optimization tools by DevOps engineers at ABC

$H2_1$: There is a relationship between optimum resource utilization and adoption of cloud optimization tools by DevOps engineers at ABC

$H3_1$: There is a relationship between unlimited scalability of resource and adoption of cloud optimization tools by DevOps engineers at ABC

$H4_1$: There is a relationship between lessened maintainability and adoption of cloud optimization tools by DevOps engineers at ABC

3.4 Operationalization

The operationalization table is given in Table 1, which depicts the indicators and the relevant sources of the independent and dependent variables, along with the relevant question numbers from the questionnaire, measurement scale.

Table 1 : Operationalization (indicators of the independent and dependent variables, and the relevant question numbers of the questionnaire)

No	Variables	Indicators	Sources	Q No	Measurements
1	Cost savings determinants	Reduced hardware costs	(Nayar, 2018)	1	1- 5 Likert Scale
		Reduced staffing costs	(Attaran, 2018); (Margherita, E.G. and Braccini, A.M., 2020)	2	
		Increased efficiency	(Shu, W., Cai, K. and Xiong, N.N., 2021)	3	
		Streamlined processes	(Zhang, J., Xie, N., Zhang X., 2018)	4	
2	Optimum resource utilization	Resource tracking	(Suresh, 2019)	5	1- 5 Likert Scale
		Process improvement	(Viegas, E., Santin, A., Bachtold, J., 2021)	6	
		Resource allocation	(Tan, 2019)	7	
		Resource planning	(Viegas, E., Santin, A., Bachtold, J., 2021)	8	
3	Scalability of resource determinants	Flexibility	(Sunyaev, A. and Sunyaev, A., 2020)	9	1- 5 Likert Scale
		Resource monitoring	(Houssein, E.H., Gad., 2021)	10	
		Capacity planning	(Aktas, M.S., 2018)	11	
		Automation	(Sadeeq, M.M., Abdulkareem, N.M., Zeebaree., 2021)	12	
4	Lessened maintainability	Modularity	(Viegas, E., Santin., 2021)	13	1- 5 Likert Scale
		Testing	(Haorongbam, 2022)	14	
		Monitoring	(Behnamghader, P. and Boehm., 2019)	15	
		Version control	(Sriram, 2022)	16	
5	Adoption of cloud optimization tools by DevOps	Cloud strategy	(Kent, 2019)	17	1- 5 Likert Scale
		Performance optimization	(Ahmed, 2020); (Yahia, 2021)	18	
		Cost optimization	(Ruithe, M., Benkhelifa, E., 2018)	19	
		Governance	(Tan, 2019)	20	

Variables and Indicators

1. **Cost Savings Determinants**: This includes reduced hardware costs, reduced staffing costs, increased efficiency, and streamlined processes.
2. **Optimum Resource Utilization**: This covers resource tracking, process improvement, resource allocation, and resource planning.
3. **Scalability of Resource Determinants**: This encompasses flexibility, resource monitoring, capacity planning, and automation.
4. **Lessened Maintainability**: This includes modularity, testing, monitoring, and version control.
5. **Adoption of Cloud Optimization Tools by DevOps**: This involves cloud strategy, performance optimization, cost optimization, and governance.

3.5 Population and Sample

For this study's population, the researcher considered ABC in Sri Lanka. About 800 DevOps work for the company. The study's sample was randomly chosen from eligible respondents using probability sampling. Three hundred eighty-four samples were taken.

Sample size = (Z-score) (p)(1-p)/(margin of error).^{2}

Where:
Z-score = standard normal distribution value for chosen confidence level (95% confidence level = 1.96). p = the predicted population percentage with a characteristic (0.5 for greatest variability if unknown). Maximum allowed margin of error is ± 5% between the sample estimate and the real population value.
The researcher required a ±5% margin of error and did not know the expected percentage of the population having the desired attribute. Researchers utilised a cautious maximum variability estimate of p = 0.5.

Sample size: $(1.96)^2(0.5)(1-0.5)/(0.05)^2$ Sample = 384.16

To provide a 95% confidence level and ±5% margin of error, the sample size for a population of 800 is around 384.

3.6 Sampling Technique

Probability and non-probability sampling are used in scientific research. The researcher uses a random sample approach to treat survey respondents equally when estimating their chance of selection. However, with non-probability sampling, the researcher's main concern is gathering a sample that is suitable for the research task, regardless of its probability. Most studies recommend simple and/or subjective sampling. This study required a probability sampling metrology-based random sampling approach.

3.7 Data Analysis

The quantitative-focused researcher explained the study's analysis. The researcher profiled study individuals after a descriptive analysis. As they examined the 95% confidence interval implications of correlation and regression analysis, the researcher paid special attention to how the variables relate. Correlation analysis measures two variables' strength and direction. It helps researchers identify whether two factors are related and how. Correlation coefficients vary from -1 to 1. As one variable rises, the other rises with a positive correlation coefficient. As one variable rises, the other falls in a negative correlation coefficient. No correlation means no association. Regression analysis examines the link between independent factors and dependent variables. Regression analysis finds the greatest match between independent and dependent variables. Based on the independent variable's value, this line may predict the dependent variable's value.

3.8 Reliability and Validity

With reliability and validity analysis, the researcher piloted 20 samples. Survey or test items' internal consistency or reliability is measured by Cronbach's alpha. more Cronbach's alpha values indicate more internal consistency or dependability. Each item's association with the set's score determines the coefficient. Data with a Cronbach Alpha above 0.7 is credible. Validity analysis assesses a test's accuracy. It ensures relevant data for accurate findings in study design. The Kaiser-Meyer-Olkin (KMO) test determines if a dataset is acceptable for factor analysis by measuring sampling adequacy.

The KMO test determines if variables in a dataset are intercorrelated and share enough variance for factor analysis. Higher KMO values indicate better factor analysis fit.

4. Results

4.1 Reliability Analysis

The reliability analysis's effects were carefully considered due to the importance of data consistency in research. A reliability study evaluates the dependability of key research project components. This may be done by assessing critical component consistency. The researcher considered the dependability implications of the Cronbach alpha test. Researchers that claim an alpha value of 0.7 or above may be confident in their findings. The contract alpha test, which is shown in the table below, showed that both the independent variables—Cost savings determinants, Optimum resource utilisation, Scalability of resource determinants, and Lessened maintainability and the dependent variable DevOps adoption of cloud optimisation tools are reliable in the current study.

Table 2 : Reliability Analysis

Variables	Cronbach Alpha
Cost savings determinants	.809
Optimum resource utilization	.833
Scalability of resource determinants	.822
Lessened maintainability	.857
Adoption of cloud optimization tools by DevOps	.910

4.2 Validity Analysis

Data consistency was the research's main goal. This was done considering validity analysis consequences. The main emphasis of a study's validity examination should be if its main elements are reliable. After analysing all the consequences of the KMO test, the researcher focused on its validity. If the KMO number is more than 0.5, the researcher trusts the data. The KMO test results, which are shown in the table below, show that both the independent variables—Cost savings determinants, Optimum resource utilisation, Scalability of resource determinants, and Lessened maintainability—and the dependent variable—DevOps adoption of cloud optimisation tools—are valid in the current study.

Table 3 : Validity Analysis

Variables	KMO
Cost savings determinants	.764
Optimum resource utilization	.793
Scalability of resource determinants	.786
Lessened maintainability	.809
Adoption of cloud optimization tools by DevOps	.835

4.3 Discussion

4.3.1 Cost savings determinants and Adoption of cloud optimization tools by DevOps Engineers

By considering the Cost savings determinants the researcher mainly focused on the reduced hardware costs, reduced staffing costs, increased efficiency and streamlined processes. Because of these considerations, the researcher was able to formulate relevant statements for the questionnaire, which led to the discovery of the following.

Table 4 : Cost savings determinants and Adoption of cloud optimization tools by DevOps Engineers

	SD	DA	NAND	AG	SA
Reduced hardware costs associated with cloud computing is an advantage for DevOps looking to streamline their operations and reduce expenses	1	5	15	46	33
Cloud computing help DevOps reduce staffing costs by outsourcing IT tasks, automating routine tasks, and offering flexible pricing options.	5	17	21	38	19
Cloud computing increase efficiency by optimizing resource utilization, enabling agility and providing automation tools	1	3	16	49	31
Streamlined processes of cloud computing DevOps reduce costs, improve quality, and enhance customer satisfaction.	6	7	11	31	45

SD: strongly disagree; DA: disagree; NAND: neither agree nor disagree; AG: agree; SA: strongly agree

Table 5 : Descriptive statistics- Cost savings determinants

Attributes	Cost savings determinants
Mean	3.91
Standard Error	0.036782
Median	4
Mode	4
Standard Deviation	1.04035
Sample Variance	1.082328
Kurtosis	0.376425
Skewness	-0.9325
Range	4
Minimum	1
Maximum	5

According to the chart, the researcher collected descriptive data on cost savings factors. Standard error 0.036781923. “Mean of 3.91” Standard errors show a variable’s average response is 4. The study found 1.08232791 sample variance and 1.040349898 variable standard deviation. It displays values’ deviations from the mean. Variance is lowest when list values match forecasts. The variable had 0.376425187 Kurtosis and -0.932503744 Skewness. Kurtosis gives a distribution’s weight above or below its mean. Similarly, skewness shows distribution disparity. Kurtosis and skewness suggest normality.

Table 6 : Correlation analysis for Cost savings determinants and Adoption of cloud optimization tools by DevOps

		Cost savings determinants
Adoption of cloud optimization tools by DevOps	Pearson Correlation	.632
	Sig. (2-tailed)	.000
	N	200

The researcher found a Pearson correlation value of 0.632 and a 95% confidence range. A significance criterion of p = 0.05 was calculated. This observation validates the researcher's premise that the study's independent variables and dependent variables are related. The Pearson correlation demonstrates that DevOps usage of cloud optimization tools is positively correlated with cost-saving aspects. DevOps' usage of cloud optimization technologies is essential to cost reduction drivers.

4.3.2 Optimum resource utilization and Adoption of cloud optimization tools by DevOps Engineers

By considering the Optimum resource utilization the researcher mainly focused on the Resource tracking, Process improvement, Resource allocation and Resource planning. Because of these considerations, the researcher was able to formulate relevant statements for the questionnaire, which led to the discovery of the following.

Table 7 : Optimum resource utilization and Adoption of cloud optimization tools by DevOps Engineers

	SD	DA	NAND	AG	SA
Reduced hardware costs associated with cloud computing is an advantage for DevOps looking to streamline their operations and reduce expenses	1	5	15	46	33
Cloud computing help DevOps reduce staffing costs by outsourcing IT tasks, automating routine tasks, and offering flexible pricing options.	5	17	21	38	19
Cloud computing increase efficiency by optimizing resource utilization, enabling agility and providing automation tools	1	3	16	49	31
Streamlined processes of cloud computing DevOps reduce costs, improve quality, and enhance customer satisfaction.	6	7	11	31	45

SD: strongly disagree; DA: disagree; NAND: neither agree nor disagree; AG: agree; SA: strongly agree

Table 8 : Descriptive statistics- Optimum resource utilization

Attributes	Cost savings determinants
Mean	3.91
Standard Error	0.036782
Median	4
Mode	4
Standard Deviation	1.04035
Sample Variance	1.082328
Kurtosis	0.376425
Skewness	-0.9325
Range	4
Minimum	1
Maximum	5

The researcher collected descriptive data on optimum resource consumption, as shown in the table 8. Standard error for "Mean of 4.03" is 0.032064. Standard errors show a variable's average response is 4. The study found 0.822472 sample variation and 0.906902 variable standard deviation. It displays values' deviations from the mean. Variance is lowest when list values match forecasts. The variable had 0.74897 Kurtosis and -0.87151 Skewness. Kurtosis gives a distribution's weight above or below its mean. Similarly, skewness shows distribution disparity. Kurtosis and skewness suggest normality.

Table 9 : Correlation analysis for Optimum resource utilization and Adoption of cloud optimization tools by DevOps Engineers

		Optimum resource utilization
Adoption of cloud optimization tools by DevOps	Pearson Correlation	.744
	Sig. (2-tailed)	.000
	N	200

The researcher found a Pearson correlation value of 0.744 and a 95% confidence range. A significance criterion of p = 0.05 was calculated. This observation validates the researcher's premise that the study's independent variables and dependent variables are related. The Pearson correlation reveals that DevOps' cloud optimization tool use is positively correlated with optimal resource utilization. As a result, DevOps must use cloud optimization technologies to maximize resource use.

4.3.3 Scalability of resource determinants and Adoption of cloud optimization tools by DevOps Engineers

By considering the Scalability of resource determinants the researcher mainly focused on the Flexibility, Resource monitoring, Capacity planning and Automations. Because of these considerations, the researcher was able to formulate relevant statements for the questionnaire, which led to the discovery of the following.

Table 10 : Scalability of resource determinants and Adoption of cloud optimization tools by DevOps Engineers

	SD	DA	NAND	AG	SA
Resource tagging allows DevOps to label and categorize their cloud resources for easier tracking and management.		2	11	44	43
By using cloud-native design principles such as microservices, containers, and serverless architecture, DevOps can improve scalability, reliability, and cost efficiency.	1	4	19	43	33
Resource allocation in cloud computing refers to the process of assigning and distributing cloud resources such as compute instances, storage, and network bandwidth to meet the demands of applications and services running in the cloud.	2	4	27	39	28
By adopting a hybrid cloud strategy, DevOps can allocate resources more effectively based on the needs of specific workloads.	2	4	23	37	34

SD: strongly disagree; DA: disagree; NAND: neither agree nor disagree; AG: agree; SA: strongly agree

Table 11 : Descriptive statistics- Scalability of resource determinants

Attributes	Scalability of resource determinants
Mean	3.81
Standard Error	0.035858
Median	4
Mode	4
Standard Deviation	1.014214
Sample Variance	1.02863
Kurtosis	-0.2275
Skewness	-0.57058
Range	4
Minimum	1
Maximum	5

As shown in the table, the researcher collected descriptive data on resource determinant scalability. "Mean of 3.81" is 0.035858 standard error. Standard errors show a variable's average response is 4. The study found 1.02863 sample variance and 1.014214 variable standard deviation. It displays values' deviations from the mean. Variance is lowest when list values match forecasts. Kurtosis was -0.2275 and Skewness -0.57058 for the variable. Kurtosis gives a distribution's weight above or below its mean. Similarly, skewness shows distribution disparity. Kurtosis and skewness suggest normality.

Table 12 : Correlation analysis for Scalability of resource determinants and Adoption of cloud optimization tools by DevOps Engineers

		Scalability of resource determinants
Adoption of cloud optimization tools by DevOps	Pearson Correlation	.728
	Sig. (2-tailed)	.000
	N	200

The researcher found a Pearson correlation value of 0.728 and a 95% confidence range. A significance criterion of p = 0.05 was calculated. This observation validates the researcher's premise that the study's independent variables and dependent variables are related. The Pearson correlation demonstrates that DevOps use of cloud optimization technologies is positively correlated with resource determinant scalability. DevOps' use of cloud optimization technologies is vital to resource determinant scalability.

4.3.4 Lessened maintainability and Adoption of cloud optimization tools by DevOps Engineers

By considering the Lessened maintainability the researcher mainly focused on the Modularity, Testing, Monitoring and Version control. Because of these considerations, the researcher was able to formulate relevant statements for the questionnaire, which led to the discovery of the following.

Table 13 : Lessened maintainability and Adoption of cloud optimization tools by DevOps Engineers

	SD	DA	NAND	AG	SA
Cloud computing for greater modularity and scalability, as functions can be scaled and deployed independently for DevOps	3	3	17	47	30
Functional testing is used to ensure that cloud-based systems and applications are functioning correctly and meeting their intended requirements	1	7	17	38	37
DevOps conduct security monitoring is used to monitor cloud-based systems and applications for security threats and vulnerabilities	4	6	16	45	29
Version control in Cloud computing allow DevOps to enable multiple team members to collaborate on the same codebase, track changes, and manage code releases.	3	2	13	45	37

SD: strongly disagree; DA: disagree; NAND: neither agree nor disagree; AG: agree; SA: strongly agree

Table 14 : Descriptive statistics - Lessened maintainability

Attributes	Lessened maintainability
Mean	3.99
Standard Error	0.033793
Median	4
Mode	4
Standard Deviation	0.955817
Sample Variance	0.913586
Kurtosis	0.888439
Skewness	-0.98508
Range	4
Minimum	1
Maximum	5

As shown in the table, the researcher collected descriptive data on their decreased maintainability. Standard error for "Mean of 3.99" is 0.033793. Standard errors show a variable's average response is 4. The study found 0.913586 sample variation and 0.955817 variable standard deviation. It displays values' deviations from the mean. Variance is lowest when list values match forecasts. Variable Kurtosis and Skewness were 0.888439 and -0.98508, respectively. Kurtosis gives a distribution's weight above or below its mean. Similarly, skewness shows distribution disparity. Kurtosis and skewness suggest normality.

Table 15 : Correlation analysis for Lessened maintainability and Adoption of cloud optimization tools by DevOps Engineers

		Lessened maintainability
Adoption of cloud optimization tools by DevOps	Pearson Correlation	.782
	Sig. (2-tailed)	.000
	N	200

The researcher determined that the findings had a confidence interval of 95%, and based on those data, he calculated that the Pearson correlation coefficient was 0.782. Moreover, a significance threshold of p = 0.05 has been computed and determined. The researcher now has data that supports

the hypothesis that there is a relationship between the study's independent variables and its dependent variables as a result of this discovery. The value of the Pearson correlation shows that there is a significant positive association between the factors that Lessened maintainability and the adoption of cloud optimization tools by DevOps. As a consequence of this, the adoption of cloud optimization tools by DevOps is a crucial factor in Lessened maintainability.

4.4 Regression Analysis

Table 16 : Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.823[a]	.677	.671	.46856	.677	102.368	4	195	.000

a. Predictors: (Constant), Lessened maintainability, Cost savings determinants, Scalability of resource determinants, Optimum resource utilization

The model summary table shows a significant link between explanatory and response variables with a R squared value of 0.677. Regression models employ R-Squared to determine how much variation in the dependent variable is due to changes in the independent variable. The adjusted R Square statistic evaluated the correlation strength at 67.1% with 95% confidence.

Table 17 : ANOVA

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	89.901	4	22.475	102.368	.000[b]
	Residual	42.813	195	.220		
	Total	132.714	199			

a. Dependent Variable: Adoption of cloud optimization tools by DevOps
b. Predictors: (Constant), Lessened maintainability, Cost savings determinants, Scalability of resource determinants, Optimum resource utilization

At the 95% confidence level, the above-described ANOVA table shows a very significant connection between the variables ($p<0.05$).

Table 18 : Coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.391	.191		2.050	.042
	Cost savings determinants	.114	.073	.113	1.547	.003
	Optimum resource utilization	.372	.088	.334	4.237	.000
	Scalability of resource determinants	.214	.073	.212	2.920	.004
	Lessened maintainability	.452	.075	.442	6.040	.000

a. Dependent Variable: Adoption of cloud optimization tools by DevOps

The researcher used the aforementioned table of coefficients to generate the following regression equation, which has a 95% level of confidence.

Adoption of cloud optimization tools by DevOps = (Cost savings determinants X 0.113) + (Optimum resource utilization X 0.334) + (Scalability of resource determinants X 0.212) + (Lessened maintainability X 0.442)

4.5 Hypotheses Summary

Table 19 : Hypotheses Summary

Hypotheses	Status
$H1_1$: There is a relationship between cost saving and adoption of cloud optimization tools by DevOps engineers at ABC	Accepted
$H2_1$: There is a relationship between optimum resource utilization and adoption of cloud optimization tools by DevOps engineers at ABC	Accepted
$H3_1$: There is a relationship between unlimited scalability of resource and adoption of cloud optimization tools by DevOps engineers at ABC	Accepted
$H4_1$: There is a relationship between lessened maintainability and adoption of cloud optimization tools by DevOps engineers at ABC	Accepted

A study analysed ABC DevOps engineers' cloud optimisation utilisation. The research focuses on ABC cloud optimisation. Cloud optimisation tools help ABC DevOps professionals save money, optimise resources, scale infinitely, and minimise maintainability, according to the report. All these variables impact DevOps engineers' cloud optimisation solution usage at 95% significance, the research revealed. All hypotheses were 95% significant.

Kair (2012) explored how cloud optimisation tools save money. DevOps engineers saved 25% over six months by automating and monitoring their cloud infrastructure. (Khan., e.,, 2020) studied how cloud optimisation technologies save resources and money. Optimisation improved cloud resource use by 20-30% and cut costs by 30-40%. Cost decrease for cloud optimisation tools (x, 2021). The strategies cut expenses by 20–30%, with some organisations saving 50%. (Singh, e., , 2021) explored DevOps and cloud optimisation technologies. These solutions freed DevOps engineers to focus on strategic tasks by reducing infrastructure administration time. Efficiency and labour savings cut costs. Kumar (2021) explored how cloud optimisation tools use resources. Cloud architecture optimisation by DevOps developers reduced resource use by 30% over six months using automation and monitoring. Cloud optimisation technologies impact resource utilisation (Khan., e., , 2020). Optimisation increased resource utilisation by 20-30% and cloud resource costs by 30-40%. Resource usage is improved using cloud optimisation technologies (Patel., e., , 2020). The strategies increased resource use by 25–30%, with some organisations claiming 50–50%. (Singh, e., , 2021) studied cloud optimisation tools and DevOps resource use. These tools helped DevOps engineers optimise resource consumption and workload performance by reducing infrastructure administration time.

Kair (2021) evaluated cloud optimization's impact on scalability. DevOps engineers scale their cloud infrastructure infinitely and optimise resource use via automation and monitoring. tested infinite-scalability cloud optimisation methods (Khan., e., , 2020). Optimisation tools improved cloud resource management, scalability, performance, and cost. For indefinite scalability, (Patel., e.,, 2020) studied cloud optimisation solutions. Technology improved cloud resource management, scalability, and deployment. Cloud optimisation technologies impact DevOps scalability (Singh, e., , 2021). Scalability and resource efficiency enhanced with these technologies, enabling indefinite growth.

5. Conclusion and Recommendations

5.1 Summary

To conduct a hypothesis test on cloud optimization with regards to cost savings determinants, optimum resource utilization, scalability of resource determinants, and lessened maintainability, researcher needed to formulate a null hypothesis and an alternative hypothesis.

Table 20 : Hypotheses Summary

Hypotheses	Correlation
H1: There is a relationship between cost saving and adoption of cloud optimization tools by DevOps engineers at ABC	.632
H2: There is a relationship between optimum resource utilization and adoption of cloud optimization tools by DevOps engineers at ABC	.744
H3: There is a relationship between unlimited scalability of resource and adoption of cloud optimization tools by DevOps engineers at ABC	.728
H4: There is a relationship between lessened maintainability and adoption of cloud optimization tools by DevOps engineers at ABC	.782

The hypothesis test enabled the researcher assess the strength and importance of the association between cost savings drivers, optimal resource utilisation, scalability, and cloud optimization's reduced maintainability. This data might guide stakeholder cloud optimisation decisions.

Choose the best cloud provider, discover consumption patterns, and optimise resource allocation by workload to save money. Automation, efficient monitoring, and avoiding overprovisioning and underutilization maximise resource efficiency. Machine learning and AI provide real-time workload-based resource allocation. Capacity planning, elastic designs, and automated allocation make scaling resources easy. Standardised methods, patch management, automated testing, and lifecycle management may increase cloud infrastructure performance, reliability, and cost savings. Implementing these concepts makes the cloud more efficient, scalable, and cost-effective.

A detailed cost-benefit analysis, deployment and training costs, and DevOps engineers in tool selection may assist decision makers maximise cloud optimisation tool cost reductions. User-friendliness, efficient training, and collaboration boost technology adoption. Maintaining optimisation success requires DevOps engineers to monitor, analyse, and cooperate. DevOps engineers may help decision makers with resource utilisation. These engineers may pick tools, monitor utilisation, define allocation guidelines, and automate procedures. Infinite scalability requires disaster preparation, automation, and recovery. Easy-to-use cloud optimisation solutions reduce maintenance work, giving DevOps more time to focus on essential projects and better work.

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MARKETING METRICS IN PRIVATE HEALTHCARE INSTITUTION

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ABSTRACT:

Public health care institutions same as private health care institutions are present in almost every city in Croatia. Public health care institutions provide stability, security, and most of allthey are traditionally among the people in Croatia. Private health care institutions are basically young and modern institutions with different and new management system. Private institutions focus on high quality service while public institutions are more based on the higher number of the patient's examinations in one day. Service and examinations in public health care institutions are financially covered by the Croatian Institute of Health Insurance and the examinations for those patients in most of the time is free, while the private institutions are financed directly from the patients. Differences between those two health care institutions bring private institutions to organize its management differently but also bring various marketing activities in order to attract patients, keep old one, survive on the market and institutionally provide a profit. These modern institutions that started with their work not more then ten years, not only in Croatia but also in Europe, marketing activities through the marketing metrics are necessary to provide in any private health care institution regardless the fact it is all about health care and its service. In this paper it will be presented how and which marketing metrics Policlinic Intermed as a privatehealth care institution use in order to make marketing decisions and activities. Main analysesand metrics which Policlinic Intermed uses in its business are SWOT analyses and BCG metrics. Through those methods and analyses this polyclinic can make right decisions in order to bring required marketing activities for this kind of business. A purpose of this research is to bring out strategies that are necessary for making marketing decisions and activities and clarify that private institutions are different then public ones and their need to be advertise and promote in order to survive on the market.

***Key words*:** *Marketing, private health care institution, public health care institution, Polyclinic Intermed, SWOT analyze, BCG matrix.*

1. HEALTH CARE INSTITUTIONS IN CROATIA

Most known and while spread health care institutions in Croatia are public institutions. Forcountry as a Croatia which was function in socialistic organization for long time, this fact is not surprising. Public health care institutions are present in almost every bigger city in Croatia. Public health care institutions provide stability, security, and most of all they are traditionally among the people in Croatia. Through the public health care insurance and its organization, citizens or in this case patients in Croatia have almost every health service in public hospitals for minimum fee or even it is free of charge. (Babic and Roksandic, 2006, 21). This kind of health care organization in Croatia, present most common difficulty in organization, service quality, satisfaction or dissatisfaction among patients but also among doctors and medical stuff. (Babicand Roksandic, 2006, 83). A huge number

of patients do not create only dissatisfaction, but also a pressure on doctors to examine a lot of patients in short period of time. Croatian institution of health care insurance in this case provides health care for every citizen in Croatia, however, the quality and addiction to a patient is a good question to observe. (Babic and Roksandic, 2006, 153- 155).

This kind of opportunity of bringing health care situation on the higher level, noticed private health care institutions, providing better organization, improved quality of service and focused more on patient as a unique customer. Higher quality of service that is accompanied with professional knowledge is the main key and the strongest position that private health care institutions can offer to their patients. ("Hrvatski zavod za zdravstveno osiguranje zaštite zdravlja na radu", 2022).

Fortunately, health care comparing to other sectors of society is highly effort concentrated project. That means that this topic in Europe Union was presented in right timing where they showed increasing interest of health care system. (Dubois, McKee, Nolte, 2006, 1). However, Croatian health care institutions will have to wait until its join to European Union in addition to confess any changes. According to other European countries, private health care organizations are also quite new. A decade ago it was hard to conceive that private and public health care organizations would be competing each other. Governments everywhere, including the social market economies of Western Europe, have a new-found interest in privatizing services and redrawing the boundary between the public and the private. According to this status of private and public health care system, it challenges many opportunities to explore anxieties between publicly funded health care systems and private ones. (Drache and Sullivan, 2005, 16)

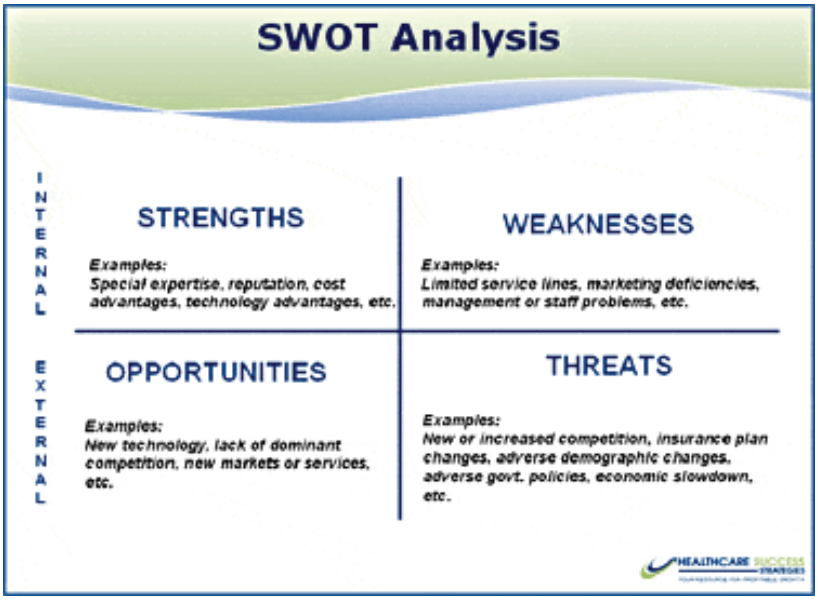
2. ORGANIZATION AND SERVICE QUALITY IN THE PUBLIC HEALTH CAREINSTITUTION, COUNTY HOSPITAL POZEGA

Public health care institutions in Croatia are traditional and most likely attended among the Croatian people. Since lately people in Croatia did not have any other choice and any different opportunity to experience other service than in the private health care institution Number of population trough the past has been changed, while the most of those public hospitals did not change a lot. Today, situation in most of public hospitals is in deficiency of doctors in almost every type of specialization. This fact brings public institutions with smaller amount of doctors and increasing number of patients. Result of this situation certainly is no good for the hospitalsfor the doctors or most of all for the patients. In this kind of situation patients are waiting too long for some examination, a waiting list of different medical technology examination are too long, sometimes patients have to wait more than six months to be exanimate. Among all of those patients, doctors do not have enough time to dedicate on a patient. Furthermore, patients most of the time do not have time for questions or explanations of their certain problem or diseases. Dedication and service to a patient in this kind of health service cannot be in high quality as patients deserve to have. However, in the last few years, the Požega hospital has recorded significant investments in order to maintain the level of health services it provides at a high level, and during the past three years alone, 4 million euros have been invested in infrastructure works and equipment (Slavonski.hr, 2024.). In most cases patients do not have other choices then be cured in those public health care institutions. In some areas in Croatia there are both public and private health care institutions. Different kind of private institutions are more likely in bigger towns in Croatia. However, in Pozega-Slavonia County, there is one private polyclinic. (Cesarik, 2020).

2.1. SWOT analyze in public health care institution

This kind of analyses is a reflection of any institution's evolution of strengths, weaknesses, opportunities and threats. The main assignment of this analyze is to follow external and internal impacts of surrounding. Internal surroundings apply to strengths and weaknesses, while external impacts apply to opportunities and threats. (Kotler, 2008, 52). Through this table of analyzes it is easy to see which are preciously and exact strengths and weakness of the public hospital in Pozega, and exact opportunities and threats as external impacts on this public health care institution.

Figure 1



Source: Healthcare success, 2024.

S - Strengths	W – Weaknesses
1. Tradition hospital	1. Insufficient training of managers in management of health
2. Built in basic physical infrastructure - a unique building hospitals	2. Marketing and advertising activities
3. Supply of new, modern equipment-tracking new technology	3. "Burn out" syndrome at work, and low self esteemof employees
4. Developing human capital	4. Improper management of conflict and neglect ofteam building
5. Awareness of their ownresponsibility for the development of hospital	5. The low level of systematic risk management -(clinical adverse event)
6. Caring about quality (Total quality management)	6. Low IT equipment - lack of modern IT department
7. Adjustment to specificterms and conditions	7. Poor construction quality of hospital facilities poor plumbing, electrical and other installations
8. Own technical service	8. Absence of alternative sources of energy
9. Equal development of all hospital departments	9. Poor air conditioning
10. Concern about the environmental clean hospital environment	10. Technical safety of old appliances
11. Rational investing	11. Weak alternative sources of income
12. Organization of nursingstudies	12. External security service and other maintenanceservices (outsourcing)

O - Opportunities	T - Threats
1. Travel and tourist offers, Wellness Centers	1. False attitude of the state
2. Developing Centers of Excellence	2. Ownership underdeveloped local government
3. The development of hospice, Department and palliative care	3. Political changes and political interference in management of hospital
4. Participation in international projects	4. Unstable business environment and development
5. Participation in government programs	5. Inadequately system of protection against external risks
6. Inclusion in the "Evidence based medicine"	6. Traffic isolation (Pozega ravine)
7. Collaboration with clinical hospital centers in Croatia	7. The unreasonable demands compensation claims, a large "appetites" of lawyers and their "cooperation" with the judiciary and the insurer
8. Cooperation with the College in Pozega	8. Revenue from the budget and Croatian institution of health insurance
9. Continuing education in leadership and management in health services	9. Monopolistic behavior of Croatian institution of health
10. Health services outside the basic insurance Health Insurance	10. Underdeveloped and unclear system of accreditation of hospitals
11. Collaboration with patients and patient associations	11. Vertical and horizontal communication

2.2. Medical technology and staff in public health care institution

Most of public health care institutions or hospitals in Croatia same as in county hospital Pozega, contain with satisfied medical technology. According to health care situation today and in the past, Croatian institution of health insurance provide as best as possible medical technology, however, the number of those medical technology is never enough. Medical technology costs a lot and it is hard to follow new and improved technology. Same situation is in county hospital Pozega, however, this hospital invest in new technology as much as opportunities it can gets. In 2015 this hospital bought a 10 mil kunas worth MR, in 2019 it also invest in new integrated operating room worth 3 mil kunas. After six decades, using the funds of the European Union, the children's department of the Požega hospital was renovated and equipped with the most modern equipment. The project, which included the Children's Department with a day hospital and one-day surgery, is worth several million kuna, so 16 million kuna has been set aside for construction work, while the equipment and associated devices cost more than 18 million kuna. However, the main problem in this hospital is long waiting list of examinations on different medical technology. Rarely appear situation when some medical technology damage and then appears a huge handicap in whole hospital. Waiting lists, that are already long, they are making huge loss for patients and medical stuff. (Požeška Kronika, 2015, 034 Portal, 2019, Požeška Kronika 2020).

Medical stuff in public health care institutions are high qualified and well educated. In Croatia most of doctors are employed in public health care institutions. In some cases they can chose which specialization they would like to specialized, but in same cases is not likely. Ambitions especially among young doctors can be seen, however, in this situation in public hospitals creates impropriate conditions at work places, frustrations and inability to improve their skills. It this situation nurses in hospitals are mostly preoccupied among huge number of patients that need medical care. (Markovic, 2022).

According to this situation doctors and nurses do not have time, ability and motivation to improve their service toward the patients. It is not reasonable to blame directly those employees and their

lack of motivation, adequately solution for this situation would be in improving quality of human resource management and its organization. (Cesarik, 2020).
However, the situation of lacking number of doctors is slowly going to a better position for both of doctors and patients. Some of doctors are coming back from different tows and foreign countries and like UK and Austria. (034 portal, 2024).

3. PRIVATE HEALTH CARE INSTITUTION IN POZEGA-SLAVONIA COUNTY

In Pozega-Slavonia there is only one private health care institution. It is Polyclinic Intermed, which is established as a private health care institution in late 2005. This polyclinic is located in city of Pozega surrounded with health center; laboratory, retire pension centre and all that very nearly to the down town center. This private health care institution covers several medical specializations. This medical specializations are based on intern medical diagnostic and they are; gynecology, radiology, pediatric specialization, urology and occupational medicine. (Polyclinic Intermed, 2023)

3.1 Organization in private health care institution, Polyclinic Intermed

From the very beginning this private polyclinic has well known management organization. On the head of this polyclinic is a manager whose idea was to start this business. Yes, a difference according to the public health care hospitals can already bee perceive. Meaning that this health care institution in not institution for social caring problems as public hospitals sometimes appear to be. However, private institutions are profitably organizations, while hospitals as public health care organizations basically are nonprofit organizations. Operational parts of this polyclinic after the head master are financial department, marketing department, maintaining and safety insurance department. Present employees, without polyclinic Intermed could not even work are professional doctors with different specializations and nurses who are focused on patients comfort. In this polyclinic, same as in many others in Croatia, doctors work both in public hospitals and also in private polyclinics or clinics. Frequently, doctors in polyclinic Intermed come to polyclinic in late afternoon or in the evening of even in the morning if the certain appointments for examinations are made. In the morning doctors work in the county hospital Pozega, and in the evening of afternoon they arrive in polyclinic Intermed. In cases when examinations are planned for the mornings, doctors arrive in polyclinic after their night shift in county hospital Pozega. Those double shifts are their choice of work.

3.2. SWOT analyze in private health care institution, Polyclinic Intermed

From the very beginning of its opening, this polyclinic monitor all aspects of SWOT analyze. Threats and weaknesses are results of micro and macro impacts that influence on achievement of this institution. Micro impacts are for example political effects, social cultural effects, demographical economic effects, technological and other similar effects, while macro impacts are clients, suppliers, employees and for sure possible concurrent. It is necessary to monitor active trends in order to establish a right marketing advisable system. The role of managers in this work is to identify opportunities and threats to a specific company. Manager should observe this situation in addition to establish an environment of opportunity and be able to recognize a good marketing and lead a company to develop and achieve profits. Marketing creates opportunities that support the company's areas of need and interest of customers and in that case profit and development can be content. (Kotelr 2008, 52),
After understanding the knowledge of opportunities, it is necessary to recognize those needs andbe able to use them, while before this polyclinic should be aware of its strength but also its weaknesses.

In some cases, Polyclinic Intermed necessarily do not work imperfectly, however,bad connection and low mutual collaboration as a team it is easy to crates its disadvantages.

3.2.1. Strength of Polyclinic Intermed and its marketing potency

The main strength in Polyclinic Intermed lies in ambulance of workers health care. Examinations that are necessary are also an obligation by Croatian law. Those examinations include examinations for professional drivers or regular drivers, before person's firs job, hunters, mariners, firemen, securities, periodically examinations and for other positions with special term on working places and conditions. Those examinations are usually in most of the cases are charged that moment after examination and for very correct prices. Moreover, equipment that is necessary for examinations are not expensive, which automatically reduce an amount of first but also later investing. In that case Polyclinic Intermed will have more money and bigger fond for marketing activities. In other perspective, amortization for this part of polyclinic is not that big as it is in other parts of diagnostic ambulances. Polyclinic Intermed with various diagnostic opportunities and huge spectra of examinations have capability to offer different diagnostic examination packets to all kind of companies. Those examinations are based on female and male special examinations that can be basic examinations or more detailed and specific examinations. Difference between those examinations is also price that very from the examination to examination which can be flexible according to companies' arrangement. Those kinds of systematic examinations toward companies are the exact way to survive today's crises. The reason why is that huge number of people cannot afford that kind of expense, however, through their company that cowers payments, they will be able to make certain examinations and polyclinic will achieve certain amount of patient's examinations. Furthermore, considering the marketing costs in this situation is basically on minimum but a product for a business and patients is on maximum. Marketing effects will be reached through the patient's experience which will be transferred (from mouth to mouth) to other potential patients. Situation like this creates a circle which positively connects company, patients and Polyclinic Intermed. Polyclinic achieves a number of examinations and marketing advertising through the patient satisfaction (or dissatisfaction), companies shows its care to their employees or if they have lack of their cash budget, compensations in some cases can be managed, while patients gets their better care for their health.

3.2.2. Weaknesses of Polyclinic Intermed

Unfortunately, the giant weakness of this polyclinic is the huge investment in many different diagnostic branches such as gynecology, radiology, cardiology and gastroenterology. Furthermore, equipment which was necessary for those various ambulances are enormously expensive and consist of ultrasounds, mammography, endoscope and others. Polyclinics employ high educated specialized doctors, their income are high which also impact on the budget of this polyclinic. According to those facts Polyclinic Intermed did not start with aggressive advertising, however, it continuously manage to be present on its potent ional market trough the local advertising media. Best advertising and reference is trough the patients. It is the strongest and effectively the best way to promote this kind of health service; however, as it can be positive patient's experience, it could also the bad one. Polyclinic Intermed is not a perfect health care institution and mistakes happens, but with good intern communication and team work, all together crates atmosphere where a patient is on the first place.

3.2.3. Possibilities of marketing freedom in Polyclinic Intermed

As already mentioned, Polyclinic Intermed do not have realistic concurrence because it is only one private health care institution in this county. However, in some fields Polyclinic Intermed can feel concurrence from the public health care institute or hospital. The possibility that private health

care institutions have according to public one is the huge opportunity of marketing and advertising. In that case polyclinics are other private health care institutions can plan their marketing activities on free market in order to attract new patients, but also to keep the old one and crates a loyalty. Polyclinic Intermed through its marketing activities and freedom crates a message of awareness and importance of patient diagnostic and prevention. Today many dates show the real importance of prevention in addition to prevent certain diseases in order to be cured.

3.2.4. Marketing threats in Polyclinic Intermed

The real threat for all kid of private health care institutions would be in case that Croatian ministry of health forbids any marketing activities in addition to promoting business instead of health. However, if Croatia plans to be one of European Union countries, this scenario should not be achieved. Croatian ministry of health can strictly define trough a law how and why they should use marketing strategies in order to be moral and human.

4. BOSTON CONSULTING GROUPE (BCG Matrix) IN POLYCLINIC INTERMED

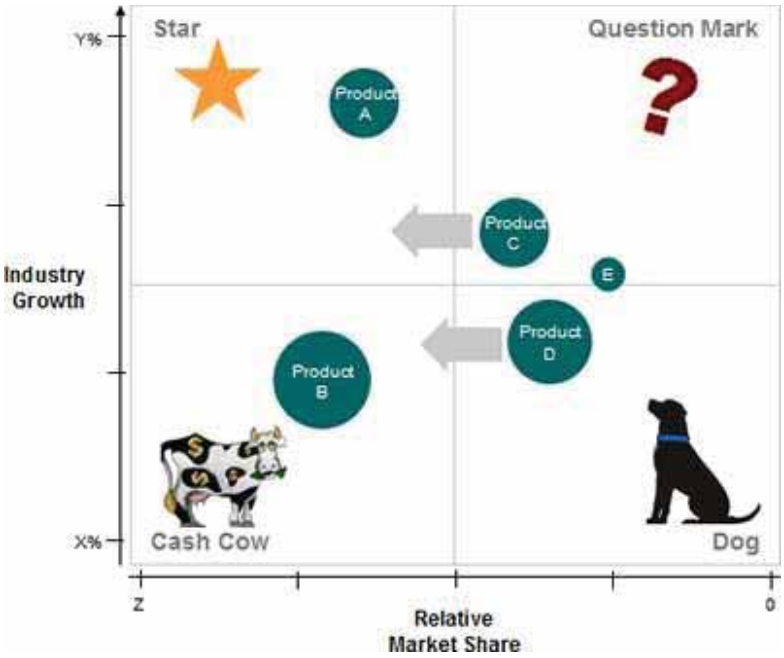
The BCG Matrix is method which is based on the product life cycle theory that can be applied in any company. Using this kind of method it is easily to verify what priorities should be given in the business to achieve a harmony. („Sveucilisni studijski centar za strucne studije“, 2010). Furthermore, to guarantee a long term value creation, any company that relay on this method should have a portfolio of product or service that contains both high growth product or service, in addition of cash contributions and low growth products that make a lot of cash. (Economy
Faculty in Zagreb, 2010).

Like in many different companies that are based on product or service, BCG matrix also can be applied in Polyclinic Intermed. This polyclinic has its stars that presents high growth and high market share, then cash cows that presents low growth and high market share, furthermore, the dog which means both low growth and low market share, and of course the question marks thatare related with high growth and low market share. According to this analyze, each medical branches can find its role in this matrix. The star in Polyclinic Intermed is an ambulance of gynecology; the question mark is radiology, while the cash cow is ambulance of workers health care. The dog with lowest potential to survive is gastroenterology.

Applying this kind of matrix on Polyclinic Intermed is not just to have clear and realistic visionof the business of all, but to have a prediction and guidelines where and why act and react in marketing activities. From this matrix it can be shown which part of specialization for some reasons should be liquidated, in that case marketing activities are worthless and any kind of advertising would be unreasonable way of spending time and money. Cow cash in this situation is specialization which investments are low; however, examinations are obligation that Croatian health law proscribes. In that case marketing activities are needed but in certain period of year potential targets are known and the actions are accommodated. For example, enrolment in high schools for certain occupation in middle of the year is ritual that is iterative and in that case Polyclinic Intermed makes sure that student knows about Polyclinic and where to find it, same as introduce Polyclinic to center of employment. The question mark is radiology which insisted a huge amount of investing in medical technology, which is automatically related to high amount of money. However, it does not that Polyclinic Intermed should not spend to promote and advertise this specialization if it has realistic chance to increase the amount of potential patients. The last part of BCG matrix is the star which is gynecology, the leading light of this polyclinic. Ambulance of gynecology has loyal patients which are willing to

pay for their examinations. However, it is necessary to create a increasing number of new patients. This goal will be achieved with patient's positive experiences, but it is also necessary to provide marketing activities in order to success and make this star even lighter.

Figure 2 BCG MATRIX



Source: 12 Manage, 2011.

5. SERVICE QUALITY IN POLYCLINIC INTRMED AS MARKETING LABEL-BRAND AND REPUTATION

Providing highest quality of service, a harmony of any kind of service business has to be based on determined and controlled roles of the workplace. Private healthcare institutions are organizations based on medical professional stuff for the purpose of providing a medical service to a patient. These exact medical employees are real presenters of certain medical organization or healthcare institution. (Fried, Fottler, Johnson , 2005, 301). Moreover, importance of harmony and professionalism of this kind of work and its service is critical for any private healthcare institution to survive on its market. Polyclinic Intermed as a private health care institution in not financial supported with Croatian institution of health insurance. This private institution income gets from its own patients. Patients that are willing and patients that have enough financial support can cover themselves examinations that this private polyclinic can offer them. According to those facts every patient in this institution is valuable. Patients in this situation do not depend on the service that Polyclinic Intermed is offering to them. In other word it is only patients' free choice to be treated in thiskind of health service and also to pay for this service or rather is examined in public health care institution. Where does lay a difference? A difference is exactly in the service quality and howthe human resource management is conducted. As already mentioned, every patient in Polyclinic Intermed is valuable, that means that all business and attention is focused on the customer or patient. Every employed person in Intermed has its roll how and in which way to please a patient.

Not only in private healthcare institutions but also in any other institution that is based on healthcare of a patient. According to definition of World Health Organization (WHO), every person of medical

profession is a person engaged in activity whose primary purpose is to enhance health. (Dal Poz, Gupta, Quin, Soucat, 2009, 12).

Nurses are the first employed persons who are patients' first contact to the polyclinic. First impression that patients get are nurses who are open and welcome for any information that they might need. This "one on one" contact is personal and individual based on patient's problem or issue. In very comfortable ambient patient should feel confidence and satisfaction. Nurses have obligation to make proper schedule of waiting list. This waiting list is important part of the organization system of this polyclinic. Situation on so called market is that patients are waiting to long for certain examinations of certain medical technology examinations, and it is a real issue to be efficacy and precisely on making an appointment for patient who will after all pay for his or hers examination. If the waiting lists are too long in the polyclinic patients will rather go in public hospitals or even wait few days longer and go in public hospitals then attend private polyclinic and pay for their examinations or examinations on certain medical technology such as ultrasounds or mammography. Nurses are basically a soul of this polyclinic. They are not the main object here, however without them this polyclinic could not function. Moreover, they care about patient's accommodation, privacy; information that they need, also that patient's results of examinations comes on time and be on right place in right time. The whole idea is to satisfy every patient on its comfortable way with one on one service, and patient should feel satisfied for that service that he or she is paying for. After experiencing wonderful and caring nurse's service, patients are having their moment of time with a certain doctor they need. Comparing to the public hospitals, here patients have enough time for all questions and dilemmas on which they would like to have answers. Doctors are focused on that patient and its unique problem as much as it is possible. Every patient has minimum 15 minutes with a specialist alone. In most of the cases this period of time showed that 15 minutes are enough for every patient's need. In any time the whole team is prepared to organize other patients in a case when this 15 minutes progress in 20 minutes or more. Thanks to well practiced organizations of waiting list, there are no many patients in the waiting room sitting and anxiously waiting for their turn. Having this kind of organization gives patient maximum privacy, in other words, less people in waiting room – more privacy. Moreover, at the moment when patient comes in the waiting room and do not see many people in a waiting room for the examination, his thoughts do not immediately goes to an idea that he is going to wait so long. With enough time, professional skills, proper information and high knowledge every patient in polyclinic Intermed have the best treatment that this private institution can offers. Both, nurses and doctors have previous experience in public health care institution and they are aware of differences how and why they should approach to a patient with proper quality of service.

High service quality in every private health care institution in Croatia is a basic characteristic that is required. Private polyclinics are institutions that are free on their market, ready to attract their potential patient in order to appear in private polyclinic. Particularly in this case, polyclinic Intermed according to its position where people are basically with lower incomes has to prove and crate certain level of quality service in order to create amount of loyal patients and create a new. Those patients have to get better and higher quality of service then it is possible to get in public hospital. In other scenario if the quality of service is poor or even worst then in public hospital, it could lose its patients. Loosing patients means reducing number of examinations, meaning that income is lowering. In this situation any kind of marketing activities or advertising would not help private polyclinic to make any profit. This kind of service, health service is based on loyalty, quality, professionalism and comfort of every patient that steps in polyclinic. Low quality of service brings bed reputation that spreads quite fast in small city of Pozega.

6. HUMAN RESOURCE AS THE BEST MARKETING LABEL IN POLYCLINICINTERMED

Many different companies provide service in different ways. Healthcare industry has this kind of service that provides care for a people who seeks for assistance. This kind of service has toprovide a trust and certain level of intimate relationship. Although, human resource department of healthcare centers has huge part of responsibility. Duties of human department are to protect and support the quality of patient's relationship with the healthcare person. To create a healthy and positive environment in any healthcare institution it is important to provide satisfied employees that will impress their satisfaction on patients with full concerned and thoughtful care. (Shi, 2007,9).

Human resource in polyclinic Intermed corresponds between this particular and unique social type of business and professional medical stuff. In addition to make any progress in this type of business it is unavoidably to respond on management requests supported with professional medical employees. Polyclinic Intermed had its important duty to insure employees' adequate and professional education same as motivation, and all that supported with right ways of developing its career. Additionally, by increasing job satisfaction of each employee and mange his personal development brings the company on the higher level.

One of departments that cannot be forgotten in the whole organization of the polyclinic Intermed is marketing department. During the process of bringing some marketing progress, each medical stuff is involved. Involving doctors in radio interview and informing potential patients on importance of prevent diagnostic brings those employees on caring and moral level of satisfaction. Furthermore, doctors have ability to express their knowledge and unique experience in polyclinic Intermed in specialized news papers intended for medical stuff. Both doctors and nurses are attending specialized convections to improve their knowledge and to be aware of new information in medical profession. Improving and refreshing polyclinic internet site with new interesting, actual and useful information is a duty that nurses maintain. According to profession, economist or any other occupation cannot replace this duty. Making this organization decision, nurses have their freedom of expressing their creativity. Sometimes it is challenge, sometimes itis motivation but it is obligation and responsibility for all of them. By organizing different actions such as free measuring of sugar in blood, free measuring of human pressure, information lecturefor pregnancy, lecture for people with high pressure and others, nurses and doctors have opportunity for their creativity and expression. Moreover, the most important information that future patient should be aware is the importance of prevention and examination for their real health status. Indirect education of all medical stuff of polyclinic Intermed should motivate both patient and medical stuff. Making a circle between patients, nurses, doctors, marketing department and manager's ideas and obligations should bring high quality of service same ashigh quality of human resource.

7. HELP BY OECD (ORGANIZATION FOR ECONOMIC CO-OPERATION ANDDEVELOPMENT)

OECD is organization that was established in late 1961, its main head office is in Paris. Todaythis organization counts 34 countries as their memberships that dispose with more than 328 million Euros budget. What and how this organization has influence in health care system? This organization and its progression trough the publications (special magazines) analyses the organization and performance of health systems and its variations. Studies are conducted on requested topics as co-ordination of care, pharmaceutical pricing, long-term care and disability, health workforce and international migration of health workers, information and communications technologies in health care. Furthermore, it focuses on policies and institutional features which most affect the supply and demand of care, but also the

fairness in access and the ability of governments to control public spending. In order to improve public health care system in many countries, not just in Croatia, it is a mission of correlation of both political influences and citizens who are has ability to design institutions and health care policy which will have high efficiencyof health care systems. The OECD collects detailed information on health policies and institutions governing health insurance and coverage, health care delivery, and the allocation and management of public health care spending. Through its missions and policy this organization helps countries that desire for better health care organization, or even any other king of organization. According to long term experience, this kind of organization might be a good choice for Croatian complex and ravel situation in health care system. (Joumard I., Hoeller P., Andre C., Nicq C, 2010, 96). Private health care institutions encourage government to fulfill a number of objectives, to reduce administrative and financial burdens, in order to providing public services increase efficiency and effectiveness of services to achieve value for money, encourage innovation, and develop more user sensitive services. All that because privatization brings interests of both government and manager in orders to improve its performances. However, another explanation for privatization in health care system is to give consumers or patients a stronger voice through increased choice and competition. (Saltman R.B., Bankauskaite V., Vrangbæk K.,248).

8. CONCLUSION

Today in Croatia both exist, public and private health care institutions. In general, offer and quality of available health services is improved. There are many similarities between public and private health institutions, but there are many differences between them. Private health care institutions have their marketing freedom in order to attracts potential patient, while public health care institutions do not have that experience, moreover, public hospitals usually have more patients then it could handle. Very often this kind of scenario brings health care institutions in situation when public hospitals have long waiting lists and in private polyclinics there is lot of unused capacities, especially in small cities such as Pozega. City of Pozega is placed in Croatia where people basically have low incomes which brings them to attend public hospital more then private one. Sometimes it is not that they do not want to experience a good quality of health service, but they usually cannot afford that kind of luxury. According to those facts polyclinic Intermed has to adjust it marketing activities on the way potential patients or potential companies can respond. That is why human resource, high quality of service and marketing and management analyses are the right key of exact kind of advertising in addition to crate as larger as possible number of patients in order to survive on this kind of market. Polyclinic Intermed, in today's difficult financial situation had to reduce its marketing activities, however, fortunately it did not resulted with lower number of patients, examinations or incomes. With quality analyses and team work, basing on right marketing target Polyclinic Intermed manage to survive extremely hard insufficiency.

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