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Highlights

Intergovernmental Transfers in Fiscal Federalism | Economic Worth of Microalgae in Urban Lakes | Product Cannibalization |

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Strengthening Fiscal Federalism Role of Inter-Governmental Transfers in India

Anuradha Prasad[1]

Abstract

The founding fathers of modern India laid the foundation of a federal governance system in the Constitution of India. It is a model of federalism that is unique to the country and perhaps best suited to manage the diversities of a large population in a democratic polity. It is a system that has endured for over 75 years adapting itself to developments over time. This article has analysed the system of fiscal transfers from the Centre to the States and attempted to delineate the measures that can be taken by the States in light of the recent developments.

1. Constitutional Context

Although the word 'Federalism' is not mentioned in the Constitution, the essence of a federal system is imbibed in Article 1 itself which lays down that "India, that is Bharat, shall be a Union of States". The Constitution provides for the division of legislative and administrative powers between the different tiers with a considered tilt towards the Centre.

Fiscal federalism broadly considers the vertical structure of the public sector, fiscal policy institutions and their interdependence.[2] Article 246 of the Constitution delineates the powers of the Union and the States through three Lists in the Seventh Schedule, namely, List I (Union List), List II (State List) and List III (Concurrent List). Centre's primacy has been ensured as the residual powers have been vested with the Union including powers to impose any tax not mentioned in either State List or Concurrent List. Moreover, in case of conflict, the Central law will prevail over the State law.

From the division of subjects between the Union and the States, it is clear that there is an asymmetry between the taxation powers and the functional responsibilities. While the Centre is assigned with taxes with higher revenue potential, States are assigned with more functional responsibilities.[3] The Reserve Bank of India has estimated that the vertical fiscal imbalance in India is higher than in

[1] Ministry of Home Affairs, Government of India.

[2] Singh N.K. and Mishra P.K. Recalibrate, Changing Paradigms, pp 53

[3] Commission on Centre-State Relations (Punchhi Commission) Report, Volume III, March 2010, pp 8

countries like Brazil and Canada with Indian States collecting 37 per cent of general government taxes while spending 64 per cent of total expenditure.[4] Further, there is also a horizontal imbalance due to the varying capacities of the States to raise revenues to fund their functional responsibilities.

The Constitution has provided for the transfer of resources from the Centre to the States to address the vertical and horizontal fiscal imbalances. There are three windows through which the resource transfer takes place, namely, in the form of States' share in the divisible pool of Central taxes, grants-in-aid under Article 275, and grants and loans under Article 282 and Article 293, respectively. The first two are statutory transfers recommended by the Finance Commission constituted under Article 280. The non-statutory transfers under Articles 282 and 293 are in the form of discretionary grants and loans to States outside the Finance Commission, example, grants under the Centrally Sponsored Schemes (CSS) with shared funding by the Centre and States, especially in areas of health, education, rural development, malnutrition, etc. and the scheme for interest free loans to States for capital expenditure introduced in 2020-21 in the wake of Covid-19 pandemic and continued since then.

2. Democratic Dynamism – Changing Nature of Transfers and Responsibilities

The model of fiscal federalism as laid down in the Constitution has not remained a static construct. As the Indian democracy has matured, so has the federal system evolved to accommodate the demands for greater devolution of powers and resources to the States even as the Centre has intervened from time to time to direct the allocation of resources to ensure all-round inclusive growth.

The ambit of tax sharing arrangement has enlarged over the years to impart greater certainty and progressiveness in the resource flows to States. The successive Finance Commissions have devolved larger share of taxes either by enhancing the coverage of shareable items or by increasing the percentage of States' share in the divisible pool. In this context, the Tenth Finance Commission (1995-2000) marked a significant milestone. Till then, proceeds of only personal income tax and union excise duties were shareable with the States. Corporation tax had been excluded from the divisible pool consequent upon an amendment in the Income Tax Act in 1959.[5]

Based on the recommendations of the Tenth Finance Commission, Parliament enacted the Constitution 80th Amendment Act in 2000

[4]State Finances, A Study of Budgets of 2023-24, Revenue Dynamics and Fiscal Capacity of Indian States, pp 39

[5]Tenth Finance Commission Report, Chapter V, pp 20 and 21

to provide for the sharing of net proceeds of all Union taxes and duties except those referred to in Articles 268 and 269 and cesses and surcharges under Article 271. This allowed the States to share in the buoyancy of total tax revenues of the Centre.

Service Tax was introduced by the Centre in 1994 under its residual powers and was later included in the divisible pool of taxes till its subsumption in GST.

Notwithstanding the enhancement of the divisible pool, substantial flow of resources to States has continued to take place beyond the Finance Commission Transfers. The adoption of five-year plans and the constitution of the Planning Commission in 1950 had created a parallel system of fiscal transfers not envisaged in the Constitution. Over time, the share of untied formula-based Plan transfers was dwarfed by other conditional Plan assistance including scheme-based grants. In 2013-14, the formula-based Normal Central Assistance was only around 24 per cent of the total Central Assistance for State Plans.[6]

The States also had to assume the compliance and enforcement costs of a number of legislations enacted by Parliament over the years. Central laws, such as the Wildlife Protection Act 1972, the Forest Conservation Act 1980, the Environment Protection Act 1986, the Biological Diversity Conservation Act 2002 and the Forest Rights Act 2006 have placed the burden of compliance on the States.

Central laws termed as 'entitlement-driven legislations'[7] were also enacted to create a structure of legally enforceable rights and entitlements to ensure uniform service delivery across States and accountability on the part of the Government at all levels. The examples of such legislation are the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), 2005, the Right of Children to Free and Compulsory Education (RTE) Act, 2009 and the National Food Security Act (NFSA), 2013.

The above developments led to the States demanding the restructuring of the fiscal transfers to increase the flow of non-discretionary funds.

3. Post-2014 Structural Transformation

The fiscal system underwent a structural change after 2014 due to two major developments. The first was the winding up of the Planning Commission, the Central Planning body for formulating Five-Year Plans and allocating resources to the States for their implementation. It was replaced by the NITI Aayog or the National Institution for Transforming India, an apex public policy think tank of the Government of India tasked with catalysing economic development but without any role in allocating funds.

[6] Source – Union Budget Documents

[7] Singh N.K. and Mishra P.K. Recalibrate, Changing Paradigms, Chapter3, Federalism in a Flux, pp 61

The fiscal space vacated by the Planning Commission was used by the Fourteenth Finance Commission to address the demands of States for more unconditional transfers. The Commission which gave its report in December 2014 covering the period 2015-2020, recommended an increase in the share of tax devolution to 42 per cent of the divisible pool as against 32 per cent under the Thirteenth Finance Commission award. The Fifteenth Finance Commission (2021-26) recommended the tax devolution at 41 per cent, maintaining the level of 42 per cent under the Fourteenth Finance Commission with an adjustment of about 1 per cent due to the bifurcation of Jammu and Kashmir into two new union territories of Ladakh and Jammu and Kashmir.

A second structural change in the fiscal federal landscape came about with the introduction of the nation-wide unified GST with effect from 1st July 2017 and the constitution of the GST Council following the enactment of the Constitution 101st Amendment in 2016. Both the Centre and the States enjoy concurrent jurisdiction to levy GST on a common base and share the revenues equally on 50-50 basis.

The compositional shift in fiscal transfers sought to be achieved by the Fourteenth Finance Commission through an increase in the share of unconditional transfers has been off-set by an increase in cesses and surcharges imposed under Article 270. The revenue collected by the Union government from cesses increased from 6.4 per cent of its gross tax revenue in 2011-12 to 17.7 per cent in 2021-22. This has resulted in shrinkage of the divisible pool from 88.6 per cent of the Centre's gross tax revenue in 2011-12 to 78.9 per cent in 2021-22 despite the 10 percentage point increase in tax devolution recommended by the Fourteenth Finance Commission.[8] However, tax devolution as a percentage of GDP has gone up from 2.8 per cent in 2011-12 to 3.8 per cent in 2021-22. The total resource transfer from the Centre to States has also increased from 6.1 per cent of GDP in 2011-12 to 7.2 per cent in 2021-22[9].

There has also been a change in the funding pattern of Centrally Sponsored Schemes from Budget 2015-16 with enhancement in the States' share and corresponding reduction in the Central support.

While the recent trends would appropriately be taken into consideration by the recently constituted Sixteenth Finance Commission, they also highlight the need for the States to reduce their dependence on Central transfers.

4. Way Forward

The Reserve Bank of India in its study of the State Budgets has noted the improvement in State finances in the post pandemic period. The gross fiscal deficit of States, which had

[8] Reserve Bank of India, State Finances, A Study of Budgets of 2023-24, pp 43

[9] Budget Documents and NSO data for the relevant years

increased from 2.4 per cent in 2018-19 to 4.1 per cent of GDP in 2020-21 has moderated to 3.4 per cent in 2022-23 (Revised Estimates) and is budgeted to go down further to 3.1 per cent in 2023-24 (Budget Estimates). States' own tax revenue (SOTR) has increased from 5.7 per cent of GDP in 2003-04 to 6.9 per cent in 2022-23. Within the SOTR, State GST has emerged as the most important source followed by sales tax/VAT, excise duty, stamp duty and registration fees, and taxes on vehicles. There is, however, a large spatial variation in the SOTR, ranging from more than 70 per cent of total tax revenue in Haryana, Maharashtra, Telangana, Tamil Nadu, Gujarat, Karnataka, Kerala and Punjab to less than 50 per cent in Bihar and Jharkhand.[10]

Going forward, in order to mobilise resources for the investment required for sustaining high rates of economic growth, the States would need to increase their own revenue with improvement in quality and efficiency of expenditure. The GST has imparted buoyancy to States' tax revenues. Reforms in tax administration for better compliance, rationalization of rates of taxes in the State domain and measures to enhance non-tax revenue such as auction of mining leases, improving recovery of electricity tariffs through smart pre-paid metering, and improving profitability of State-owned enterprises provide further scope for enhancing own revenues.

The expenditure efficiency can be improved through digitalization, Direct Benefit Transfer and effective cash management to reduce the idling of funds. The implications arising from the decision by some of the State Governments to revert to the old defined-benefit pension system will also have to be catered for in a transparent manner.

The road ahead will have to be traversed by the States with the support of the Centre in the spirit of cooperative federalism.

[10]Reserve Bank of India, State Finances, A Study of Budgets of 2023-24, pp 28, 29 and 61.

Ecological and Economic Worth of Microalgae in Urban Lakes

Asulabha K.S.[1], Jaishanker R.[4], Sincy V.[1,4] and Ramachandra T.V.[1,2,3*]

Abstract

Microalgae are primary producers in aquatic ecosystems, which aid in the ecological processes of primary production, biogeochemical cycling, nutrient cycling, etc. The biochemical composition of microalgae includes high protein, fat, and carbohydrate, which constitute a vital raw material in the biofuel, pharmaceutical, and nutraceutical industries for the manufacture of biofuel, food, supplements, animal feedstock, medicine, bioplastics, and fertilizer. However, selecting appropriate strains for an economically viable production process is challenging, necessitating an exploration of commercially viable algal strains. The composition and assemblage of algal species reflect the ecological health of aquatic ecosystems and are utilized as bioindicators of aquatic environments, revealing their physical and chemical health. The present study determines the diversity and composition of microalgal species in lakes in the Hebbal-Nagavara Valley, Bangalore. The study documents microalgae belonging to Cyanophyta, Chlorophyta, Euglenozoa, Bacillariophyta, Charophyta, Ochrophyta, and Glaucophyta, with Chlorophyta being the dominant group. Dominance (D) varied from 0.25 to 0.55, with a maximum at Narsipura 2 Lake and a low at Kogilu Lake, whereas the Shannon diversity index ranged from 0.69 to 1.60. All physicochemical and microalgal data were subjected to cluster analysis to categorize the lakes according to their environmental status based on the level of contamination. Therefore, alterations in the physical and chemical properties of waterbodies are immediately reflected in the composition of the biotic community within the ecosystem. Microalgae-based biomonitoring is a very effective and cost-effective technique for determining the degree of pollution in water based on species assemblages.

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Keywords: Microalgae, Lakes, Diversity Index, Water Pollution, Bioindicator.

1. Introduction

The structure and functioning of aquatic ecosystems are being altered due to anthropogenic activities, evident from the deteriorating physicochemical conditions, sustained inflow of nutrients through untreated wastewater, eutrophication, declining vegetation cover in the catchment, increased grazing pressure, etc. (Ramachandra *et al.*, 2020). Microalgae, being the primary producers or autotrophs, are crucial for aquatic ecosystem stability, and the composition of species indicates the ecological health of waterbodies as an ecological indicator. Hence, microalgae are a dependable tool for assessing the ecological status and water quality of wetlands (Crossetti & Bicudo, 2005). Algae are unicellular or multicellular, eukaryotic or prokaryotic (Asulabha *et al.*, 2022). In nature, microalgae are abundant and omnipresent, requiring different nutrients and temperatures. Algae can survive in a wide range of habitats, including freshwater, marine, hypersaline conditions, etc., and species vary in size, shape, colour, behaviour, and habitat (Khalil *et al.*, 2021). Freshwater microalgal groups include Chlorophyta, Cyanobacteria, Rhodophyta, Euglenoids, Eustigmatophyta, Chrysophyta, Haptophyta, Synurophyta, Bacillariophyta, Pyrrhophyta, Cryptophyta, and Phaeophyta (Wehr *et al.*, 2015).

Microalgae, the primary producers in aquatic ecosystems, play a crucial role in the aquatic food chain in transferring materials and energy. Microalgal population density, diversity, and composition vary depending on the ecological health of aquatic ecosystems and hence aid as crucial water quality indicators (Zhang *et al.*, 2021). Investigations of algal assemblages offer a sensitive, valuable, and quantitative representation of ecological changes (Paerl *et al.*, 2003) and aid in pollution monitoring because of their large population, quick pace of development, affordable cost, easy maintenance, and ability to respond quickly to low pollution levels. Algae are valuable indicators of the extent of water quality degradation and its short-term effects, as the prevalence of blue-green algae indicates eutrophic conditions in water bodies. In contrast, the dominance of green algae and diatoms indicates oligotrophic conditions (Khan *et al.*, 2011).

Sustained discharge of untreated industrial effluent, domestic sewage, agriculture, and urban runoff alters the chemical integrity of aquatic ecosystems, as evidenced by water quality degradation and the composition of algal species. Water quality parameters Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved oxygen (DO), Potential of Hydrogen (pH), nitrogenous compounds, cations, and anions indicate physicochemical elements influencing phytoplankton species assemblages (Mohammed & Mahran, 2022).

Microalgae, which are sensitive to water quality variations, help understand the extent of water contamination and aid in economically monitoring and managing ecosystems. Changes in the climate due to global warming with escalating greenhouse gas (GHG) footprint have necessitated an exploration of ecologically feasible, economically viable, and environmentally sound energy options to address the challenges of dwindling stock of fossil fuels and the need for mitigating GHG footprint. Bio-based feedstocks, such as microalgal biomass, have emerged as a viable alternative due to higher photosynthetic efficiency, lipid accumulation, shorter cycling time, and efficient carbon sequestration apart from the scope of a viable alternative to fossil fuels. Selecting an appropriate algal strain based on unique characteristics, including cellular contents, growth behaviour, and metabolic pathways, is crucial for biorefinery processes and products (Sarma *et al.*, 2021). The current study through biomonitoring investigates (i) the diversity and the economic worth of microalgae in Hebbal-Nagavara Valley lakes, and (ii) explores the scope of third-generation feedstock for a sustainable and cost-effective biorefinery.

2. Materials and Methods

2.1 Study Area: Lakes in Hebbal-Nagavara Valley of Greater Bangalore

Greater Bangalore (latitudes 12°49'5' N and 13°08'32" N, longitudes 77°27'29" E and 77°47'2" E), located at 920 meters above sea level, has three watersheds: Koramangala-Challaghatta, Hebbal-Nagavara, and Vrishabhavathi. Due to the undulating topography of the Bangalore landscape, several tanks were built in the early 18th century to meet water requirements for irrigation and domestic purposes, apart from fishing and washing. The open-source GIS software QGIS[3] was used for spatial analyses, and Figure 1 depicts the distribution of monitored lakes in the Hebbal-Nagavara Valley, Greater Bangalore.

2.2 Sample Collection and Analyses

Field investigations were carried out during 2018–2020, and water samples were collected in disinfected water sampling containers at inlets and outlets of lakes in the Hebbal-Nagavara Valley. Physicochemical parameters such as water temperature, dissolved oxygen, pH, total dissolved solids, electrical conductivity, turbidity, chloride, total hardness, calcium, magnesium, total alkalinity, chemical oxygen demand, biochemical oxygen demand, nitrate, and orthophosphate were estimated using the standard protocol (APHA, 2012).

Microalgae were collected by filtering 50 liters of lake surface water with a plankton net. Microalgae samples were fixed in a 4 per cent Lugol iodine solution and concentrated at 50 mL. The samples were labelled and preserved

[3]https://qgis.org

Figure 1: The Map Depicts the Urban Lakes in The Hebbal-Nagavara Valley, Bangalore.

Source: Authors'Compilation

in plastic bottles before being taken to the laboratory for taxonomic study. Microalgae samples were identified and counted using standard keys using an optical microscope (Olympus) (Desikachary, 1959; Prescott, 1970; Guiry & Guiry, 2023).

2.3 Statistical Analysis

PAST software[4] was used to compute microalgae diversity, diversity indices (such as the Shannon-Weaner diversity index, Simpson diversity index), Dominance index, Pielou Evenness index, and cluster analysis.

3. Results and Discussion

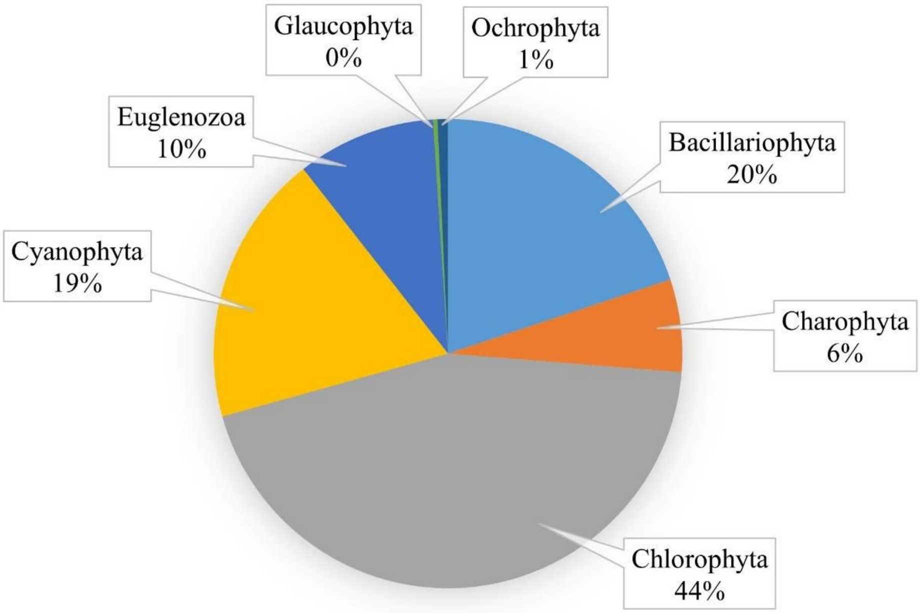
3.1 Microalgal Composition in Urban Lakes

The study documents microalgal species belonging to groups like Cyanophyta (19 per cent), Chlorophyta (44 per cent), Euglenozoa (10 per cent), Bacillariophyta (20 per cent), Charophyta (6 per cent), Ochrophyta (1 per cent), and Glaucophyta (<0 per cent).

Figure 2 illustrates that the Chlorophyceae group is more diverse (44 per cent) than the Bacillariophyceae group (20 per cent). This density may be due to the highly enriched

[4] https://past.en.lo4d.com/windows

Figure 2: The Taxonomic Compositions of Microalgal Communities in Urban Lakes



Source: Authors'Compilation

organic waste load and nutrients providing favorable conditions for their growth. The diversity of the Chlorophyceae group in these lakes could also be attributed to carbon inputs due to anthropogenic activities involving the discharge of untreated sewage and the dumping of solid waste. The optimal water temperature for the growth of Cyanobacteria and Chlorophyta is around 18–25 °C (Liu et al., 2011). Phytoplankton can adjust their light conditions by altering their light-harvesting pigments, such as Chlorophyll a (Chl a) (Arrigo *et al.*, 2010).

3.2 Microalgal Diversity in Lakes

Figure 3 depicts the multiple diversity indices computed for monitored lakes in the Hebbal-Nagavara valley, with the Shannon Wiener (H') index ranging from 0.69 to 1.60. Dominance (D) ranged from 0.25 to 0.55, with a maximum at Narsipura 2 Lake and a minimum at Kogilu Lake. Species evenness index (J') ranged from 0.63 to 1. Simpson index (1-D) values were highest (0.75) in Kogilu Lake and lowest (0.45) in Narsipura 2 Lake.

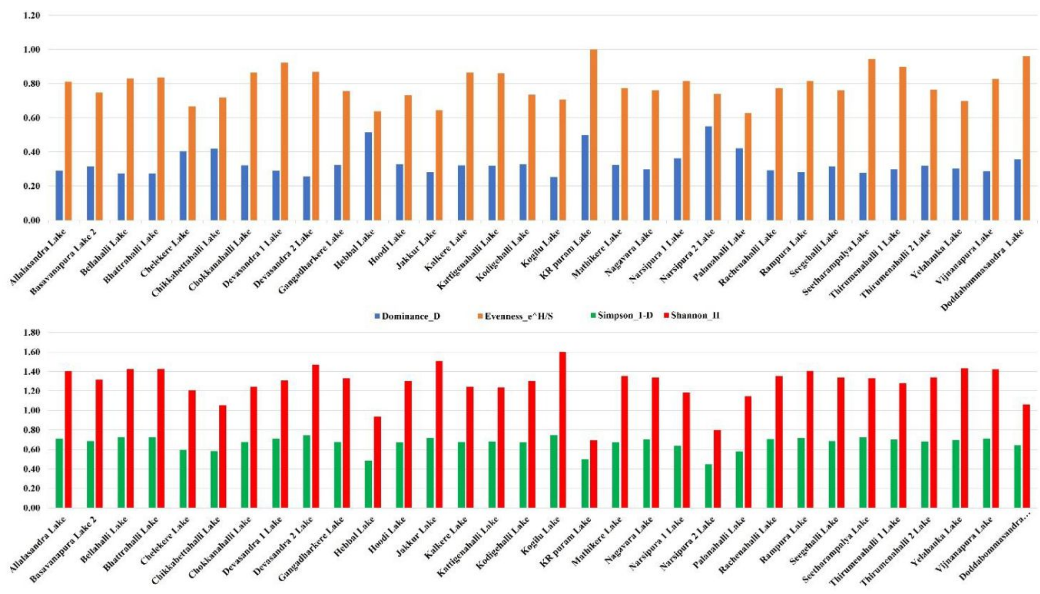
The index of diversity (H') and evenness index

(J') indicate the degree of pollution in water. H' values range from 0 to 1, indicating highly polluted water; the values range from 1 to 3, indicating not critically polluted water; and the values > 3 indicate clean water. Meanwhile, J' values range from 0 to 0.3, indicating highly polluted water. Lastly, J' values range from 0.3 to 0.5, indicating not critically polluted water, and 0.5 to 0.8, indicating clean water (Li *et al.*, 2019). The present study suggests lakes are contaminated due to the sustained inflow of untreated sewage water (Figure 3).

3.3 Relationships between Lakes, Water Quality Data, and Microalgal Species

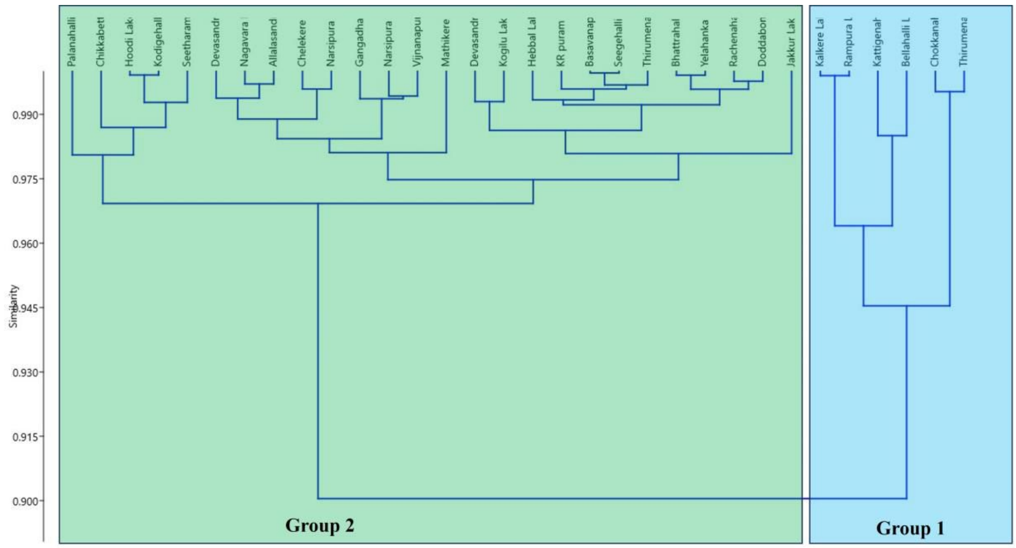
Cluster analysis (CA) is a multivariate statistical technique that provides intuitive similarity relationships between lakes, considering microalgal species with water quality data. The data classifies 32 freshwater lakes based on (i) microalgal groups, like Bacillariophyta, Charophyta, Chlorophyta, Cyanobacteria, Euglenozoa, Glaucophyta, and Ochrophyta, and (ii) physicochemical status. The results showed that Group 1 (G1) is more polluted with higher ionic and nutrient contents and has less phytoplankton diversity, which includes Bellahalli Lake, Chokkanahalli Lake, Kalkere Lake, Kattigenahalli Lake, Rampura Lake, and Thirumenahalli 2 Lakes (Figure 4). Changes in the algal community can be attributed to environmental stressors, notably nutrient

Figure 3: The Diversity Indices of Microalgae in Different Hebbal-Nagavara Valley Lakes



Source: Authors'Compilation

Figure 4: Microalgal Groupings Based on Physical and Chemical Status



Source: Authors'Compilation

pollution, leading to lower oxygen concentrations, which affect other organisms in the aquatic food chain (Johnstone *et al.*, 2006; Camargo & Alonso, 2006). Conductivity, COD, and BOD are crucial variables, indicating variation in water chemistry and nutrient levels, which determine algal species assemblages. COD and BOD are commonly used organic pollution indicators in water bodies, and the amount or type of organic matter significantly affects microalgal community structure (Kim *et al.*, 2021).

3.4 Commercial Importance of Microalgae

A biorefinery is a process that turns a single biomass into many products. Microalgae are light-driven cell factories, generating bioactive substances from primary metabolites (carbohydrates, lipids, and proteins) and secondary metabolites (carotenoids, pigments, sterols, and vitamins) at different development phases (Kiran & Venkata Mohan, 2021), which constitute vital feedstock for the pharmaceutical, cosmetic, and nutritional sectors. Microalgae can cure cancer, hypertension, diabetes, neurological illnesses, and autoimmune disorders, besides being beneficial for the heart, brain, and immunity (Udayan *et al.*, 2023).

Microalgae, contrary to higher plants and animals, constitute a vital source of necessary enzymes to synthesise PUFA (Docosahexaenoic acid, Eicosapentaenoic acid, ã-Linolenic acid, and Arachidonic acid), which are essential in food chain (Spolaore *et al.*, 2006; Pulz & Gross, 2004). Compared to chemical fertilisers, biofertilisers are more economical and environmentally benign since they may increase soil fertility, improve nutrient availability, encourage sustainable plant development, and lessen the harmful effects of excessive chemical inputs on the environment. It has been reported that the well-known genera Nostoc and Anabaena may fix up to 20–25 kg N/ha. During the rainy season, they are applied to rice crops as biofertiliser (Kumar *et al.*, 2022).

The burgeoning population and escalating energy demand have necessitated exploring viable energy alternatives to mitigate fossil fuel dependence through algal biofuel from the third-generation feedstock, such as microalgae, which has emerged as a viable renewable fuel option. Compared to other terrestrial plants, microalgae have higher photosynthetic efficiency with biomass output containing relatively higher protein, carbohydrate, and lipid content, making microalgae a viable feedstock for biofuel, and value-added products (Table 1).

Table 1: Valuable Products from Microalgae

Microalgae	Valuable products	Reference
Chlorella vulgaris	Biodiesel	Moradi & Saidi,2022
Spirulina maxima	Biodiesel	Rahman *et al.*,2017
Spirulina platensis	Bioethanol and Biomethane	Rempel *et al.*,2019
Chlorella vulgaris	Bioethanol	Condor *et al.*,2022
Chlamydomonas reinhardtii	Bioethanol	Nguyen *et al.*,2009
Chlorococum sp.	Bioethanol	Harun *et al.*,2010
Chlamydomonas reinhardtii	Microalgal biochar	Torri *et al.*,2011
Chlorella vulgaris	Microalgal biochar	Yuan *et al.*,2015
Haematococcus pluvialis	Astaxanthin and Lutein	Molino *et al.*,2018
Acutodesmus dimorphus, Spirulina platensis, Chlorella vulgaris, Scenedesmus dimorphus, Anabaena azolla, and Nostoc sp.	Bio-fertilizers	Ammar *et al.*,2022

Source: Authors' compilation

Microalgae paves the way for third-generation biofuels with high photosynthetic efficiency, a low land requirement, and the potential to replace traditional liquid fossil fuels with sustainable alternatives. Microalgae with a basic cellular structure and shorter life cycles (approximately 1–10 days) would synthesize significant amounts of lipids per dry-weight biomass (40–86 per cent) and use less water than terrestrial crops. They also grow well in wastewater and do not require pesticides, herbicides, or fertilizers to thrive. They can be produced under controlled conditions in specially built bioreactors or grown in brackish or saltwater on non-arable soil. Additionally, microalgae are utilized to create highly valuable, commercially profitable products with extra utility and help with carbon sequestration and bioremediation (Verma *et al.*, 2010; Rodolfi *et al.*, 2009). Three distinct methods exist for growing microalgae: autotrophic, mixotrophic, and heterotrophic cultures (Sharma *et al.*, 2022). Compared to autotrophic and heterotrophic modes of culture, the mixotrophic mode of microalgal cultivation is an effective way to yield a greater amount of lipids (Zhan *et al.*, 2017).

The biochemical conversion of microalgal biomass through anaerobic digestion provides biogas; alcoholic fermentation would yield bioethanol, and photobiological hydrogen production (Sivaramakrishnan *et al.*, 2022). The market prices for microalgae-based biodiesel, glycerine, and algal meal were 0.73 USD/L, 320–500 USD/ton, and 1200–1800 USD/ton, respectively (Subhadra and Edwards, 2011). The MBSP (minimum biodiesel selling price) is estimated to be $2.17/L, and to be competitive, the price needs to be at or below the average petroleum diesel price of $1.09/L. The feasibility of the process is significantly influenced by factors such as oil content, nitrogen content in waste effluents, and extraction and esterification efficiencies (Zewdie and Ali, 2022).

Microalgae biomass is being utilized in cattle feed formulations as a valuable source of triglycerides, vitamins, pigments, and essential amino acids (Ahmad *et al.*, 2022) and in aquaculture for partial feed replacement, oxygen generation, and wastewater treatment (Han *et al.*, 2019). Algal biochars, rich in nutrients and ion exchange capacity, are useful as agricultural soil amendments and adsorbents in wastewater treatment for removing pollutants. Biofuels such as bioethanol, biodiesel, biocrude oil, pyrolytic bio-oil, biomethane, biohydrogen, and bio-jet fuel may be manufactured from microalgal biomass. However, there are challenges for commercial application, and an integrated biorefinery strategy, together with the selection of appropriate strains, the development of biomass pre-concentrating processes, and the use of wet microalgal biomass might improve both economic viability and environmental sustainability (Khan *et al.*, 2023).

An economic analysis of photobiological

hydrogen generation from *Chlamydomonas reinhardtii* indicates a selling price of $0.57/kg to $13.53/kg for algae-produced hydrogen (Amos, 2004). An estimated 5000 tonnes of chlorella are grown worldwide each year (García *et al.*, 2017), and about12,000 tonnes per year of dried whole algae, Spirulina (at the cost of $30/kg) is produced per year with 70 per cent of the production by the South Asian countries - China, India, and Taiwan.

Microalgae from lakes have a significant economic value, evidenced by the accounting of ecosystem services. The provisioning service offered by microalgae from Karnataka, India, wetlands were valued at 110467 Rs/ha/year, considering the prospects of biofuel, protein, and glycerol production (Ramachandra *et al.*, 2021). Microalgae, with high protein content, omega-3 fatty acids, vitamins, and antioxidants, is evolving as the major industry with increasing consumer interest due to its nutritional benefits. The Microalgae Market Outlook (2023-2033) predicts a valuation of US$ 11.8 billion in 2023 and $25.4 billion by 2033, with an 8% compound annual growth rate (CAGR) during this forecast period (https://www.futuremarketinsights.com/reports/microalgae-market). The global food and beverage microalgae market, valued at $125 million in 2023, is expected to grow at a 7 per cent annual rate between 2023 and 2033, reaching $247.4 million by 2033. This growth is driven by the growing use as food additives due to microalgal ability to enhance taste, texture, flavor, aroma, and nutritional values[5]. Microalgae have emerged as a viable third-generation feedstock for sustainable biorefineries, reducing costs and aiding in effective bioremediation with their ability to uptake nutrients (Sarma *et al.*, 2021).

The strategic approach to benefiting the national economy is through the algal bio-economy and establishing research centers, exploring viable strains, educating start-up businesses, and developing financing instruments for projects and research. Microalgal research institutes focusing on application research, technology advancement, product development, process improvement, publications, and patent commercialization would herald the sustainable energy path.

4. Conclusion

Microalgae are a valuable source of triglycerides, vitamins, pigments, and essential amino acids and are widely used as an important biological resource in various sectors, including the food sector, the manufacturing of biofuels, wastewater treatment, cosmetics, and medicines. Unplanned anthropogenic activities have been impacting aquatic ecosystems, evidenced by the erosion of the physicochemical characteristics and microalgae composition of

[5] https://www.futuremarketinsights.com/reports/microalgae-food-and-beverage-sector

the lakes in the Hebbal-Nagavara Valley, Bangalore city. The current investigation documents microalgal species of the groups Cyanophyta, Chlorophyta, Euglenozoa, Bacillariophyta, Charophyta, Ochrophyta, Glaucophyta, and Chlorophyta, which constitute a dominant group. The diversity indices showed the extent of lake pollution. Cluster analysis of 32 lakes in Hebbal-Nagavara Valley showed that Group-1 lakes are more polluted with less phytoplankton diversity than Group-2 lakes, necessitating urgent restoration and conservation measures to prevent further eutrophication. Microalgae based biorefineries are emerging as a viable industry for manufacturing biofuels and value-added goods such as protein, pigment, and antioxidants, which support the livelihood of local people at disaggregated levels. Lakes, rich in microalgal biomass, generate valuable bioproducts and offer environmental benefits like bioremediation and nutrient cycling. These microalgae may be separated and farmed on a vast scale, providing long-term, environmentally favourable options as the world seeks sustainable solutions. The city should implement restoration programs and initiate conservation measures involving local stakeholders in and around the lakes.

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References

Ahmad, A., W. Hassan, S., & Banat, F. (2022). An Overview of Microalgae Biomass as A Sustainable Aquaculture Feed Ingredient: Food Security and Circular Economy. *Bioengineered*, *13*(4), 9521-9547.

Ammar, E. E., Aioub, A. A., Elesawy, A. E., Karkour, A. M., Mouhamed, M. S., Amer, A. A., & El-Shershaby, N. A. (2022). Algae as Bio-Fertilizers: Between Current Situation and Future Prospective. *Saudi Journal of Biological Sciences*, *29*(5), 3083-3096.

Amos, W. A. (2004). Updated Cost Analysis of Photobiological Hydrogen Production from Chlamydomonas Reinhardtii Green Algae: Milestone Completion Report (No. NREL/MP-560-35593). National Renewable Energy Lab., Golden, CO. (US).

APHA (2012). Standard Methods (20 Ed.) For The Examination of Water and Wastewater, APHA, AWWA, WPCE, Washington DC.

Arrigo, K. R., Mills, M. M., Kropuenske, L. R., van Dijken, G. L., Alderkamp, A. C., & Robinson, D. H. (2010). Photophysiology in Two Major Southern Ocean Phytoplankton Taxa: Photosynthesis and Growth of Phaeocystis Antarctica and Fragilariopsis Cylindrus Under Different Irradiance Levels. *Integrative and Comparative Biology*, *50*(6), 950–966.

Asulabha, K.S., Jaishanker, R., Sincy, V., & Ramachandra, T.V. (2022). Diversity of Phytoplankton in Lakes of Bangalore, Karnataka, India. 10th Chapter, in: Shashikanth Majige (Eds), Biodiversity Challenges: A Way Forward, Daya Publishing House, New Delhi, 147-178.

Camargo, J. A., & Alonso, Á. (2006). Ecological and Toxicological Effects of Inorganic Nitrogen Pollution in Aquatic Ecosystems: A Global Assessment. *Environment International*, *32*(6), 831-849.

Condor, B.E., de Luna, M.D.G., Chang, Y.H., Chen, J.H., Leong, Y.K., Chen, P.T., Chen, C.Y., Lee, D.J., &

Chang, J.S. (2022). Bioethanol Production from Microalgae Biomass at High-Solids Loadings. *Bioresource Technology*,*363*,128002.

Crossetti, L. O., & Bicudo, C. E. D. M. (2005). Structural and Functional Phytoplankton Responses to Nutrient Impoverishment in Mesocosms Placed in A Shallow Eutrophic Reservoir (Garças Pond), São Paulo, Brazil. *Hydrobiologia*,*541*,71-85.

Desikachary, T.V. (1959). Cyanophyta. Indian Council for Agricultural Research, New Delhi.

García, J. L., De Vicente, M., & Galán, B. (2017). Microalgae, Old Sustainable Food, and Fashion Nutraceuticals. *Microbial biotechnology*,*10*(5),1017.

Guiry, M.D. & Guiry, G.M. 2023. AlgaeBase. World-Wide Electronic Publication, National University of Ireland, Galway. https://www.algaebase.org

Han, P., Lu, Q., Fan, L., & Zhou, W. (2019). A Review On the Use of Microalgae for Sustainable Aquaculture. *Applied Sciences*,*9*(11),2377.

Harun, R., Danquah, M. K., & Forde, G. M. (2010). Microalgal Biomass as A Fermentation Feedstock for Bioethanol Production. *Journal of Chemical Technology & Biotechnology*, *85*(2),199-203.

Johnstone, C., Day, J. G., Staines, H., & Benson, E. E. (2006). The Development of A 2, 22 -Azinobis-(3-Ethyl-Benzothiazoline-6-Sulfonic Acid) Radical Cation Decolourisation Assay for Evaluating Total Antioxidant Status in an Alga Used to Monitor Environmental Impacts in Urban Aquatic Habitats. *Ecological Indicators*,*6*(2),280-289.

Khalil, S., Mahnashi, M. H., Hussain, M., Zafar, N., Khan, F. S., Afzal, U., Shah, G. M., Niazi, U. M., Awais, M. & Irfan, M. (2021). Exploration and Determination of Algal Role as Bioindicator to Evaluate Water Quality–Probing Fresh Water Algae. *Saudi Journal of Biological Sciences*,*28*(10),5728-5737.

Khan, M., Hussain, F., & Musharaf, S. (2011). A Fraction of Fresh Water Algae of Kalpani Stream and Adjoining Area of District Mardan, Pakistan. *International Journal of Biosciences*, *1*(3),45-50.

Khan, S., Das, P., Abdul Quadir, M., Thaher, M. I., Mahata, C., Sayadi, S., & Al-Jabri, H. (2023). Microalgal Feedstock for Biofuel Production: Recent Advances, Challenges, And Future Perspective. *Fermentation*,*9*(3),281.

Kim, M. S., Ahn, S. H., Jeong, I. J., & Lee, T. K. (2021). Water Quality Drives the Regional Patterns of an Algal Metacommunity in Interconnected Lakes. *Scientific Reports*,*11*(1).

Kiran, B. R., & Venkata Mohan, S. (2021). Microalgal Cell Biofactory—Therapeutic, Nutraceutical and Functional Food Applications. *Plants*,*10*(5),836.

Kumar, S., Sindhu, S. S., & Kumar, R. (2022). Biofertilizers: An Ecofriendly Technology for Nutrient Recycling and Environmental Sustainability. *Current Research in Microbial Sciences*, *3*,100094.

Li, X., Yu, H., Wang, H., & Ma, C. (2019). Phytoplankton Community Structure in Relation to Environmental Factors and Ecological Assessment of Water Quality in The Upper Reaches of the Genhe River in The Greater Hinggan Mountains. *Environmental Science and Pollution Research*,*26*(17),17512–17519.

Liu, X., Lu, X., & Chen, Y. (2011). The Effects of Temperature and Nutrient Ratios On Microcystis Blooms in Lake Taihu, China: An 11-Year Investigation. *Harmful Algae*,*10*(3),337–343.

Mohammed, K. A., & Mahran, B. N. (2022). Environmental Studies On Phytoplankton Diversity in Drainage Water of Main Drains in Eastern Delta, case study. *The Egyptian Journal of Aquatic Research*,*48*(3),211-216.

Molino, A., Mehariya, S., Iovine, A., Larocca, V., Di Sanzo, G., Martino, M., Casella, P., Chianese, S., & Musmarra, D. (2018). Extraction of Astaxanthin and Lutein from Microalga Haematococcus Pluvialis in The Red Phase Using CO_2 Supercritical Fluid Extraction Technology with Ethanol as Co-Solvent. *Marine Drugs*,*16*(11),432.

Moradi, P., & Saidi, M. (2022). Biodiesel Production from Chlorella Vulgaris Microalgal-Derived Oil Via Electrochemical and Thermal Processes. *Fuel Processing Technology*, *228*, 107158.

Nguyen, M. T., Choi, S. P., Lee, J. W., Lee, J. H., & Sim, S. J. (2009). Hydrothermal Acid Pretreatment of Chlamydomonas Reinhardtii Biomass for Ethanol Production. *Journal of Microbiology and Biotechnology*, *19*(2), 161-166.

Paerl, H. W., Dyble, J., Moisander, P. H., Noble, R. T., Piehler, M. F., Pinckney, J. L., Steppe, T. F., Twomey, L. & Valdes, L. M. (2003). Microbial Indicators of Aquatic Ecosystem Change: Current Applications to Eutrophication Studies. *FEMS Microbiology Ecology*, *46*(3), 233-246.

Prescott, G.W. (1970). How to Know Freshwater Algae.2nd ed., W.C. Brown. Dubuque, Iowa.

Pulz, O., & Gross, W. (2004). Valuable Products from Biotechnology of Microalgae. *Applied Microbiology and Biotechnology*, *65*, *635*-648.

Rahman, M. A., Aziz, M. A., Al-Khulaidi, R. A., Sakib, N., & Islam, M. (2017). Biodiesel Production from Microalgae Spirulina Maxima by Two Step Process: Optimization of Process Variable. *Journal of Radiation Research and Applied Sciences*, *10*(2), 140-147.

Ramachandra, T.V., Sincy, V., & Asulabha, K.S. (2020). Efficacy of Rejuvenation of Lakes in Bengaluru, India. *Green Chemistry & Technology Letters*, *6*(1), 14-26.

Ramachandra, T.V., Sincy, V., & Asulabha, K.S. (2021). Accounting of Ecosystem Services of Wetlands in Karnataka State, India. *REaD*, *18*, 1-26.

Rempel, A., de Souza Sossella, F., Margarites, A.C., Astolfi, A.L., Steinmetz, R.L.R., Kunz, A., Treichel, H. and Colla, L.M., 2019. Bioethanol from Spirulina Platensis Biomass and The Use of Residuals to Produce Biomethane: An Energy Efficient Approach. *Bioresource Technology*, *288*, 121588.

Rodolfi, L., Zittelli, C. G., Bassi, N., Padovani, G., Biondi, N., Bonini, G., & Tredici, M. R. (2009). Microalgae for Oil: Strain Selection, Induction of Lipid Synthesis and Outdoor Mass Cultivation in A Low Cost Photobioreactor. *Biotechnology and Bioengineering*, *102*(1), 100-112.

Sarma, S., Sharma, S., Rudakiya, D., Upadhyay, J., Rathod, V., Patel, A., & Narra, M. (2021). Valorization of Microalgae Biomass into Bioproducts Promoting Circular Bioeconomy: A Holistic Approach of Bioremediation and Biorefinery. *3 Biotech*, *11*, 1-29.

Sharma, P., Gujjala, L. K. S., Varjani, S., & Kumar, S. (2022). Emerging Microalgae-Based Technologies in Biorefinery and Risk Assessment Issues: Bioeconomy for Sustainable Development. *Science of The Total Environment*, *813*, 152417.

Sivaramakrishnan, R., Suresh, S., Kanwal, S., Ramadoss, G., Ramprakash, B., & Incharoensakdi, A. (2022). Microalgal Biorefinery Concepts' Developments for Biofuel and Bioproducts: Current Perspective and Bottlenecks. *International Journal of Molecular Sciences*, *23*(5), 2623.

Spolaore, P., Joannis-Cassan, C., Duran, E., & Isambert, A. (2006). Commercial Applications of Microalgae. *Journal of Bioscience and Bioengineering*, *101*(2), 87-96.

Subhadra, B. G., & Edwards, M. (2011). Coproduct Market Analysis and Water Footprint of Simulated Commercial Algal Biorefineries. *Applied Energy*, *88*(10), 3515-3523.

Torri, C., Samorì, C., Adamiano, A., Fabbri, D., Faraloni, C., & Torzillo, G. (2011). Preliminary Investigation On the Production of Fuels and Bio-Char from Chlamydomonas Reinhardtii Biomass Residue After Bio-Hydrogen Production. *Bioresource Technology*, *102*(18), 8707-8713.

Udayan, A., Pandey, A.K., Sirohi, R., Sreekumar, N., Sang, B.I., Sim, S.J., Kim, S.H. and Pandey, A., 2023. Production of Microalgae with High Lipid Content and Their Potential as Sources of Nutraceuticals. *Phytochemistry Reviews*, *22*(4), 833-860.

Verma, N. M., Mehrotra, S., Shukla, A., & Mishra, B. N. (2010). Prospective of Biodiesel Production Utilizing Microalgae as The Cell Factories: A Comprehensive Discussion. *African Journal of Biotechnology*, *9*(10), 1402-

1411.

Wehr, J. D., Sheath, R. G., & Kociolek, J. P. (Eds.). (2015). Freshwater Algae of North America: Ecology and Classification. Elsevier.

Yuan, T., Tahmasebi, A., & Yu, J. (2015). Comparative Study On Pyrolysis of Lignocellulosic and Algal Biomass Using a Thermogravimetric and A Fixed-Bed Reactor. *Bioresource Technology*, *175*,*333*-341.

Zewdie, D. T., & Ali, A. Y. (2022). Techno-Economic Analysis of Microalgal Biofuel Production Coupled with Sugarcane Processing Factories. *South African Journal of Chemical Engineering*,*40*(1),70-79.

Zhan, J., Rong, J., & Wang, Q. (2017). Mixotrophic Cultivation, A Preferable Microalgae Cultivation Mode for Biomass/Bioenergy Production, And Bioremediation, Advances and Prospect. *International Journal of Hydrogen Energy*,*42*(12),8505-8517.

Zhang, Y., Gao, W., Li, Y., Jiang, Y., Chen, X., Yao, Y., Messyasz, B., Yin, K., He, W. & Chen, Y. (2021). Characteristics of The Phytoplankton Community Structure and Water Quality Evaluation in Autumn in The Huaihe River (China). *International Journal of Environmental Research and Public Health*,*18*(22),12092.

Product Cannibalization: Launching Time Strategy to Transform Risk into Profits

Bobby Basu[1]

Abstract

The strategy of a firm to offer a number of similar products within a product category is often deliberately aimed at increased cannibalization of an existing product(s) by the new product. The ability of a firm to continuously cannibalize and replace its existing product or technology at appropriate times is believed to become the dominant corporate strategy of the future. The objective of this paper is to develop a framework for designing the early/delayed timing for the introduction of a new product when it has the potential of cannibalizing an existing product of the firm. The problem of cannibalization has been expressed in terms of a linear programming problem (LPP) where the objective of the firm is to maximize the total profit generated by the sales of its all products. A numerical analysis is presented based on the synthetic data to illustrate the impact of profit margin and market potential of the new product on its launch timing. The framework suggests that the launching of the new product could be delayed to some extent till the existing product reaches its maturity state if the profit margin of the new product (NP) is more than the existing product (EP) but the fixed cost for NP is higher than EP. However, the firm should make a decision on the early introduction of a new product if the profit margin of NP is less than the EP and if the market potential of NP is higher than EP.

Keywords: Cannibalization, Strategy, Innovation, Market potential.

1. Introduction

The difference between complementary and substitute products lies on the sign of influence on each other: positive for complements and negative for substitutes. Substitutability has been defined functionally as the degree to which two products perform the same function for a customer (Porter, 1980) or economically as the degree to which one product's price change will impact the demand for the other (Bain, 1952). If the two substitutable products belong to competing organizational entities, one firm gains customers who would have otherwise bought from the rival and this is called a competitive draw. Instead, if the substitutable products are sold by the same firm, they will appeal to overlapping customer segments. This will lead to intra-organizational instances of sales

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diversion known as sales cannibalization. Cannibalization is typically viewed as a phenomenon having an adverse impact on corporate performance (Traylor, 1986). Still, there are many firms like Apple, that routinely develop and introduce products that cannibalize their existing products. Apple has a track record of cannibalizing its own products through launching new products (Kate & Taylor, 2017). In 2005, when the demand for iPod Mini remained huge, the Nano was launched, effectively destroying the revenue stream generated by the existing product. While iPod sales were going still through the roof, Jobs launched \the iPhone in 2007, which combined iPod, cell phone, and internet access into a single device. Apple has released a total of 38 iPhones over the years from 2007 to 2022. It has gone through a lot of changes, from a 16 Gigabytes web browser to a 1 Terabyte, all-in-one camera, workspace, and entertainment center. Steve Jobs justified the idea of trading a highly profitable business for an unknown future by saying that if we don't cannibalize ourselves, someone else will.

2. Literature Review

A significant amount of research has been carried out on cannibalization. Mason and Milne (1994) define cannibalization as the extent to which one product's customers are at the expense of other products offered by the same firm (Yu & Malnight, 2016). Kotler and Keller (2012) define Cannibalization as a reduction in sales volume, sales revenue, or market share of one product as a result of the introduction of a new product by the same producer (Mason & Milne, 1994). Thus, product cannibalization occurs when a company's new product steals sales away from its existing products. Essentially, the products are competing against each other instead of with the competitors. Product Cannibalization is a problem when it is unplanned. However, when planned, it may lead to the generation of more profit for the company. The literature review reveals that the decision taken by companies to practice cannibalization is guided by a number of strategic decisions. Firstly, products which are based highly on current technology, it is expected that new products will eventually replace the existing product. Many firms may also decide to let the new and existing products co-exist until the new product gains market acceptance and then gradually phasing out the existing product (Kotler & Keller, 2012). This is called gradual planned obsolescence. The reasons for gradual planned obsolescence may be a high inventory of existing products, prevailing contractual arrangements, or when the profit margin of an existing product is higher than the new product. Gradual obsolescence is also planned when product loyalty for an existing product may not easily be transferred to the new product. Secondly, firms broaden/diversify their product range in order to increase their customer base. New products are introduced in several configurations so as to appeal to different market segments. Introducing new products helps in enhancing brand value in the minds of the consumers. Having multiple substitutes in a firm's product line may help spread the risks of economic downturns caused by one.

A strategy to offer a number of similar products within a product category can signal a firm's market strength and is often designed to prevent competing firms from entering the market (Levinthal & Purohit, 1989). Sometimes, firms develop new products to counteract the effects of their competitor's products with the objective of the firm to arrest the switching from the existing product of the firm to the competitor's product (Traylor, 1986).

The product design and marketing activities are also deliberately aimed so as to increase the cannibalization of existing products with the new product. As cited by Kate & Taylor (2017), long-term benefits due to cannibalization outweigh the short-term loss as evidenced by the decrease in sales of original Cola when Coca-Cola introduced Zero Sugar Cola, but there was a boost in the company's total revenue and customer base. Foster (1986), and Moore & Pessemier (1993) have emphasized that the dominant corporate strategy of a firm in the future will be the ability to continuously cannibalize and replace its existing products or technology at appropriate times.

3. Research Gap

Although there is quite extensive literature depicting the benefits of cannibalization, little research has been directed towards the study of the impact of profit margin and market potential of the existing and new products on the launching time of the new product. The author aims to address this gap by developing a framework that strategically determines when to introduce such a product.

4. Objective

The primary focus of the paper is to fill this research void by presenting a framework for determining the delayed or immediate timing of introducing a new product, which has the potential to cannibalize the existing product. This framework aims to guide businesses in making informed decisions about when to introduce a potentially cannibalizing new product, considering the dynamics of profit margins and market potential in order to maximize total profits from the original product and the line extension.

5. Methodology & Illustration

5.1 Framework for Launching Time of New Product

A heterogeneous market of S customer segments that differ in their preferences in choosing a product has been considered. Let Ns be the number of customers in segment s, s = 1,2……S. For simplicity, we assume Ns = 1, s = 1,2, S. So, instead of segment s, we have customer s.

A manufacturer's goal is to maximize its profit by offering a set of products with different configurations or models that satisfy the customer's needs. Let the number of models offered to the customer be j, j varying from 1 …. J from the firm's perspective, the firm wants to choose K products from a set of J products with specified characteristics (K< J), which could be offered to the customers at a given time so that the total value to the seller from the K products could be maximized.

From the customer's perspective, each customer while choosing a product tries to maximize the value of money from buying the product. Further, it is assumed that each customer restricts the quantity of purchase to a single product. A necessary, but not sufficient condition for consumer 's' switch to a particular model j within a given product line is that the product's utility Usj, be greater than that of the utility, Uso, for the status quo. Uso may be referred to the utility associated with no purchase at all or the utility associated with the consumer's current model or the perceived utility for the brand that may be purchased by consumer 's', in the absence of model j offered by the firm.

While machine learning is powerful for large-scale data analysis, the discussion has been restricted to a 3-product model. The following variables are defined:

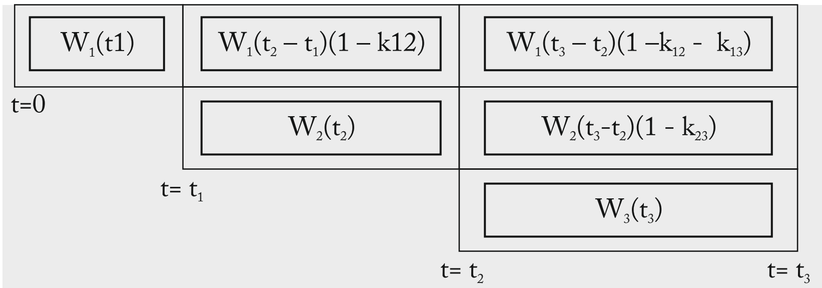
Let yj = 1, if product j is included in the product line offered to the customers and 0 otherwise, for j = 1, 2 & 3, i.e,

yj = 1, if product (model) j is offered to the customers

= 0, else.

xsj = 1, if consumer s switches to product j i.e., if customer s buys model j.

= 0, else, for s = 1, 2… S and for J = 1, 2 and 3.



The planning horizon starts at t=0 when the existing product is launched. The first and second new products have been launched at time t_1 and t_2 respectively. Till time t1, the sale of existing products is not affected by the first new product. We assume that customers do not withhold purchases of existing products in anticipation of the new product introduction. For simplicity, the discussion has been restricted to 3 products floated or offered by the company at a given time. The total length of the time horizon is t_3. Let the per unit profit of the existing product 1 and the successive new products 2 and 3 be p1, p2, and p3 respectively. Let the rate at which sales of the existing product 'm' are decreased by the introduction of new product 'n' due to cannibalization effects be kmn. Let Wi represent the sales of product i. From the organization's perspective, the objective function is to maximize the total profit Z from the sales of all 3 products.

Mathematically, the objective function is

Maximize Z = [W1(t1) + W1(t2 − t1)(1 − k12) + W1(t3 − t2)(1 −k12 - k13)]*p1 + [W2(t2) + W2(t3-t2)(1 - k23)] *p2 + W3(t3)* p3.

The greater the similarities between the offered products, the greater will be the mutual cannibalization. Total cannibalization may be viewed as an index of similarity between the products.

kij ≠ 0, when product 'i' is cannibalized by-product 'j'. The value of kij lies between 0 and 1.

The objective function is subjected to the following constraints:

$\sum_{j=1}^{3} x_{sj} \le 1$	s = 1, 2………… S	(1)
xsj≤ yj,	j = 1, 2 and 3 and s = 1, 2………… S	(2)
yjUsj ≥ ymUsm– M*(1 - xsj),	j = 1, 2 & 3 and s = 1, 2………… S m = 1, 2 & 3 with m ≠ j & j > m.	(3)
$\sum_{j=1}^{j=3} y_j \le K$		(4)
xsj= 0,1	j = 1, 2 & 3 and s = 1, 2………… S	(5)
yj= 0, 1	j = 1, 2 & 3.	(6)

Constraint (1) ensures that a consumer may switch to at most one model offered by the company. Constraint (2) requires that product or the model j needs to be offered by the company if a customer s switched to product j. Constraint (3) considers that a consumer will search for a product with maximum utility from those available within the offered models. A large number M is used to relax or make the constraint binding, as appropriate. Thus a consumer can only switch to a product j (i.e., xsj= 1) if j is within the proposed models (i.e., yj, = 1) and its utility, Usj is greater than or equal to the utility Usm, of each other product m within the offered models. When xsj= 0, the constraint is not binding due to the presence of large value of M. Constraint (4) limits the number of products/models offered by the company to at most K. Constraints (5) and (6) provide the required 0-1 restriction for xsj and yj respectively.

5.1 A Numerical Illustration

The analysis has been carried out with synthetic data. The illustration has been restricted to 2 products, an existing product and a new product which cannibalizes the existing product at a known cannibalization rate. A planning horizon of 5 years is considered. To keep the illustration simple, the growth rates of both the products are considered to be fixed over the years. All computations are carried out using Microsoft excel worksheet.

In order to carry out cannibalization analysis, we assume the following information to be known:

i. Unit profit of all the products
ii. Initial demand of existing product, without cannibalization
iii. Forecasted demand of new products
iv. Expected cannibalization rate of exiting product due to introduction of new products.

Case I: Profit margin of new product is more than the existing product, but the fixed cost is same.

The computations (see Table 1) are done assuming the profit margins of existing product (EP) to be 35 per cent and the that of new product (NP) to be 40 per cent. The fixed cost for both the cases is assumed to be same. The rate at which existing product is cannibalized by the introduction of new product 1 is assumed to be 50 per cent.

A higher profit margin of 40 per cent for the new product compared to a profit margin of 35 per cent of the existing product at 50 per cent cannibalization leads to higher total profit for the organization and hence calls for the immediate introduction of the new product (NP). In such cases, the firm should accelerate the demise of existing product by offering discounts on existing product, if the demand for the existing product is low to clear out their inventory.

Case II: Profit margin of new product is more than the existing product, but the fixed cost of new product (NP1) is more than existing product (EP).

The computations (see Table 2) are done assuming the profit margins of existing product (EP) to be 35 per cent and the that of new product (NP) to be 40 per cent. However, the fixed cost for NP is assumed to be much higher than the existing product, EP. The rate at which existing product is cannibalized by the

introduction of new product is assumed to be 50 per cent.

Table 1: Numerical Illustration for Case I

	Unit Price	Unit Cost	Net Profit	Demand	Total Profit	Cannibalization. Units
EP (w/o Cannibalization)	1000	741	259	1000	259259	
EP (with Cannibalization)	1000	741	259	800	207407	200
New Product	1100	786	314	400	125714	
			Total Profit		**333121**	

Table 2: Numerical Illustration for Case II

	Unit Price	Unit Cost	Unit Profit	Demand	Total Profit	Fixed Cost	Net Profit	Cannibalization. Units
EP (w/o Cannibalization)	1000	741	259	1000	259259	50000	209259	
EP (with Cannibalization)	1000	741	259	800	207407	50000	157407	200
New Product	1100	786	314	400	125714	90000	35714	
			Total Profit		**333121**		**193122**	

Here, the surplus generated by the new product during the initial years does not compensate for the decrease in profit from an existing product due to the high fixed cost needed for technological up-gradation. This leads to a loss in the initial years followed by a gain in subsequent years. The launching of the new product could be delayed to some extent till the existing product reaches its maturity state. However, the decision taken by a company regarding the launching time of a new product should also take into consideration the moves taken by its competitors in launching their products.

Case III: Market Potential of new product is high compared to the market potential of existing product.

The computations (see Table 3) are done assuming the profit margins of the existing product (35 per cent) to be more than the new product (20 per cent). The rate at which existing product is cannibalized by the introduction of new products is assumed to be 50 per cent. The growth rate of existing product (1.5 per cent) is lesser than the new product (4 per cent).

Figure 1 shows the graph for total profit without and with cannibalization over 5 years, starting from the launching year. The above analysis shows that if a new product has less profit margin but a large market potential in the future, the firm should take the decision on its early introduction. A similar result was obtained by Wilson & Norton (1989), which suggested that it is advisable to launch paper-back versions of books immediately after the hardcover editions are introduced (Moore & Pessemier, 1993).

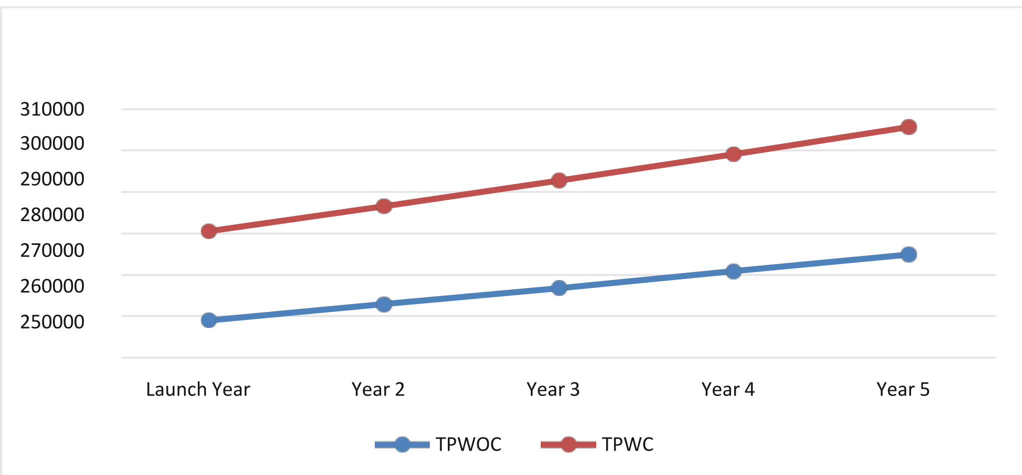
6. Discussion

Determining the right time to launch a new product is a strategic decision. This decision involves a comprehensive analysis, taking into account factors such as profit margins, fixed costs associated with each product, and the

Table 3: Numerical Illustration for Case III

	Unit Price	Unit Cost	Unit Profit	Growth Rate	Initial	Year 2	Year 3	Year 4	Year 5	Total Profit in 5 years
EP (w/o Cannibalization)	1000	741	259	1.5%	1000	1015	1030	1046	1061	**1334437**
EP (with Cannibalization)	1000	741	259	1.5%	800	812	824	837	849	1067550
New Product	1100	917	183	4%	400	416	433	450	468	397197
Cannibalized from EP			-76			8	8	9	9	-2571
										1462176
Total Profit w/o Cann.					259000	262885	266828.3	270831	274893	**1334437**
Total Profit with Cann.					280533	286575	292780	299155	305704	**1464747**

Figure 1: Impact of Cannibalization on Total Profit



Source: Author's Compilation

overall market potential for both existing and new products. The launching of the new product could be delayed to some extent till the existing product reaches its maturity state if the profit margin of the new product (NP) is more than the existing product (EP) but the fixed cost for NP is higher than EP. However, the firm should take a decision on the early introduction of a new product if the profit margin of NP is less than the EP and if the market potential of NP is higher than EP. This strategic approach ensures that the launch aligns with market dynamics, maximizing the chances of success. The decision-making process outlined involves an integration of various factors. It's not solely about maximizing profits but also about understanding the market landscape, potential risks, and the long-term sustainability of product offerings. Integrating machine learning predictions with traditional business insights enables a more comprehensive decision-making process.

7. Limitations & Future Extensions

The proposed framework of the study has a few limitations. One limitation is that the study is based on synthetic data as it is very challenging to obtain real data related to profit and fixed cost associated with the different products. The confidentiality issues or restricted access to proprietary data led to the decision to use synthetic data. Secondly, it does not take into consideration the impact of the introduction of similar products by the competitors. A firm may introduce a new product not to maximize long-term profits but simply to deter competitors from entering the market. Thirdly, the framework assumes a static situation where profit margin, cannibalization rate, and market potential of products are considered to be constant over the planning horizon. Moreover, future profits are not discounted to account for the time value of money. Future research should incorporate the said dynamic factors into the framework to enhance its managerial implications.

8. Conclusion

Innovation is the lifeline of any business. A product which delights the customers today may not be of any use to the customers' tomorrow. Product Cannibalization is a problem when it is unplanned. However, when planned, it may lead to generation of more profit to the firm. The dominant corporate strategy of a firm in future will be the ability to continuously cannibalize and replace its existing products or technology at appropriate times. In this fast changing technological world, a firm can't afford to avoid cannibalization. Rather, it should focus on determination of right launch timing of the new product(s) and also on the products to be offered to the customers. By addressing the timing of new product introductions with a focus on cannibalization potential, the research aims to assist companies in navigating the complexities of product lifecycle management.

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References

Bain, J. S. (1952). *Price Theory*. New York: Holt and Company.

Foster, R. N. (1986). *Innovation: The Attacker's Advantage.* New York: Summit Books.

Kate & Taylor (2017). Coca-Cola Cannibalism: Diet Coke's sister brand is pushing it closer to the brink of destruction. Retrieved from: https://www.businessinsider.in/coca-cola-cannibalism-diet-cokes

Kotler, P., & Keller, K. L. (2012). *Marketing Management.* Prentice Hall.

Levinthal, D. A., & Purohit, D. (1989). Durable Goods & Product Obsolescence. *Marketing Science, 8*(Winter), 35-56.

Mason, C. H., & Milne, G. R. (1994). An approach for identifying cannibalization within product line extensions and multi-brand strategies. *Journal of Business Research, 31*(2-3), 163-170.

Moore, W., & Pessemier, E. (1993). *Product Planning and Management: Designing and Delivering Value.* McGraw-Hill.

Porter, M. E. (1980). Competitive strategy: Techniques for analyzing industries and competitors. New York: Free Press.

Star, S. H., & Urban, G. L. (1988). The Case of the Toss Market Toss Up. *Harvard Business Review, 66*(5).

Traylor, M. B. (1986). Cannibalism in Multibrand Firms. *The Journal of Consumer Marketing, 3*(Spring), 69-75.

Wilson, L. O., & Norton, J. A. (1989). Optimal Entry Timing for a Product Line Extension. *Marketing Science, 8* (Winter), 1-17.

Yu, H., & Malnight, T. W. (2016). The Best Companies Aren't Afraid to Replace Their Most Profitable Products. *Harvard Business Review*. Retrieved from: https://hbr.org/2016/07/the-best-companies-arent-afraid-to-replace-their-most-profitable-products

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