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# CONCEPTUALIZING INTEGRATED LIFE-CYCLE MANAGEMENT FOR SUSTAINABLE AND OPTIMAL UTILIZATION OF USED COOKING OIL (UCO)

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## ABSTRACT

*Used Cooking Oil (UCO) is generally viewed as waste discarded from household kitchens in rather small quantities. Contrary to this popular belief, UCO is generated in large volumes from high-end food-based operators (FBOs), amongst which fine-dining hotels and quick-service restaurants are the major contributors. As per the industry insights as well as several government reports, there exists a strong market for UCO in India as it is used in many industrial applications (biodiesel production and soap manufacture), apart from being recycled back into the food chain. In the face of climate change, emission reduction from the Indian freight transport sector remains a priority. Biodiesel has emerged as an effective alternate solution in reducing the emissions attributable to conventional internal combustion engine-based freight vehicles. Since the first-generation feedstock for biodiesel faces a debate revolving around 'food vs fuel' discussions, the second-generation feedstocks, such as UCO become even more relevant. Further, the biodiesel produced from UCO has been proven to be less polluting than petro-based diesel. It has a lesser environmental footprint as compared to the biodiesel produced from first-generation feedstock (e.g., biodiesel from palm stearin, for which native plant species are destroyed because of large-scale palm tree cultivation). However, the used cooking oil volumes emanating from various distribution facilities are largely inaccessible by the biodiesel manufacturers, primarily due to a lack of organized supply chain management in India. Since UCO is the end-of-life byproduct of edible oil as well as a raw material for biodiesel, the present study explores a possible conceptual template for a sustainable and integrated life cycle of oil in India, pivoted around the supply chain management of UCO. Industry insights have been used in this study to affirm the conceptual structure of the envisaged integration template.*

***Keywords*:** Used Cooking Oil, Biodiesel, Crude Oil, Integrated supply chain, Blockchain

## ABBREVIATIONS & SYMBOLS

| | |
|---|---|
| CAD | Current Account Deficit |
| EVO | Edible Vegetable Oil |
| FBO | Food Business Operator |
| FSSAI | Food Safety and Standards Authority |
| GHG | Green House Gas |
| GIS | Geographic Information System |
| NFP | Non-Food Production |
| NVO | Non-edible Vegetable Oil |
| RUCO | Repurpose Used Cooking Oil |
| SDG | Sustainable Development Goal |
| TPC | Total Polar Compound |
| UCO | Used Cooking Oil |
| $gCO_{2eq}/MJ$ | gram $CO_2$ equivalent per Mega Joule |

## INTRODUCTION

India is a net importer of vegetable and crude oils to meet its food and fuel demands, respectively. India's consumption of edible vegetable oil (EVO) has been rising over the last two decades, doubling from nearly 9 kg/capita in 2000-01 to about 18 kg/capita in 2020-21 [1]. In India, soap, oleochemical, and other industries consume non-edible vegetable oil (NVO). Its import had increased rapidly over the last few years due to low import duties imposed and it had touched 0.64 million tonnes in 2018-19 [1].

In the total oil import basket of India (EVO, NVO, and crude oil), the import of crude oil has the highest share in terms of the import costs on the exchequer. The import costs incurred on crude and vegetable oils by India have been shown in **Figure 1**. It also reflects that a major share of India's forex goes towards the import of oil. In the pre-COVID era (before 2020), the import share of oil (crude oil and EVO combined) has gone up from 24% in 2015-16 to 29.2% in 2019-20 in terms of forex value [2, 3].

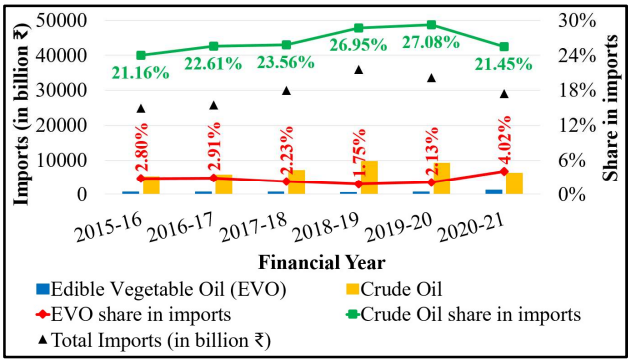


**FIGURE 1.** Import status of edible vegetable oil and crude oil in India

The demand for vegetable and crude oil has increased in the last few years as domestic production has not kept pace with the consumption. Since both these oil products have a wide range of end applications in India, a causal relationship between the import patterns of the two can't be established. However, a common link between the two is developing increasingly as the world seeks to move away from crude oil owing to the high emissions associated with it. The rise in biofuels (ethanol and biodiesel) and their blends with petrol and diesel, respectively, have curbed global Green House Gas (GHG) emissions by a considerable amount. Amongst the various raw material sources for biofuels, Used Cooking Oil (UCO) connects the life cycles of the two oils imported by India, i.e., crude oil and edible vegetable oil (EVO). UCO is generated as the end-of-life waste from EVO, and this waste is used as a second-generation raw material source for biodiesel production. A comprehensive life cycle of UCO is depicted in **Figure 2**.

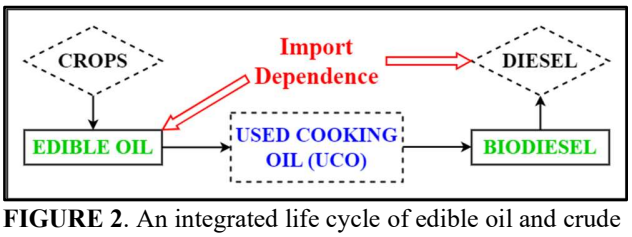


**FIGURE 2**. An integrated life cycle of edible oil and crude oil with Used Cooking Oil (UCO) as the connecting link

The EVO is used in all the household kitchens of India, but it finds bulk use in restaurants, eateries, institutional canteens, and ready-to-eat food manufacturing facilities, leading to bulk generation of UCO [4]. Repurpose Used Cooking Oil (RUCO) policy booklet issued by the Food Safety and Standards Authority of India (FSSAI) under its 'Eat Right India' program says that 60% of EVO is used by households while the rest 40% is utilized by the commercial establishments [5]. The amount of leftover oil post-cooking process depends on the source type. In Indian households, leftover UCO amounts to less than 1% of EVO used in cooking which generally ends up in drains, often leading to the choking of the kitchen pipelines and sewers. The amount of left-over UCO in restaurants varies from 2% to 30% of the EVO quantity used, depending on the dining class. Fine dining hotels and chains of quick service restaurants generate UCO at the rate of 10-30% of cooking oil volume, while the quantity from the casual dining outlets remains in the 2-5% range [6].

The roadside eateries leave no leftover oil from their EVO usage, in practice. Such practices have serious health implications in terms of heart ailment, organ failure, and even cancer caused by a high percentage of Total Polar Compounds (TPC). Therefore, there is an urgent need to relook into the sustainable utilization of UCO, such that the core spirits of Sustainable Development Goals (SDGs) 2 and 3 are protected. SDG 2 acknowledges food and nutritional security as its core targets, and SDG 3 focuses on healthy lives and the promotion of well-being for all [7].

## USED COOKING OIL (UCO) ECOSYSTEM

Used Cooking Oil (UCO) has a great market value in India since it is used as raw material for producing biodiesel, as well as for the manufacturing of soaps, lubricants, grease, and animal feed. As per an estimate by the RUCO policy booklet, India generates 9-10% of UCO annually from the total EVO consumed in the country [5]. In 2020-21, nearly 24.6 billion liters of EVO was consumed in India and therefore, the potential availability of UCO was pegged at around 2.2 billion liters. The economic value of this leftover depends upon its quality, source of generation, and the current market prices of edible oil and diesel.

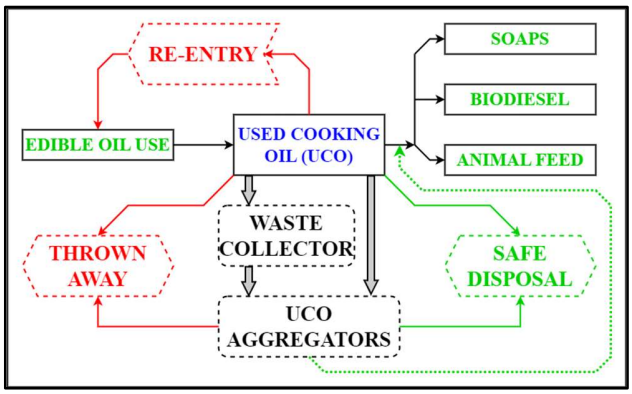


**FIGURE 3.** Existing ecosystem for UCO management

The most concerning part of UCO usage in India is its diversion back into the food chain for re-use since it is generally 50% cheaper than the virgin edible oil available in the market. As per the FSSAI, 60% of the generated UCO goes back into the food chain making it not only unhealthy for the citizens but also depriving industries (esp. biodiesel manufacturing) of a critical raw material [5]. The existing ecosystem for UCO disposal is depicted in **Figure 3**.

Biodiesel, as a fuel, is very similar to conventional diesel in its physicochemical properties. Its complete combustion accounts for very less GHG emissions (11-16 $gCO_{2eq}$/MJ) per unit of energy delivered as compared to diesel (92-95 $gCO_{2eq}$/MJ) [8]. These make biodiesel the most suitable alternative to diesel in the short-to-medium term. As the world is looking forward to the next generation ($2^{nd}$ and $3^{rd}$) feedstocks for biofuels [9], the use of Used Cooking Oil for biodiesel production becomes indispensable. It also adds to environmental sustainability since the greasy waste oil is effectively utilized. **Figure 3** reflects that the supply chain management associated with UCO is not very streamlined in India, and therefore, UCO diversion for the sole purpose of biodiesel production has not been achieved. A substantial fraction of UCO is repurposed and reused in manufacturing spurious edible oil produced by unorganized entities, while some portion is released into the environment through the drains (as evident from **Figure 3)**. Consequently, it leads to serious environmental, as well as health consequences (see **Figure 4**). However, **Figure 4** also depicts the potential economic as well as environmental benefits that can be achieved by streamlining the utilization of UCO mainly for biodiesel production, which has direct benefits in terms of reduced import bills as well as employment generation (both direct and indirect) in the waste-to-wealth value chain.

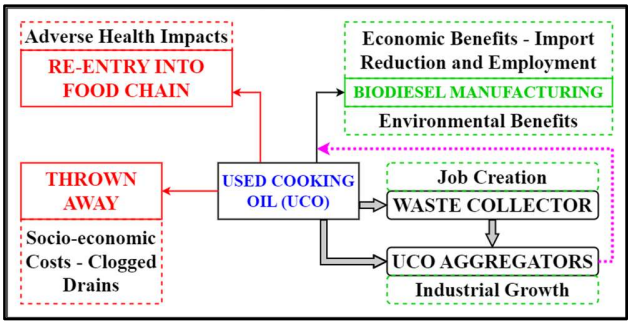


**FIGURE 4.** Costs and benefits associated with the Used Cooking Oil (UCO) ecosystem

The FSSAI issued the guidelines for the collection of UCO by the Non-Food Production (NFP) units in 2022 [10]. It mandates that all the NFP units for the collection of UCO from the Food Business Operators (FBOs) have to obtain an authorization letter. All the NFP units have to ensure that UCO doesn't go back to the food chain through reselling, and any violation in this regard invites penal action. Despite such steps taken earlier, the diversion of UCO back into the food chain takes place primarily due to the price differential between the virgin edible oil and the recycled UCO. The price of edible oil remains high in India (₹ 75/kg to ₹ 175/kg depending on variety) due to limited production in India and import dependence. This encourages a parallel, undesirable network run by non-approved aggregators that collect UCO from the FBOs and supply it back to the food chain.

***Industry Insights:*** The authors have interviewed a few UCO aggregators regarding the ground reality of UCO collection from the FBOs. Their concerns around UCO supply chain management can be reflected in three broad themes.

i. ***Supply assurance*** – The regular supply of UCO is essential for the commercial viability of biodiesel plants. This can only be achieved when the price of virgin EVO becomes pocket-friendly. To reduce the price of virgin EVO, the farmers must be incentivized to produce oilseeds commercially. Further, strict adherence to the disposal norms for UCO by the FBOs, customer awareness regarding the harmful health impacts of using recycled UCO, and transformation in consumer behaviour towards the safe disposal of discarded oil with individual commitment towards the environmental protection are some of the ways to streamline UCO collection. Consumer awareness has led to the effective collection of UCO from households, and it is subsequently diverted for biodiesel production in Hungary [11]. Such models should also be encouraged in Indian households with proper monitoring from the urban municipal bodies.

ii. ***Transparency and Accountability*** – There is an urgent need for strict adherence to the rules by all stakeholders (FBO, UCO collector and aggregator, biodiesel manufacturer and supplier, etc.) to ensure that UCO doesn't go back to the food chain and the defaulters should be penalized to ensure better accountability. The possibilities of using modern technology in India should be explored to ensure transparency across the UCO supply chain.

iii. ***Coordination within the ministries*** – Since UCO is an end-of-life product for edible oil as well as a raw material for biodiesel, the handling of UCO by different ministries results in a serious lack of coordination in the logistics. A coordinated effort is, therefore, essential for the most apt utilization of UCO. A right open-market price discovery mechanism for UCO is of utmost importance since India is becoming increasingly dependent on imports for both edible and crude oil. Heavy import dependence will result in a severe Current Account Deficit (CAD). Therefore, channelizing UCO for

biodiesel production is a promising pathway to alleviate the import bills associated with oil (crude oil and EVO combined).

## DISCUSSION

Two main bottlenecks are currently limiting the diversion of UCO towards biodiesel production. The primary issue is the lack of coordination amongst various ministries concerning UCO. The production of oilseeds (crushed to produce edible oil) is controlled by the Ministry of Agriculture and Farmers Welfare, and edible oil production and consumption come under the domain of the Ministry of Consumer Affairs, Food and Public Distribution. UCO is looked after by the FSSAI which comes under the Ministry of Agriculture, while the lifecycle of biodiesel is tackled by the Ministry of Petroleum and Natural Gas. It calls for better coordination among different ministries so that the life cycle of edible oil doesn't end at the generation of UCO but at the end of the life cycle of diesel, i.e., the wheels of a transport vehicle [12]. PM-Gati Shakti is a government initiative that was unveiled in 2021 where sixteen ministries come together on a digital platform for integrated planning and coordinated implementation of infrastructure connectivity projects [13]. Similar efforts are needed for the non-infrastructure-based segments.

The role of technology remains critical for the effective execution of integrated planning. Taking the example of PM Gati Shakti, the role of digitization (application software), and Geographic Information System (GIS)-based mapping remain at the core of the master plan. Similarly, the role of futuristic technology such as blockchain would prove to be a game changer for better supply chain management of Used Cooking Oil (UCO). As per a study done by the RSB and BioLedger in 2021, a blockchain database for UCO would significantly improve transparency and accountability in the supply chain [14], and the stakeholders will have verifiable proof of origin for UCO. It will lead to secure consignments, simplified processes (collection, aggregation, manufacturing, and supply), audit efficiency, robust data integrity, and will facilitate centralized governance.

## CONCLUSION

The benefits of an integrated life-cycle understanding of Used Cooking Oil (UCO) are multifold comprising social, environmental, and economic aspects. It can be realized by managing the UCO supply chain more efficiently by strict adherence to the norms as well as by the use of modern technology. It can only be accomplished through effective coordination between various ministries and departments within the government.

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