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Market Assessment of RRR Business Models – Bangalore City Report

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Executive Summary

Introduction

The feasibility studies conducted in Bangalore are a core of the research project and sought to explore across different settings the applicability, adaptability and comprehensiveness of the proposed business models in real-life settings; resulting in the strengthening of the methods and procedures, but also in view of scalability and viability. A key component of the feasibility studies is the market assessment of the RRR business models as functioning markets, an enabling institutional environment and positive economic and financial conditions are essential for sustainable business activity in any sector including the waste reuse sector. This report thus presents the results of the market assessment as part of the feasibility testing for the implementation of waste reuse (resource recovery and reuse - RRR) business models in Bangalore, India.

The set-up of any RRR business and the commercialization of a new product in a new market requires an accurate or close to accurate estimation of the relative market size for the new product. The successful development of any subsector market depends among other factors particularly on market demand. Specifically, the question of whether a demand actually exists and the price end-users are willing to pay for this new product needs to be explored. "Demand, even among those with limited resources, is not automatic." (Phillip et al., 2003; page 194). For this reason, the market assessment set out to evaluate the current and potential market for the recovered resource and the effect of different factors (e.g. socio-cultural aspects and perceptions, price of substitute products, etc.) on market demand. Information on market segments, potential clients of the RRR product, their actual and potential number and resource absorption capacity and their willingness-to-pay (WTP) were assessed.

Additionally, the adoption of effective marketing and pricing strategies to ensure business sustainability require entrepreneurs to comprehensively understand the dynamics inherent in the relevant sub-sectors. This translates into the need for evaluating the structure (i.e. competition, differentiation of substitute products, barriers to market entry, among others) of the product market they operate in, i.e. how the behavior and performance of other businesses influence their decision making. Another important facet to the market assessment is demand forecasting – i.e. market outlook. Market forecasting is a crucial element for business owners in assessing future capacity requirements, evaluating their decisions in the implementation of new business strategies and pricing decisions. Businesses need to adopt different strategies ranging from establishing key partnerships and price markups to maintain a competitive advantage and ensure sustainability. An assessment of the above listed aspects provides entrepreneurs with a solid market information base crucial for business start-up and sustainability. In that regard, the specific objectives of the market assessment were:

1. To assess the market value of the RRR products under consideration –
    a. To assess consumers' willingness-to-pay (WTP) and differences in WTP estimates across different consumer segments and related factors influencing consumer demand;
    b. To estimate the potential market size for the RRR product;
2. To assess the extent and characteristics of the market structure;
3. To evaluate the market outlook of the RRR products and to what extent the RRR products would be viable over time in the market.

A total of 12 RRR business models were selected for the feasibility studies in Bangalore. For the purposes of the market assessment, an end-use typology of the business models was employed as although the underlying concept of the business models were different, a number of the end-products

were the same across different business models. Thus for some business models, the related customer segments and relevant actors along the value chain considered would be the same. In that regard, for the selected business models, the following 6 value-added products were considered: 1) briquettes, 2) electricity, 3) wastewater-fed fish, 4) treated wastewater, 5) MSW-based compost and 6) faecal sludge-based compost. Untreated wastewater is not considered a marketable commodity as it is considered to increase human health risk and environmental pollution and thus potential users' valuation was not assessed.

Table A: List of RRR business models and related products

Business Model	Value-added product	Recovered resource
Model 1a: Dry fuel manufacturing: agro-waste to briquettes	Briquettes	Energy
Model 4: Onsite energy generation by sanitation service providers	Electricity	
Model 6: Power capture model - Livestock waste to energy		
Model 8: Phyto-remediative wastewater treatment and fish production	Wastewater-fed fish	Fish
Model 9, 11 and 12: On cost savings and recovery (treated wastewater for irrigation, energy, fertilizer)	Treated wastewater	Wastewater
Model 10: Informal to formal trajectory in wastewater irrigation	Untreated to partially treated wastewater	
Model 15: Large-scale composting for revenue generation (MSW to compost)	MSW-based compost	Nutrients
Model 16: Decentralized multi-partnership community based model		
Model 17: High value fertilizer production for profit (faecal sludge to compost)	Faecal sludge-based compost	
Model 20: Informal reuse of faecal sludge for agricultural production (FS collection service and on-farm use)	Farm treated faecal sludge	

Methodology

▪ Overview of Methodology

The successful development of any RRR business depends on the effective workings of different facets of the respective value chain including: (a) market linkages between related subsector markets; (b) business dynamics between relevant economic actors and (c) consumers' responsiveness to newly developed and available products. When introducing a new product into the market, businesses are particularly interested in three factors: current and future consumer demand, competition and production costs. Though cost estimations are simple and straightforward, the assessment of consumer demand (as measured by willingness-to-pay (WTP)) and competition are comparatively more complicated and not a straight forward calculation as historical data of consumer purchase patterns are guidelines at best (Lusk and Hudson, 2004). Specific methods were developed and used for the evaluation of the consumers' WTP, the assessment of market structure and outlook. The choice of methods for evaluating the different research questions were dependent on the context, the related RRR product, access to data and analytical tools to be employed. The WTP and market outlook analysis viewed the business models from an end-product perspective, whilst the market structure was conducted from a sector perspective; i.e. (a) alternative fuel market, b) electricity market, c) fish market, d) water market and e) fertilizer market.

- **Study Area and Data**

The primary survey covered several key districts in Bangalore (urban, peri-urban and rural). For the WTP and market size assessment, primary data on price offers from market experiments, information on demographics and socio-economic factors were collected from different groups of respondents depending on the RRR product. Data on price of substitute products, macro-economic factors, amongst others were collected from secondary sources. WTP measures were derived directly from the purchase price and additional econometric analysis. For the market structure, both primary and mostly secondary data were collected and used for the supply chain analysis, although this was dependent on the RRR product. Data on the number and size of key players, players' characteristics (e.g. economies of scale, access to financing, marketing and distribution costs, and level of integration and nature of contractual agreements) were collected from primary sources. For the market outlook assessment, data on market demand and market share were obtained from the WTP and market structure assessment components. Additional secondary data on alternative products, prices and quantity of sales of existing competing products in the market was collected from relevant institutions (e.g. marketing boards and departments).

Results of the Market Assessment

- ***Model 1: Dry fuel manufacturing: Agro-waste to briquette***

The results indicate that there is a fair market demand for agro-waste briquettes in Bangalore, although not substantial. Among the surveyed households (both urban and rural), none were currently noted to be using briquettes. Furthermore, the estimated supply of agro-waste for the generation of briquettes and the estimated demand for briquettes from the identified segments of the economy broadly reveal that there is no significant demand supply gap for briquettes, although the estimated demand exceeds estimated supply. This suggest that an appropriate planning and marketing strategy will be required for new briquette businesses to gain a share of the market. New briquette businesses also will need to accommodate customer expectations in terms of credit, delivery, and near nil expenditure for marketing by the current market players. Differential pricing can help in gaining market share, although its implementation needs to be studied in greater detail. Across all the studied markets product promotion and marketing is close to nil. New briquette businesses would need to invest in R&D in order to mitigate the effects of high social barriers. This would place them at a competitive disadvantage compared to their competitors.

There are also both policy induced factors and environmental factors that are representative of entry barriers for briquettes to penetrate the household sector. Government subsidies for existing competing products in the energy market (LPG and Kerosene) can pose a challenge to new briquette businesses, and thus appropriate product positioning and customer targeting would be very essential to overcome the challenges posed by the subsidy. Additionally, the extensive established network of LPG has improved the product's accessibility not only in urban areas but also in rural areas - thus a significant competitor for briquettes. Similarly, the steady improvement of electrification has resulted in households relying on electricity at least for lighting. In addition, urban low income households have the access to kerosene both through public distribution system and open markets; and in the rural areas, households have the luxury of collecting firewood free of cost.

- ***Model 4: Onsite energy generation by sanitation service providers and Model 6: Power capture model - Livestock waste to energy***

The electricity market is heavily regulated and monopolized by state agencies. Private participation although present is very limited and permitted only for certain aspects of power generation. Pricing of electricity is negotiated between the private entrepreneurs and the respective electricity reforms commission. As private electricity suppliers do not supply directly supply to households but rather to

the national grid, the only direct market/ consumer is with the latter. In that regard, a willingness-to-pay assessment was not conducted for business models 4 and 6. An assessment of the market structure and outlook is provided in detail in the 'Institutional analysis' report.

- ***Model 8: Phyto-remediative wastewater treatment and fish production***

The results show that consumers derive a negative utility from wastewater-fed fish and wild fish. The primary survey shows that wastewater fish is presently not being consumed by the households. In absence of the revealed preference data an approximate price of wastewater fed fish with information about the source and certification is Rs. 173.6/Kg (which considers only the information price and certification price). The actual payment for wastewater-fed fish among the consumers was estimated to be Rs. 63.97/Kg which lower than the current market price of non-certified fish with no source information. The results show that consumers are willing to pay Rs.37.25/kg to know the source of the fish (i.e. which medium the fish was reared in) and Rs. 136.36/kg for certification.

The market prospect for wastewater-fed fish has some promise but will face social barriers and consumer perceptions in the initial stages. Innovative marketing strategies including pricing and product promotion strategies will be require to facilitate the entry of new businesses into the market. It is suggested that food products made from fish harvested in treated wastewater must be priced differentially lower than that of food products of freshwater fish, in order to capture a share of the market. An aggressive marketing strategy for the promotion of treated wastewater fish is also recommended. Overall, wastewater-fed fish has a good market outlook but will have to compete aggressively with their alternative products to sustain in the market eventually. Freshwater fish is a very a close substitute for fish from treated wastewater. Therefore, this product will offer a high degree of competition to the RRR product. With an ever-expanding cultivation of freshwater fish and with an ever increasing level of income and population, the demand for freshwater fish will grow steadily. However, if proper labelling is done by appropriate regulatory authorities to educate the prospective consumers that the consumption of fish reared from treated wastewater will not pose any health risks, and if it is sold at a competitive price, it will find its way into the market, though gradually and steadily.

- ***Model 9: Cost recovery - Treated wastewater for irrigation, fertilizer and energy and Model 10: Informal to formal trajectory in wastewater irrigation***

The results from the WTP assessment show that the majority of farming households (93% of surveyed respondents) are willing to use and pay for treated wastewater for irrigation purposes, especially during the drier seasons (summer months). A lower percentage (63%) were however noted to be willing to pay for treated wastewater during the monsoon season. On average, 89% of these farmers were willing to pay for using treated wastewater for irrigation. The farmers were willing to pay Rs.482/- per 10000 litres (10 m^3) of treated/partially treated wastewater. The results also showed that the farmers placed a higher value on treated wastewater under a scenario of 'increased water scarcity' compared to any increment in cost of water supply. The bids offered by the farmers for an increase in cost of water at the initial levels (10% to 25%) are similar in terms of the average value (Rs.315.38). This increases marginally by Rs. 66 when an option of 100% cost increment is faced by the farmers. In comparison, the marginal change in the bid offered when scarcity of water increases from 25% to 50% is about Rs. 210 per 100m^3 which is 3 times the increase in the bid offered for cost changes. The results also showed that farmers with more farming experience were willing to pay a relatively higher fee than the other groups. It is however important to note that the standard deviation for these farmers was also higher in comparison to the groups. Additionally, farmers dependent on rainwater for irrigation were willing to pay a higher fee for wastewater for irrigation than farmers utilizing groundwater. This might be due to the fact that farmers practising rain-fed farming are willing to hedge the risk of vagaries of rainfall and hence have a higher willingness to pay. The farmers dependent on groundwater pay a relatively higher price for water compared to the other group of

farmers and may not consider treated wastewater a substitute with the assured water supply they presently receive. Another reason for lower preference for payments is due to the fact that farmers who have already invested for groundwater are reluctant to phase it out completely since it entails a higher establishment cost.

In regards to the businesses, the results showed that on average of 84% of the surveyed enterprises were willing to pay for treated wastewater. The average WTP value was Rs.455/- per tanker of treated/partially treated wastewater. However, among the larger enterprise respondents, they were willing to pay on an average of Rs.1160/- per 8000 litre tanker. The results also indicated that the enterprises value treated wastewater relatively higher under the scenarios of 'increment in cost of water supply' than that of 'water. Under the water scarcity scenario, it was found that the payments offered by the enterprises were relatively lower. In fact even with a 10% scarcity of water, the enterprises were willing to pay about the same charges as when there was no water scarcity. Another important consideration is that while for the first 15% increase in scarcity of water the WTP for treated wastewater (a substitute) rises by Rs.50 (a rise of 10%) and for the next 75% increase in scarcity of water, the WTP rises by about Rs. 141 (about 28%). Thus the changes in the WTP move in an opposite direction (as availability decreases, WTP rises) although not proportional to the change in the scarcity of water (which would become dearer which scarcity of water). This implies that the enterprises do consider wastewater as a substitute to water although not a perfect substitute. The enterprises included in the survey comprised of institutional houses (*Kalynmantapas*), hotels, car services, washer-man and industries (like brick manufactures, chemicals and garments). Except for the industries, it was found that other businesses incur water costs less than Rs.5000 and hence have lower payments for wastewater as can be seen from the above table. Similarly, the consumption of these businesses are lower than that of the industries and hence have lower preference for WTP for treated wastewater. These smaller (and some medium) enterprises thus have a lower substitutability for treated wastewater rather than the larger industries and hence their demand curves are more inelastic to price changes of water.

It is clear that there is a fair demand for treated wastewater. In particular, the demand is higher among farmers but characterized by a WTP lower during the monsoon seasons that the summer season. Demand for treated wastewater among businesses was found to be specific to the enterprise type and use. Demand for water is expected to grow exponentially in the future particularly in the agricultural and industrial sectors. In terms of the structure of the water market, it is a well-regulated market and it is foreseen that the supply and distribution of wastewater and the related market structure will most likely follow a similar pattern.

- ***Model 15: Large-scale composting for revenue generation (MSW-based compost), Model 16: Decentralized MSW composting and Model 17: High value fertilizer production for profit (faecal sludge-based fertilizer)***

The analysis shows that there is a significant demand for MSW compost and Fortifer. The potential market for MSW-compost is noted to be substantial with the demand estimated at 578,400 tons/year, with an adoption rate of 20% and application rate of 12.5 tons/ha/year. The total cultivated area is 231,377 ha[1]. The results indicate that farmers are willing to pay 1.458 INR/kg more to know the source of the waste input used to produce the compost; and an even higher premium of 5.359 INR/kg for pelletization and 14.397 INR/kg for certification. Nutrient content and quality which have direct positive effects on farm yields and profits are preferred attributes. Given these marginal estimates, the full analysis shows the estimated WTP for compost to be 61.214 INR/kg, which is significantly higher than the current market of competitive products. The results suggest that the demand for compost could increase if the abovementioned attributes are factored into the final product for the

[1]http://agcensus.dacnet.nic.in/districtT1table1.aspx

market. From a business perspective, it is pertinent to evaluate the costs of introducing any of these attributes as against the benefits, which are measured through the WTP estimates. In the instance where such product differentiation is not cost-effective, it is important to explore the opportunities that partnerships can offer and also those related to some form of government subsidization.

The potential market for Fortifer is noted to be substantial with the demand estimated at 54,249 tons/year, assuming an adoption of 40% and application rate of 0.59 tons/ha/year. The total cultivated area considered is 231,377 ha[2]. Chemical fertilizer application rates were used as a basis for the calculation of the application rates of Fortifer (DOA, 2014). The average chemical fertilizer applications were estimated at 117 kg/ha and Fortifer at 5 times this estimate as Fortifer is considered a close competitive substitute product. The results indicate that farmers are willing to pay 10.63 INR/kg more for fortification and an even higher premium of 14.97/kg for pelletization. Interestingly, the farmers were however noted to have a lower valuation for the certification attribute and would need a compensation of 0.77 INR/kg for certification. Nutrient content and quality which have direct positive effects on farm yields and profits are preferred attributes. It is important to note that the noted premiums are slightly lower when socio-economic variables are factored into the choice set. Given these marginal estimates, the full analysis shows the estimated WTP for fortified and certified Fortifer to be 67.06 INR/kg, which is significantly higher than the current market of competitive products.

The market structure assessment suggests an oligopolistic fertilizer market, plagued by market distortions attributable to limited infrastructure (installed capacity); high energy requirements for production and a growing organic agricultural sector which has created an opportunity for business development in the organic fertilizer sub-sector. The chemical fertilizer sector is also a capital-intensive industry. Thus, limited access to financing at a large scale further exacerbates supply-related constraints (IFDC and CHEMONICS, 2007). There is however a large-scale government fertilizer program that provides subsidized fertilizer to farmers and a fairly active private fertilizer sector that supplies fertilizer at competitive prices; this represents a potential limitation for market entry of organic fertilizer businesses. It is important to note that there could be a potential revision to the current subsidy regime in the instance that the national budget deficit continues to grow. On the other hand, the growing organic foods market will increase the demand for organic fertilizers and the respective producers certainly have an opportunity to play a key role in filling this gap in the fertilizer market.

The overall feasibility of the business models was then evaluated based on the different aspects (market demand, market structure and market outlook). It was noted that models 1a, 9, 15/16, 17, have a medium feasibility from a markets' perspective (Table B). On the other hand, waste-to-energy models, in particular agro-waste and faecal sludge to electricity have a low feasibility potential as is the wastewater-fed fish business model from a market perspective.

[2]http://agcensus.dacnet.nic.in/districtT1table1.aspx

Table B: Overall feasibility of the selected RRR business models from a market perspective

Business model	WTP and Market Demand	Market Structure	Market Outlook	Cumulative feasibility score	Value-added product/recovered resource
Model 1a – Dry fuel manufacturing: agro-waste to briquettes	WTP > Current market price of substitute product	1. Fairly easy market entry 2. Low-to-medium level of concentration 3. Limited to no product differentiation 4. Price setter 5. Potential net profit margins	4-5 years to reach growth stage in business life cycle	**Medium feasibility**	**Briquettes**
Model 4 – Onsite energy by sanitation service providers **Model 6 – Power capture model - Livestock waste to energy**	Consumers are price-takers. As electricity is subsidized - we assume that WTP = current market price	1. Medium to difficult market entry - regulated market 2. Medium to high level of concentration (oligopolistic market) 3. No product differentiation 4. Price taker 5. Potential negative profit margins (without subsidies)	Future demand scenario assessment indicates fair possibility for the government to fulfill supply gap	**Low feasibility**	**Electricity**
Model 8 – Beyond cost recovery: the aquaculture example	WTP < Current market price of substitute product	1. Medium level of ease for market entry 2. Low to medium levels of market concentration 3. Limited to no product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	10 -11 years to reach growth stage in business life cycle	**Low feasibility**	**Wastewater-fed fish**
Model 9, 11 & 12 – On cost savings and recovery (wastewater reuse)	WTP > Current market price (among farming households)	1. Medium level of ease for market entry 2. Low to medium levels of market concentration 3. Limited to no product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	Anticipated exponential growth in demand esp. in agricultural and industrial sectors	**Medium feasibility**	**Wastewater**
Model 10 – Informal to formal trajectory in wastewater irrigation	Not evaluated as policies, legislations and organizational structures are not supportive of this practice.			**No feasibility**	
Model 15 – Large-scale composting for revenue generation (MSW to compost) **Model 16– Subsidy-free community based composting (decentralized composting)**	WTP > Current market price of competitive/ substitute products	1. Medium level of difficulty for market entry 2. Fair level of concentration 3. Fair level of product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	6 -7 years to reach growth stage in business life cycle	**Medium feasibility**	**MSW-based Compost**
Model 17 – High value fertilizer production for profit	WTP > Current market price of competitive/ substitute products	1. Easy entry 2. Fair level of concentration 3. Fair level of product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	6 -7 years to reach growth stage in business life cycle	**Medium feasibility**	**Faecal sludge-based organic fertilizer**
Model 20– Outsourcing faecal sludge treatment to the farm	Although practiced in the private sector, disposal of raw faecal sludge on farmland is illegal.			**Low feasibility**	

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Abbreviations

BWSSB	Bangalore Water Supply and Sewerage Board
BBMP	Bruhat Bangalore Mahanagara Palike
BETs	Biomass efficient technologies
BMRDA	Bangalore Metropolitan Region Development Area
CE	Choice Experiment
CL	Conditional Logit
CV	Contingent Valuation
DCE	Discrete Choice Experiments
DOA	Department of Agriculture
FKCCI	Federation of Karnataka Chamber of Commerce and Industry
FS	Faecal Sludge
GDP	National Gross Domestic Product
HACCP	Hazard analysis and critical control points
HHI	Herfindahl-Hirschman Index
ICLEI	International Council for Local Environmental Initiatives
IIA	Independence of Irrelevant Alternatives
INR	Indian Rupees
IWMI	International Water Management Institutes
KCDC	Karnataka Compost Development Corporation
KSFIC	Karnataka State Forest Industries Corporation limited
LIG	Low Income group
LPG	Liquid Petroleum Gas
MC	Market Concentration
MCA	Multi-Criteria Assessment
MLD	Million Liters per day
MNRE	Ministry of New and Renewable Energy
MSW	Municipal Solid Waste
MTPD	Million ton per day
NBS	Nutrient Based Subsidy
NCAP	National Centre for Agricultural Economics and Policy Research
NCOF	National Centre of organic Farming
NGOs	Non-Governmental Organizations
NSSO	National Sample Survey Office
OWC	Organic waste converters
PCA	Principal Component Analysis
RPL	Random parameter logit model
RRR	Resource Recovery and Reuse
RUT	Random Utility Theory
SCP	Structure–Conduct–Performance
STD	Standard Deviation

TWW	Treated Wastewater
WHO	World Health Organization
WTP	Willingness to pay
WtR	wastewater treatment and reuse
WWF	wastewater-fed fish

1. Introduction

Functioning markets, an enabling institutional environment and positive economic and financial conditions are essential for sustainable business activity in the resource recovery and reuse (RRR) waste sector. The feasibility study methodology builds on a multi-criteria assessment (MCA) and identified performance indicators which allow the accurate assessment of the viability and scalability potential of the RRR business models based on several elements including an institutional, policy and market, health and environmental assessment. Assessing the feasibility of a business model in settings of different levels of development means that (1) if a business was to be set-up based on a particular model would it be viable – *replication potential*, or (2) would a particular model be viable at different scales - *scaling-up potential.* This requires an in-depth understanding of the functionings of both the input and output markets, enabling institutional environments and positive economic and financial conditions, which are all essential in assessing the sustainability of business activity.

In particular, the set-up of any RRR business and/or commercialization of a new product in a new market requires an accurate or close to accurate estimation of the relative market size for the new product. The successful development of any subsector market depends among other factors particularly on market demand. Specifically, the question of whether a demand actually exists and the price end-users are willing to pay for this new product needs to be explored. For this reason, the market analysis sets out to assess the current and potential market for the recovered resource and a myriad of factors (e.g. socio-cultural aspects and perceptions, substitute products available in the market, etc.) that will influence market demand. Information on market segments, potential clients of the recovered resource, their actual and potential number and resource absorption capacity (e.g. who, what, when, where, how much, how often) and their willingness-to-pay was assessed. Additionally, businesses adopt different strategies ranging from establishing key partnerships, price markups, etc. to maintain a competitive advantage and ensure sustainability. This information base will serve the purpose of providing new and existing entrepreneurs with pertinent market information crucial for the start-up/development of their business but also opportunities to explore new market segments and further solidify the sustainability of their businesses. In that regard, the specific objectives of the market assessment were:

1. To assess the market value of the RRR products –
    a. To assess consumers' willingness-to-pay (WTP) and differences in WTP estimates across different consumer segments and related factors influencing consumer demand;
    b. To estimate the potential market size for the RRR product;
2. To assess the extent and characteristics of the market structure;
3. To evaluate the market outlook of the RRR products and to what extent the RRR products would be viable over time in the market.

A total of 12 RRR business models were selected for the feasibility studies in Bangalore

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Table 1: Selected RRR Business Models for Feasibility Testing in Bangalore

RRR Business Models	Brief Description
ENERGY	
Model 1a: Dry Fuel Manufacturing: Agro-Waste to Briquettes	The business entity processes crop residues like wheat stalk, rice husk, maize stalk, groundnut shells, coffee husks, saw dust etc. (any agro-based waste) and converts them into briquettes as fuel to be used in households, large institutions and small and medium energy intensive industries.
Model 4: Onsite Energy Generation by Sanitation Service Providers	The business model is initiated by either enterprises providing a sanitation service such as public toilets or by residential institutions such as hostels, hospitals and prisons with a concentrated source of human waste (i.e. faecal sludge). The business concept is to process and treat human waste in a bio-digester to generate biogas to be used for lighting or cooking.
Model 6: Power capture model: Livestock waste to energy	The business processes crop residues like wheat stalk, rice husk, maize stalk, groundnut shells, coffee husks, saw dust etc. to generate electricity which is sold to households, businesses or local electricity authority.
WASTEWATER REUSE	
Model 8: Beyond cost recovery: the aquaculture example	The business concept is to treat wastewater to an advanced tertiary state and during that process produce fish for human consumption. The concept offers business opportunities at medium scale, where existing in-use treatment plants can be used to raise fish for sale into the market, providing avenues for cost recovery to municipal wastewater management entities.
Model 9, 11 and 12: On Cost Savings and Recovery	The business concept is to treat wastewater for safe reuse in agriculture, forestry, golf courses, plantations, energy crops, and industrial applications such as cooling plants. The sludge from the treatment plant can be used as compost and soil ameliorant and energy generated can be used for internal purposes resulting in energy savings.
Model 10: Informal to Formal Trajectory in Wastewater Irrigation - Incentivizing safe reuse of untreated wastewater	Informal reuse of wastewater is commonly practiced by farmers in developing countries but it also entails significant health costs, often borne by the public and are of social nature. This social nature of these costs justifies public investments in incentives to promote safe reuse of wastewater and minimize risk along the entire value chain as such incentives could potentially turn this unsafe informal activity into a safe and formal one with shared rewards for all the stakeholders.
NUTRIENTS	
Model 15: Large-Scale Composting for Revenue Generation	The business concept is to better manage Municipal Solid Waste (MSW) and recover valuable nutrients from the waste that would otherwise be disposed off in landfills without reuse. Compost from MSW is sold to farmers, landscaping, and plantations and other entities.
Model 16: Decentralized multi-partnership community based model	The business concept is similar to that on model 15, with the exception of operations and production of the compost taking place in a decentralized manner.
Model 17: High value Fertilizer Production for Profit	Similar to Model 15 in concept but in addition to MSW, the business uses faecal sludge as an input from onsite sanitation systems which is rich in nutrients. There are opportunities for pelletization and blending of faecal sludge-based compost with rock-phosphate, urea/struvite or NPK which is an additional value proposition that can be explored under this business model, allowing the product to have nutrient levels specific

	for target crops and soils, and a product structure improvement (pellets) to improve its competitive advantage, marketability and field use.
Model 20: Informal reuse of faecal sludge for agricultural production (FS collection service and on-farm use)	This concept is based on the practice of on-farm treatment of faecal sludge supplied by pit emptiers to farmers.

For the purposes of the market assessment, an end-use typology of the business model was employed as although the underlying concept of the business models were different, the end products were the same. Thus for some business models, the related customer segments and relevant actors along the value chain considered would be the same. In that regard, for the selected business models, the following 6 value-added products were considered: 1) briquettes, 2) electricity, 3) wastewater-fed fish, 4) treated wastewater, 5) MSW-based compost and 6) faecal sludge-based compost (Table 2). Untreated wastewater is not considered a marketable commodity as it is considered to increase human health risk and environmental pollution and thus potential users' valuation was not assessed.

Table 2: Selected RRR Business Models for Feasibility Testing in Bangalore

Business Model	Value-added product	Recovered resource
Model 1a: Dry fuel manufacturing: agro-waste to briquettes	Briquettes	Energy
Model 4: Onsite energy generation by sanitation service providers	Electricity	
Model 6: Power capture model - Livestock waste to energy		
Model 8: Phyto-remediative wastewater treatment and fish production	Wastewater-fed fish	Fish
Model 9, 11 and 12: On cost savings and recovery (treated wastewater for irrigation, energy, fertilizer)	Treated wastewater	Wastewater
Model 10: Informal to formal trajectory in wastewater irrigation	Untreated to partially treated wastewater	
Model 15: Large-scale composting for revenue generation (MSW to compost)	MSW-based compost	Nutrients
Model 16: Decentralized multi-partnership community based model		
Model 17: High value fertilizer production for profit (faecal sludge to compost)	Faecal sludge-based compost	
Model 20: Informal reuse of faecal sludge for agricultural production (FS collection service and on-farm use)	Farm treated faecal sludge	

Chapter 2 provides an overview of the methods used in assessing each of the specific objectives. Chapter 3 is categorized into five sub-chapters covering the WTP, market structure and outlook assessment for each of the value-added products outlined in Table 2. This chapter provides the results and discussions of the related analysis. The overall feasibility assessment of the business models is presented in Chapter 4.

2. Methodology

2.1 Overview of Methodology

The successful development of any RRR business will depend on the effective workings of different facets of the respective value chain including: (a) the market linkages between the related subsector markets; (b) the business dynamics between relevant economic actors and (c) consumers' responsiveness to newly developed/ available products. When introducing a new product into the market or simply entering a new industry, businesses are particularly interested in three factors: current and future consumer demand, competition and production costs. Though cost estimations are simple and straightforward, the assessment of consumer demand (as measured by willingness-to-pay) and competition are comparatively more complicated and not a straight forward calculation as historical data of consumer purchase patterns are guidelines at best (Lusk and Hudson, 2004). Specific methods were developed and used for the evaluation of the consumers' WTP, the assessment of market structure and outlook. The choice of methods for evaluating the different research questions were dependent on the context, the related RRR product, access to data and analytical tools to be employed. The subsequent sections will outline in detail the data collection tools and estimation approaches. The WTP and market outlook analysis viewed the business models from an end-product perspective, whilst the market structure was conducted from a sector perspective (a) alternative fuel market, b) electricity market, c) fish, d) water market and e) fertilizer market).

2.1.1 Willingness-to-pay and Market size estimation

When introducing a new product into the market, businesses are particularly interested in two factors: consumer demand and production costs. Stated and revealed preference methodologies have gained immense popularity in eliciting consumers' valuation of new products (Lusk and Hudson, 2004; Kimenju and Groote, 2008).The choice between the use of stated or revealed preference methods is dependent on the RRR product under consideration. Stated preference methods such as contingent valuation method are typically used for assessing consumer WTP of products with inexistent market price (Adamowicz and Deshazo, 2006; Freeman, 2004). An example would be that of faecal sludge-based organic fertilizer which is a new product in the fertilizer market. Alternatively, revealed preference methods such as hedonic pricing can be used to obtain the price of a good via real market purchasing mechanisms. These methods are grounded in economic theory of welfare analysis and can normally also be used for the valuation of goods and services without market prices or shadow prices. Contingent valuation approaches have been successfully applied in the estimation of the demand for compost in Ghana (Danso et al., 2006); Tanzania (Valerian et al., 2011), and Ethiopia (Hagos et al., 2012). For the purposes of this study, contingent valuation methods were applied for the WTP assessment of the energy business models (i.e. briquettes, electricity) and choice modeling for the nutrient and wastewater business models. Based on the WTP measures, the potential market size of the RRR products was estimated.

2.1.2 Market structure assessment

This assessment was based on the notion that businesses require information on the extent and characteristics of the market structure for decision-making on strategies that ensure firm performance. To achieve this, a structure–conduct–performance (SCP) evaluation model was applied along the different stages of the product supply chain. The SCP approach provides insights into how markets function in the real world as opposed to in theory (Holtzman 2002; Wanzala et al. 2009). The SCP approach is based on the underlying rationale from economic theory of competitive markets,

which suggests that competitive markets produce efficient prices and quantities. If a monopolist or oligopolist dominates a market, the lack of competition yields higher prices and lower quantities traded. If the market structure is monopolistic or oligopolistic, then prevailing prices may be higher than what they would be in a competitive market. The SCP approach assesses the structure of the market (number of actors involved), their conduct (what products/services they perform), and how those two things lead to the performance of the market—in terms of prices, quantities traded, and costs of performing various functions. Based on this analysis, insights of market performance and possible strategies that businesses can adopt (measured in terms of price and accessibility) can be drawn. To set the stage for assessing the market structure, the supply chain for competitive products was evaluated. This served to identify the constraints and distortions affecting the functioning of the markets of competitive products been considered and propose suitable mitigation measures to address these distortions. The supply chain analysis utilized data from the market size, key players in the supply chain, regulatory framework and subsidy programs. The SCP framework was applied as follows:

1. The **structure of the market** was assessed from four aspects: market concentration (MC), product differentiation (as measured by businesses' awareness of differentiated products), market integration (e.g. extension of credit between businesses) and conditions for entry in sector (threshold capital requirements, sources of funding). An MC ratio based on market share was calculated and monthly turnover data for relevant businesses was used to measure market share.
2. The **market conduct** was evaluated based on the behaviour (whether players are price-taking or price-making agents: pricing and promotion) and activities of existing competing businesses. If data was available, their performance was assessed as reflected in the variation of their cost elements. A structural pyramid of players, functions and the **performance** of the product markets was developed to highlight the different dynamics.
3. An overview of the factors affecting the functioning of the different market was evaluated to capture supply-side constraints (e.g. business environment, taxes, tariffs) and demand-side factors (access to financing, production risk, purchasing power).

Both primary and secondary data were collected and used for the supply chain analysis, although this was dependent on the RRR product. For example, supply chain analyses have been conducted on the fertilizer market in many agricultural dependent countries. If applicable to the city/country, these served as key sources for secondary data. Data on the number and size of key players, the characteristics of these players (e.g. economies of scale, access to financing, marketing and distribution costs, and level of integration and nature of contractual agreements) was collected from primary sources.

2.1.3 Market outlook assessment

The evaluation of the market outlook, i.e. market forecasting will aid new and existing RRR businesses in planning for the future. Because investment toward an uncertain future is very difficult and risky, market forecasting tools have been developed to alleviate the risk and to obtain more accurate or reliable information. This assessment is a projection of demand levels in the future, based on current or past evolutions. A Bass model is usually used to describe consumers' behavior in relation to their loyalty towards a product. Most frequently, this model is used in marketing for dynamic forecasts of the market demand against the background of intense rivalry between products or brands. Since most of the RRR products are new in the market, it will be difficult to obtain time series data to develop a standard demand equation for the market trend analysis. Thus, to forecast the revenue or profit of a new product, the initial income from existing businesses if available was used. For a given RRR product, a Bass model and econometric analyses were applied to analyze the market demand over time. In addition, this approach was used to estimate the growth in demand of an RRR-business product with other competing products.

2.2 Study Area and Data

The primary survey covered the key districts in Bangalore (urban, peri-urban and rural areas). For the WTP and market size assessment, primary data on price offers from market experiments, information on the demographics and socio-economic factors was collected from different groups of respondents depending on the RRR product. Additionally, data on price of substitute products, macro-economic factors, etc. was collected from secondary sources. WTP measures were derived directly from the purchase price and additional econometric analysis. For the market structure, both primary and mostly secondary data was collected and used for the supply chain analysis, although this was dependent on the RRR product. Data on the number and size of key players, the characteristics of these players (e.g. economies of scale, access to financing, marketing and distribution costs, and level of integration and nature of contractual agreements) was collected from primary sources. For the market outlook, data on market demand and market share was obtained from the WTP and market structure assessment components. Additional secondary data on alternative products, prices and quantity of sales of existing competing products in the market (e.g., quantity of fertilizer sold per year, time series data of fertilizer, etc.) was collected from relevant institutions (e.g. marketing boards and departments). Revenues and cost data was collected from existing business as well as alternative input and output products markets. The sampling strategy for the different research aspects and models are outlined in Table 3.

Table 3: Sampling Strategy for Market Assessment

Sub-research components			**Business Models**						
	BM 1a [Briquette]		**Model 2a & 4 [Electricity]**	**Model 9 [Fish]**		**Model 9, 12 & 13 [Wastewater]**		**Model 15 [Compost]**	**Model 17 & 19 [Faecal sludge-based fertilizer]**
WTP and Market size	H = 60	B = 120	*Electricity market* (primary and secondary data	H =93	B =60	F = 30	B = 150	F = 52	F = 48
Market structure	*Alternative fuels sector* (primary and secondary data)		*Electricity market* (primary and secondary data)	*Fish market* (primary and secondary data)		*Water sector (*primary and secondary data)		*Fertilizer market* (primary and secondary data)	
Market Outlook	Time series 2º data; 1º data from WTP assessment								

Legend:

H = Households F = Farmers

B = Businesses

2.3 Data Collection Tools and Estimation Approach

Willingness-to-pay and Market size estimation

When introducing a new product into the market, businesses are particularly interested in two factors: consumer demand and production costs. Stated and revealed preference methodologies have gained immense popularity in eliciting consumers' valuation of new products (Lusk and Hudson, 2004; Kimenju and Groote, 2008).

- ***Stated preference methods:*** Stated preference methods refer to a direct survey approach to estimating the value place on a non-market good or services. This approach attempts to measure the willingness-to-pay directly through surveys that ask respondents about their evaluation of changes in the level of quality of a good or services (i.e. value-added compost). The approach does

not require the good or services to be linked to actual market transactions. It asks respondents in a hypothetical market if they would pay a specified amount for a prescribed product (Adamowicz and Deshazo, 2006; Freeman, 2004).

- ***Revealed preference methods****:* Critics argue that stated preference methodologies are not incentive-compatible as individuals' dominant strategies are not truthfully revealed with respect to their preference for the good as WTP values are elicited in a hypothetical and less than realistic environment and are based on intended behavior. Preference-revealing methods such as experimental auctions and real-purchase decision mechanism procedures address the problem of hypothetical bias when eliciting WTP values for new product attributes. Based on behavior rather than intentions, methodologies such as experimental auctions, real purchase decision mechanisms involve the exchange of real money and real goods in a market environment which offers great incentives for consumers to reveal their true preferences (Lusk et al., 2006; Shaw et al., 2006). With subjects aware of the fact that an exchange of real money and real goods occur even in an experiment, this enforces them to reveal their true valuation of the product. Revealed preference theory is based on the notion that consumers are rational and make purchasing decisions subject to a budget constraint. They buy goods from a set of alternatives that maximize their utility, given prices of other goods and prices they can afford to pay and their socioeconomic and demographic characteristics (Deaton and Muellbauer, 1980).

The choice between the use of stated or revealed preference methods was dependent on the RRR product under consideration. Stated or revealed preference methods can be used in estimating the market size of RRR products. Stated preference methods such as contingent valuation method are typically used for assessing consumer WTP of products with inexistent market price (Adamowicz and Deshazo, 2006; Freeman, 2004). An example would be that of faecal sludge-based organic fertilizer which a new product in the fertilizer market is. Alternatively, revealed preference methods such as hedonic pricing can be used to obtain the price of a good via real market purchasing mechanisms. These methods are grounded in economic theory of welfare analysis and can normally also be used for the valuation of goods and services without market prices or shadow prices. Contingent valuation approaches has been successfully applied in the estimation of the demand for compost in Ghana (Danso et al., 2006); Tanzania (Valerian et al.,2011), and Ethiopia (Hagos et al., 2012). For the purposes of this study, the contingent valuation method was applied for the WTP assessment of the energy business models (i.e. briquettes, electricity) and choice modeling for the nutrient and wastewater business models. Based on the WTP measures, the potential market size of the RRR products was estimated. These results provide useful information that will help business owners and policy makers decide on the most cost effective means of obtaining inputs and setting their product market price. The estimation of the potential market size of any RRR product will be determined by: 1) identifying the major users of the product in each city; 2) developing a criteria to stratify and sample within each group with an appropriate sampling technique; and 3) estimating the demand for the product based on the willingness to pay and ability to pay of the end-users.

3. Results and Discussion of Market Assessment

3.1 Model 1a: Dry fuel manufacturing: agro-waste to briquettes

3.1.1 Willingness-to-pay and Market Estimation

3.1.1.1 Background and Justification

In the past years, there have been many challenges associated with the use of biomass for local economic developments. In recent years however, biomass as a renewable energy is getting better recognition internationally and locally because it can improve the basic energy supply in developing countries. Although there are many biomass products, briquettes and the pelletization of organic products have contributed to the energy crises in the developing world, where their primary need is for heating and cooking. The increasing demand of briquettes in many developing countries can be linked to increased socio-political discussions on future energy supply to technological progress, which has helped change the perceptions of biomass as a renewable energy source worldwide. It is obvious that the use of briquettes and other biomass products as a renewable energy source can improve the overall economic conditions of households and businesses. However, like many new technologies, economic and marketing challenges still remain to be resolved. This analysis seeks to contribute to this discussion via the assessment of the potential demand and influencing market factors for the briquette industry in Bangalore, India.

There are many approaches that energy economists, resource economists and other development economists apply to assess the demand for renewable energy products. In this study, a choice experiment was used to estimate the market demand for briquettes in Bangalore. To develop a solid baseline on consumer consumption of alternative fuels and their purchasing decisions, the key objectives of the analysis was:

1. To assess consumers' knowledge, current use and willingness-to-pay (WTP) for briquettes;
2. To determine factors that influence consumers' willingness-to-pay for briquettes;
3. To estimate the current and potential market demand for briquettes in Bangalore.

The subsequent sub-sections outline the research methods, data collection and analytical assumption and key findings.

3.1.1.2 Research Methods and Data Collection

Theoretical Framework

Discrete Choice Experiments (DCEs) primarily depend on the creation of a hypothetical market where different choice scenarios for a particular good or service is presented to a respondent - potential client. The choice sets provided to the respondents are mutually exclusive hypothetical alternatives that relate to the potential change in the good or service as a consequence of any policy changes or market interventions. With the use of primary survey, data is collected on their preferences which is then analyzed to obtain their marginal utility valuation for changes in the levels of the attributes. The theory of discrete choice experiments is embedded in the theory of Lancaster's 'Characteristics Theory of Value' (Lancaster, 1966) combined with 'Random Utility Theory (RUT)' (proposed by Luce, 1959; McFadden, 1974). Lancaster proposed that a consumer derives utility not from a particular good as a whole but from its attributes. Therefore, in choice experiments, respondents are asked to choose between different levels of an attribute one of which is price (or some proxy of price) (Hanley et al., 2006). The levels of different attributes are combined to form different alternatives in a choice set and the respondent required to select the preferred alternative in each choice set.

In addition every choice set contains an alternative that reflects the current status (status quo) of the good being evaluated. The price attribute in each alternative is used to reflect the cost of the policy change to the respondent (usually, the status quo option incurs no cost). This DCE format allows marginal utility estimates for changes in the level of each attribute to be easily converted to WTP estimates. In addition, given that compensating variation measures can be obtained, the total value of improvements to the public good as a consequence of the policy change can be calculated (Hoyos, 2010). As is standard practice with DCE data, the random utility model (RUM) as developed by McFadden (1974) is used to analyze the choices made by the respondents. The RUM model is based on the premise that utility for an individual is composed of an observable component $\beta' x_{ni}$ and a random component ε_{ni}, which leads to the following representation of utility:

$$U_{njt} = \beta_n^{'} x_{njt} + \varepsilon_{njt} \qquad (1)$$

The above equation can be interpreted as that of the utility obtained by the nth individual (in a sample of N respondents) choosing alternative *j* on occasion *t* (facing J alternatives on T choice occasions).The coefficient β_n is a vector of individual-specific coefficients, x_{njt} is a vector of observed attributes relating to individual *n* and alternative *j* on occasion *t*, and ε_{njt} is a random error term that is assumed to be independently and identically distributed extreme value. The density for β is denoted $f(\beta/\theta)$, where θ are the parameters of the distribution. Conditional on knowing β_n , the probability of respondent *n* choosing alternative *i*on occasion t , conditional logit formula of McFadden (1974) is given by:

$$L_{nit}(\beta_n) = \frac{\exp(\beta_n^{'} x_{nit})}{\sum_{j=1}^{J} \beta_n^{'} x_{njt}} \qquad (2)$$

The probability of the observed sequence of choices conditional on knowing β_n is given by:

$$S_n(\beta_n) = \prod_{t=1}^{T} L_{ni(n,t)t}(\beta_n) \qquad (3)$$

where *i (n,t)* denotes the alternative chosen by individual *n* on occasion *t*. The unconditional probability of the observed sequence of choices is the conditional probability integrated over the distribution ofβ:

$$P_n(\theta) = \int S_n(\beta) f(\beta \mid \theta) d\beta \qquad (4)$$

This specification is general, allowing the fitting of models with both individual-specific and alternative-specific explanatory variables. The log likelihood for the model cannot be solved analytically so it is approximated using simulation methods (Train, 2003). The simulated log likelihood is given by:

$$SLL(\theta) = \sum_{n=1}^{N} \ln\left\{ \frac{1}{R} \sum_{r=1}^{R} S_n(\beta^r) \right\} \qquad (5)$$

where R is the number of replications and β^r is the rth draw from $f(\beta/\theta)$. Conditional logit (McFadden, 1974; Chamberlain, 1980) with non-random parameters is a special case of the mixed logit model with random parameters when the variance of random parameters is not significantly different from zero (Train, 2003). The assumptions underlying the conditional logit model are restrictive mainly by the assumption of “independence and identical distribution” condition of the error terms. As a result, it is now commonplace to estimate more flexible specifications, one of which is the random parameter logit (RPL) model. In the RPL model, the parameters vary over decision-makers in the population with a density function. Therefore, the unconditional choice probability represents the integral of the logit probabilities over all possible values of β_n given by equation (4) above. Even in case the 'Independence of Irrelevant Alternatives' (IIA) assumption of the non-random parameters specification is not rejected and the conditional logit model may still be unbiased. The conditional logit model also seems to be robust to misspecification and can capture average tastes well even when tastes are random (Train, 2003). This all leads to over-estimation of the marginal utilities of the attributes derived from the conditional logit models. For the above reasons, we use a mixed logit specification with a non-linear, or effects coded, attribute specification (Hensher et al., 2005).

In the following, we distinguish willingness-to-pay (*compensating surplus*) of non-marginal improvements of bundles, from the *implicit price* of marginal improvements in any one attribute. We assume that utility is linear in the attributes of alternatives:

$$U_{njt} = \beta_{oi} + \beta_1 X_{1njt} + \cdots + \beta_K X_{Knjt} + \beta_C C_{Cnjt} + \varepsilon_{njt} \qquad (6)$$

where β_{0i} is a constant which reflects the mean impact of unobservable components of utility of alternative i. $\beta_1 \ldots \beta_K$ are the coefficients for attributes $X_{1njt} \ldots X_{Knjt}$, and β_C is the coefficient for the cost of alternatives (irrigation water charge). The marginal value, or implicit price (IP), for an improvement in a specific attribute or its level$X_k$is found by solving for dC/dX_k:

$$\frac{dC}{dX_k} = IP_k = -\frac{\beta_k}{\beta_C} \qquad (7)$$

In order to compute WTP confidence intervals for the estimated mixed logit models in a consistent manner, we used the Krinsky-Robb method (Krinsky-Robb 1986, 1990), also known as the parametric bootstrap (Efron and Tibshirani, 1993).

Choice experiment framework

Households' and businesses' willingness-to-pay (WTP) for briquettes was assessed using the choice sets. For briquettes, although they can be manufactured from different sources (type of agro/municipal solid waste), with varied calorific values, sizes, and then their corresponding prices, three key attributes were considered with varied levels to arrive at different choice sets. Each choice set represents a purchasing decision scenario. Respondents were asked to choose the most appropriate alternative out of the three options given. The respondents were requested to make a selection by checking the appropriate alternative. They were expected to treat each of these choice sets as independent purchasing decisions and choose only one in each of the option sets. The choice sets for households and enterprises were derived and the same are presented in Table 4 below.

Table 4: Choice sets for households and enterprises

Briquette Attributes	Levels	Description
1. Purchase price (INR/kg)	3 [10, 20, 30]	Price per kg of briquette product in Rupees (INR/kg)
2. Energy value Kcal/kg	3 [Less, Same, More]	Energy value of product as measured in Kcal/kg (e.g. higher energy value is defined by longer burning time, higher thermal value, lower moisture content)
3. Ease of Handling	3 [Easier, Comparable, Harder]	▪ Product is easy to handle (non-bulky, high level of cleanliness) product ▪ Product is fairly easy to handle (non-bulky, low level of cleanliness) product ▪ Product is difficult to handle (bulky, low level of cleanliness)

Sampling Strategy

At the outset, the prospective customer segments for briquettes were ascertained through a scoping study and interactions with households and industries. For the households, based on the census results it was apparent that low-income urban and rural farming households were still largely dependent on firewood. Therefore among the households, low-income urban households and rural households were considered potential customer segments. As discussed earlier, middle and higher income households were excluded. The exclusion of middle and higher income households was justified based on the following reasons: a) it is important to note that Bangalore has an effective supply chain for the distribution of LPG and as a result LPG has successfully penetrated the middle

income and the high income households across Bangalore city; b) additionally, an informal survey of these households revealed that they are unlikely to view briquettes as an alternative source of fuel even if their regular supply is assured at a subsidized price. For the industrial and services sectors, the scoping study looked at energy-intensive industries as the potential customer segment. Among these, the following were short-listed as there is a considerable number of them in Bangalore (accounting for a minimum of 500 units each):

a) Heating intensive industries
b) Hotels and hostels
c) Road side eateries
d) Kalyana Mantapas (Choultries)

Thus, the study focused on rural farming households in the periphery of Bangalore city and low-income households, and energy intensive industrial and service enterprises in Bangalore city. To identify the villages for the subsequent selection of rural farming households, several villages in the periphery of Bangalore city were visited and a select group of households in each village based on the availability of household heads / members were selected. Wherever, a positive response was received, the specific villages were shortlisted. After the short-listing of villages, a minimum of 5 households was selected in each village. In Bangalore city, the low-income household localities were identified and shortlisted and a minimum of 5 households in each locality was also selected. To formulate a sample of energy intensive industries and services, the researchers made use of the membership directory of Federation of Karnataka Chamber of Commerce and Industry (FKCCI), Bangalore, an association which has both industrial and service enterprises as its members including energy intensive enterprises. A minimum of 30 units from each of the four categories referred above was selected. In order to assess the willingness to pay for briquettes and estimate the market size, questionnaires were designed to elicit responses from different customer segments identified above. The questionnaires were administered to a sample size for each customer segment described above. Primary data from the targeted enterprises was collected via interviews and the use of predesigned questionnaires, during November 2013 - February 2014.

Table 5: Description of the sample size of households and enterprises

Households		**Enterprises**	
Types of households	Number of observations	Types of enterprises	Number of observations
Rural Households	30	Hotels and Eateries	60
Urban Households	30	Kalyana Mantapas	30
		Energy intensive industries	30

3.1.1.3 Results and Discussion

- **Socio-economic characteristics and consumption patterns of households and businesses**

  - **Households**

The number of both urban and rural households interviewed was 60. The average age of the respondents was 52 for rural households while it was 43 years for urban households. The respondents' age ranged from 18 years to 84 years for the overall sample, however, it ranged from 27 years to 84 years among the rural and from 18 years to 70 years among the urban households. Of this, the majority of respondents were males (88%). The average household size was 3.8, with 4 being the size for rural households and 3.6 for urban households. The average annual income of rural farm households was Rs.35, 720/-, while it was Rs.66,667/- of urban households. The combined average annual income for

both rural and urban households was Rs.52600/-. With respect to the agriculture production, about 63% of the farmers grow millets (Ragi being the most popular), followed by scarce plantations of coconut and areca. The majority of them grow mixed cropping growing vegetables like beans, bitter gourd, etc.

In regard to the prevalent consumption patterns, no household (urban or rural) was noted to be currently using briquettes (Table 6 and Table 7). They mainly use LPG, firewood, kerosene and electricity to meet their various energy demands. Among the low-income urban households, the consumption of LPG for either heating or cooking is noted to be about 7 kg with an average monthly expenditure of Rs.210/-. Similarly, the average monthly consumption of firewood and kerosene was 38 kg and 6.25 litres, respectively with an average monthly expenditure of Rs.171/- and Rs.60.9/-, respectively. The average monthly expenditure on electricity was Rs.355/-. Relative to low-income urban households, the rural households appeared to use more LPG with a consumption of about 14 kg and an average monthly expenditure of Rs.420. With firewood being available in abundance and mostly gathered for free by rural households, estimating either their price or quantity was not possible from the surveys. However, the consumption of kerosene was about 5 litres per month with an average monthly expenditure of Rs.75/-. Electricity was mostly used only for lighting and none of them used for either heating or cooking.

Table 6: Summary of responses from rural households

	Sources of fuel types				
Variables	**Briquette**	**LPG**	**Firewood**	**Kerosene**	**Electricity**
Number of Households	0	6	26	14	25
Heating Purpose	0	0	22	12	-
Cooking Purpose	0	6	11	6	-
Average Monthly Quantity used (kg or L or units, as appropriate)	0	14	-	5	-
Average Monthly Expenditure (Rs.)	0	420	-	75	-
Averaged Unit Price (Rs.)	0	30	-	15	6

Table 7: Summary of responses from urban households

	Sources of fuel types				
Variables	**Briquette**	**LPG**	**Firewood**	**Kerosene**	**Electricity**
Number of Households	0	16	29	4	25
Heating Purpose	0	1	29	4	25
Cooking Purpose	0	15	0	0	-
Average Monthly Quantity used (kg or L or units, as appropriate)	0	7	38	6.25	59.167
Average Monthly Expenditure (Rs.)	0	210	171	60.9375	355
Averaged Unit Price (Rs.)	0	30	4.5	9.75	6

The major source of fuel for cooking and heating the households is firewood, with a majority of the respondents gathering it for free (52%). About 29% of the respondents obtained them from wholesalers and 17% purchase from retailers. A majority of the households (55%) purchased firewood only as and when required without any specific interval, whereas the remaining households purchased it daily (13%), bi-weekly (6 %) and weekly (26%). It is important to note here that the major source of

fuel has certain disadvantages as identified by the respondents, viz. higher and increasing cost, shorter burning time and health hazards owing to smoke. All of those who procured firewood from the market did so by paying cash directly. It is interesting to note that 13% of those who procured from the market thought that firewood prices would remain stable, whereas about 29% thought that it would significantly in the near future and that would prompt them to switch to an alternative product. This implies that not all those who consume firewood are its loyal customers and are therefore price sensitive.

- **Enterprises**

The enterprises were mainly comprised of heating intensive industries, Kalyana Mantapas (marriage halls), hotels/hostels including a few roadside eateries, garments, and brick kilns among other industries with heating requirements. Most enterprises interviewed were on an average more than a decade old. About 23% purchased fuel from varied sources. In regard to the prevalent consumption patterns in big hotels (Table 8), only one respondent used briquettes while the majority used LPG. Of the lone respondent using briquettes, the average consumption of briquette was about 900 kg with an estimated monthly expenditure of Rs.4500/-. The average quantity consumed per month of LPG users was 1500 kg with an estimated expenditure of Rs.180, 000/- per month. Among the fast food eateries (Table 9), they all used LPG. The average quantity of LPG consumed per month was about 1260 kg with an estimated expenditure of Rs.151200/- per month. In the Kalyana Mantapas (Table 10), apart from LPG used by everyone, 2 of them used firewood. The average quantity of LPG consumed was 314 kg per month and firewood consumption was 1150 kg per month. The estimated average expenditure on LPG and firewood was Rs.36100/- and Rs.3450/- per month.

Table 8: Energy Consumption by large-scale hotels

	Fuel types	
Variables	**LPG**	**Briquette**
Number of Enterprises	30	1
Average Daily Quantity used(kg or L)	50	30
Average Daily Expenditure (Rs.)	6000	150
Averaged Unit Price (Rs.)	120	5
Average Monthly Quantity used (kg or L)	1500	900
Average Monthly Expenditure (Rs.)	180000	4500

Table 9: Energy consumption by fast food eateries

	Fuel type
Variables	**LPG**
Number of Enterprises	30
Average Daily Quantity used(kg/L)	42
Average Daily Expenditure	5040
Averaged Unit Price	120
Average Monthly Quantity used(kg/L)	1260
Average Monthly Expenditure	151200

Table 10: Energy consumption by Kalyana Mantapas

	Types of fuels		
Variables	**LPG**	**Briquette**	**Firewood**
Number of Enterprises	30	-	2

Average Daily Quantity used(kg/L)	10.467	-	38.333
Average Daily Expenditure	1203.667	-	115
Averaged Unit Price	115	-	3
Average Monthly Quantity used(kg/L)	314	-	1150
Average Monthly Expenditure	36110	-	3450

The industries use a variety of fuel sources (Table 11): LPG, briquette, firewood, charcoal, diesel, and paddy husk. The average quantity of each of the sources consumed was 38 kg, 46.8 kg, 29.09 tons, 9.2 tons, 6776 litters, and 5 tons respectively for LPG, briquette, firewood, charcoal, diesel, and paddy husk. The average expenditure on LPG, briquette, firewood, charcoal, diesel, and paddy husk was Rs.4,560; Rs.241,020; Rs.83,983; Rs.92,552; Rs.406,560 and Rs.23,665 per month respectively. Key disadvantages of the fuel sources currently been used noted by the respondents were identified as smoke and dust, shorter burning time, unstable and steadily increasing prices, and health hazards with firewood, charcoal, diesel and paddy husk. The current sources of fuel are primarily procured by the enterprises themselves (64%) from manufacturers whereas about 17% of them procure it from wholesalers as well as retailers. Furthermore, these fuels are purchased on a daily basis by a majority (58%), whereas 40% purchased them on a weekly basis. These sources of fuel are purchased through cash transactions without exception. Despite the majority of the respondents (90%) expecting the prices of current fuels used to go up in the future, they are keen to continue using the current sources of fuel and only a negligible percentage (2%) of them are willing to shift to an alternative product.

Table 11: Energy consumption by Industries (enterprises)

	Types of fuels					
Variables	**LPG (kg)**	**Briquette**	**Firewood (Tons)**	**Charcoal**	**Diesel**	**Paddy Husk**
Number of Enterprises	2	10	16	5	3	3
Average Daily Quantity used	1.267	1.56	0.97	0.307	225.867	0.167
Average Daily Expenditure in INR	152	8034	2799.427	3085.07	13552	788.833
Averaged Unit Price	120	5150	2887	10,060	60	4733
Average Monthly Quantity used	38	46.8	29.09	9.2	6776	5
Average Monthly Expenditure in INR	4560	241020	83982.83	92552	406560	23665

- **Perceptions of Environmental Protection**

  - **Households**

In regard to the households' perception of environmental protection, they were only familiar with the term ‘deforestation’. Interestingly about 73% households think that deforestation doesn’t contribute to climate change. Further, about 80% households are not really keen to contribute to reduce deforestation by using energy from renewable, environmentally friendly sources. This can be attributed to their limited understanding of environmental issues. This is further substantiated by the fact that about one-third of those who refused to contribute to the reduction of deforestation

conveyed that they did not care about the environment in general and about 39% were not concerned about the adverse health effects of pollution.

- **Businesses**

Unlike the households, environmental awareness was found to be higher among the enterprises: the majority of enterprises (55%) have heard about climate change and the remaining 45% are aware of deforestation. But surprisingly only about 12% of the total enterprises thought deforestation contributed to climate change and the majority of the total enterprises (61%) did not want to contribute to the reduction of deforestation by resorting to environmentally friendly renewable energy sources. Obviously, a majority of these enterprises did not care about the environment. But it is interesting to note that 96% of the enterprises expected incentives if they had to adopt environmentally friendly fuels.

Knowledge and Source of Information on Briquettes

- **Households**

Only one respondent had heard about briquettes through television media. Thus the households by and large are ignorant of the availability and usage of briquettes. This suggests that the information barrier for briquettes is fairly high among the households. But it is interesting to note that despite their limited knowledge of briquettes, 44% of the surveyed households responded positively and expressed their willingness to use briquettes. This suggests that the information barrier can be mitigated via product promotion and awareness programs.

- **Businesses**

The awareness of briquettes was found to be higher among the enterprises (26%), while 19% had used briquettes before and 18% are using briquettes currently. Of the enterprises currently using briquettes, a quarter of them found it to be more economical, 18% of them felt that briquettes had a lower ash content, 16% noted the product to have a higher energy value, 14% a longer burning time, and 13% used them due to its environmentally friendly nature. Thus, almost all of the current users of briquettes noted at least one positive attribute of the product that incentivized their use. This results suggests that the current briquette users are likely to continue with its use or increase the quantity of its consumption.

Factors influencing the willingness-to-pay of households and enterprises

Table 12 shows the results of the mixed logit models for both the households and the industry. The price attribute along with two other attributes related to briquettes were considered in the analyses - the energy level and the ease of handling. The table shows that in both the random parameter logit model estimated the price co-efficient is negative which is theoretically correct. Considering the primary attribute levels in both of these models (energy levels and the ease of handling), the estimated models yields parameters which are theoretically correct. The positive parameters for higher energy and ease of handling illustrates the fact that respondents are willing to pay higher for briquettes if it has higher energy content and it is easy to handle compared to the base level. However, the willingness to pay for fuels with lower energy content and which are hard to handle would be lower and this in fact for the estimated models are negative. It implies that consumers perceive a disutility of these attributes of briquettes. The other factors considered in the model are interactive variables. The present study incorporated a supplementary feedback question after respondents made their choices from each choice-set. Every respondent were asked to state in a Likert scale of 1-10 as to how certain they were about the purchase of briquette. A respondent indicating a 10-point suggests that they are very certain about their purchasing decision. Thus, for the analysis, respondents who had a score of 9 or 10 were considered as being very certain of purchasing briquettes and substituting them

for their current fuel of choice. These respondents were further dummy coded as sure purchasers (coded 1) compared to the others (coded 0). Subsequently, this variable was interacted with the price variable of the choice experiment to understand whether with certainty in choices utility from money is negative or not. A negative coefficient thus implied that provided the present budget condition, a consumer (or producer in case of industry) who is certain of substitution would not exceed the budget for production or domestic consumption. The respondents who are sure of substitution indicated a cautious approach towards replacement of the fuel and hence it can be assumed that respondents have not over-estimated their payments for the good.

The other interactive variable[3] that was used for the industry model included type of the industry interacted with price variable. The present study considered the following industries – brick making, garments, chemical, metal, rubber as well as eateries and hotels and other institutions (like *Kalyanamantapas*). While classifying the types of the industry the fuel variant used was considered. While eateries hotels and institutions were found to be dependent on Liquefied Petroleum Gas (LPG), the other industries were dependent on wood, charcoal, paddy husk, briquettes as their source of energy and hence coded in two different groups as a dummy variable. The industries utilizing sources other than LPG and industries utilizing LPG were coded 0 and 1 respectively. The results from the econometric model shows that the coefficient of the interactive term is negative implying that industries using LPG have a higher preference for briquette and are willing to pay for it. This is primarily due to the fact that while there are fuel substitutes for the industries not utilizing LPG, the situation for eateries, hotels and institutions is different as they need to pay higher for obtaining LPG.

Similarly, in the household model, interactive variables were included. Apart from the interaction of the certainty dummy with the price, the willingness to use variable for briquettes was interacted with the price variable and also with the higher energy used in the choice experiment. The estimated model shows that the coefficients are negative and are insignificant. The negativity implies that respondents who are willing to substitute for briquettes are not overestimating their willingness to pay and substitution of fuels for higher energy levels and rather they are cautious about the hypothetical product. The respondents who had a preference for higher energy fuels were not quite sure whether briquettes had higher energy content than the fuel in use.

In a mixed logit model it is considered that the magnitudes of the standard deviation provide an idea about the preference heterogeneity for all the attributes among the respondents. The standard deviations are relatively higher for the industries compared to the households and are significant in some of the cases which refers to the fact that there exists preference heterogeneity among the consumers with regards to ease of handling, and interaction variables like certainty of consumption and type of industry. In case of the households, none of the standard deviation were significant implying that the preferences were homogeneous across the group. A likelihood ratio test for the joint significance of the standard deviations was reported for both the models. The associated p-value is noted to be small for the industries which leads to the rejection of the null hypothesis that all standard deviations are equal to zero, while this is just the opposite for the household model. This is quite obvious primarily due to the fact that intuitively while households considered for the study would have homogeneous preferences for fuels for their activities, it would vary across the industries because different industries were being sampled which different needs for fuels have based on different activities.

[3]One important concern with utilizing more than one interactive variable is the problem of multicollinearity. Post-estimation the Variance Inflation Factors were estimated for both the models and the results were 1.74 1nd 1.44 for the industry and the household model respectively. This indicates no multicollinearity for the models estimated.

Table 12: Mixed logit model results for the estimation of factors affecting households' and enterprises willingness-to-pay (WTP) for briquettes

Industries			Households		
Variable	**Mean**	**Standard Deviation**	**Variable**	**Mean**	**Standard Deviation**
Price	-0.159***		Price	-0.0452***	
	(0.0097)			(0.0061)	
More energy content	0.112	0.050	More energy content	0.1151	-0.000126
	(0.116)	(0.106)		(0.0841)	(0.073)
Less energy content	-0.0003	-0.021	Less energy content	-0.0033	-0.00045
	(0.119)	(0.124)		(0.0757)	(0.0815)
Easier to handle	0.125	0.761*	Easier to handle	0.512***	-0.00142
	(0.154)	(0.177)		(0.0803)	(0.0654)
Hard to handle	-0.425**	0.445***	Hard to handle	-0.683***	0.00246
	(0.167)	(0.270)		(0.1107)	(0.094)
Certainty*price	-0.348***	0.346***	Certainty*price	-0.00275	-0.00375
	(0.060)	(0.045)		(0.00885)	(0.0138)
Type*price	-0.127***	0.148***	WTU*price	-0.0636	0.095
	(0.031)	(0.030)		(0.0847)	(0.0801)
			WTU*E	-0.0459	-0.0017
				(0.386)	(0.395)
Number of obs = 4320			Number of obs = 2160		
LR chi2(6) = 329.40			LR chi2(7) = 4.76		
Prob > chi2 = 0.0000			Prob > chi2 = 0.6897		
Log likelihood = - 513.768			Log likelihood = -653.97048		

*** Significant at 1% probability level ** Significant at 5% probability level * Significant at 10 % probability level
Figures in parentheses represents standard errors.
Source: Estimation from the primary survey 2014

- **Marginal willingness-to-pay estimates for briquettes**

Table 13 shows the marginal willingness to pay for the different attribute levels where for the energy level and the ease of handling attributes, the same level of energy and comparable ease of handling were the base levels. Thus, the marginal utility derived from a fuel with higher level of energy content or lower content as shown in the table below.

Table 13: Estimates of the marginal willingness to pay for the attribute levels

Attribute levels	Enterprises (Rs./ton)	Households (Rs./Kg)
Higher Energy	214.3	2.54
Lower Energy	- 10.16	-0.072
Easier to handle	715	11.31
Difficult to handle	-1694.4	-15.09
Source: Calculated from the estimated mixed logit models		

The above table indicates lower marginal values of the industries for the attribute levels compared to the households on an average. This might be attributable to the fact that there are several alternatives existing for the industries to procure the fuel which is a constraint for the households and hence they value the briquettes more. It also implies that the demand curve for fuel is inelastic for the industries since there are alternatives which are substitutable. Lower price changes can produce substantial

changes in the market demand for briquettes in case of the industries. The actual willingness to pay values can however be calculated by utilizing the present market prices of the fuels and that of the marginal utilities (payments) attributed to different levels of the briquette. The following tables[4] (Table 15) provides the market prices and the estimated prices for different fuels across the industry and the households respectively. The calculations of the estimated prices includes valuation of the briquettes with changes in the energy level from the present fuel across different industries. In fact, the estimated market prices show the ranges in the prices which the industries and the households attribute to briquettes in terms of the energy content and given these market prices they would be substituting to briquettes over the present fuel in use.

Table 14: Estimated WTP values for different types of briquettes (per ton)

Type of Industry	Briquette with Wood			Briquette with Charcoal			Briquette with Paddy husk			Briquettes		
	Mean Mkt Price	Mean Est. Price (Higher energy)	Mean Est. Price (Lower energy)	Mean Mkt Price	Mean Est. Price (Higher energy)	Mean Est. Price (Lower energy)	Mean Mkt Price	Mean Est. Price (Higher energy)	Mean Est. Price (Lower energy)	Mean Mkt Price	Mean Est. Price (Higher energy)	Mean Est. Price (Lower energy)
Bricks	2905	3164.3	2939.84	9050	9714.3	9489.84	4850	5064.6	4839.84			
Garments	3600	3814.3	3589.84							**3470**	**3684.6**	**3459.84**

Table 15: Average prices of competitive products for briquettes

	Fuel wood			Kerosene		
	Mean Mkt Price	Mean Est. Price (Higher energy)	Mean Est. Price (Lower energy)	Mean Mkt Price	Mean Est. Price (Higher energy)	Mean Est. Price (Lower energy)
Rural	-	-	-	14.54	17.08	14.47
Urban	3.29	5.83	3.218	9.75	12.29	9.68

- **Estimation of potential market size**

The feasibility analysis of briquettes as an RRR product to enter and survive in the market will require estimating the potential market size for these products. In all, the estimated market size or demand per year is about 1,275,517 tons per year, which is a significant quantity. From the preliminary estimate, the possible MSW that can be used for producing briquettes stands at 3000 MTPD, which would enable the manufacturing and supply of about 11 million tons per year. This suggests that with a proper marketing strategy developed based on WTU and WTP, focusing on the appropriate segments of the economy, the market demand for briquettes will be able to absorb the entire market supply. The composition of the total estimated demand reveals that a substantial chunk of the demand would emerge from heat intensive industries (87%) and rural households (11%). The remaining 2% is accounted by low-income urban households, hotels and hostels, and roadside eateries which constitute a very negligible share. It is noted that Kalyana Mantapas (Choultries) were very reluctant to use briquettes. This was primarily due to religious beliefs and ease of operations. Given these, it may be appropriate to target briquettes primarily among heat intensive industries and rural low income households.

[4]In this exercise we do not consider industries using LPG as a fuel and also those industries where representation in the sample is one or two.

Table 16: Estimation of potential market size

Potential Customers	Estimated Numbers	% of respondents willing to use	Potential Users	Average consumption (kg per year)	Estimated demand per year (tons/ year)
Low-income urban households	136486 [5]	23 % [6]	31392	456 [2]	14,315
Rural households	378021 [7]	68 % [2]	257054	548 [5]	140,737
Hotels and hostels	5136 [8]	13 % [2]	668	10800	7,211
Heating Intensive Industries	3299 [9]	37 % [2]	1221	910680	1,111,603
Roadside Eateries	10000 [10]	6.67 %	667	2500	1,668
Kalyana Mantapas	500 [11]	-	-	-	-
				Total =	**1,275,517**

3.1.2 Market Structure

3.1.2.1 Background and Justification

Energy is one of the most important sectors of a country that drives economic growth. Ensuring proper energy balance is one of the major challenges in the developing context due to limited availability and high prices and limited sustainable production systems. Energy consumption is dominated by biomass - the main fuel source for rural livelihoods for cooking and heating purposes. Modern types of energy such as LPG is the key energy source for cooking purposes for urban consumers, in particular, high income consumers, whilst lower-income households resort to comparatively cheaper traditional energy sources. This among other factors has resulted in households looking for comparatively safe and affordable alternative energy sources.

An agricultural-based country, India (in this context - the city of Bangalore) boasts a wide variety of biomass sources in large volumes that are usable for energy production. Primary solid biomass sources in Bangalore - India comprise: (i) wood energy; (ii) waste from wood processing (sawdust, butt ends, etc.); and iii) agricultural waste. While India has large resources of biomass, Bangalore does not quite boast such significant quantities. This represents great business opportunities involved in the conversion of biomass into briquettes. In many developing countries, there are policy strategies that aim to encourage private sector investment in the energy sector due to the poor financial resources base. Private sector participation in green energy production, however, greatly depends on the degree of freedom in the market structure (i.e. ease of entry and long-run sustainability). New RRR businesses can only be successful if their operations are fine-tuned to the existing market structure, which in turn influences their performance. Thus, new businesses require information on the characteristics of market structure to identify the existing opportunities to enter and further penetrate the market. Moreover, information on the existing level of competition in the market,

5Based on no of slums / low income households as per Bangalore CDP, Govt. of Karnataka.
6Based on sample survey.
7Based on 2011 Census, Primary Census Abstract. Rural households in Bangalore and Bangalore Rural district.
8 Based on Zomato – Online directory of hotels in Bangalore
9 Based on number of industries from District at a Glance, Govt. of Karnataka.
10 Govt. of India reports 30000 street vendors in Bangalore and about one-third of them is assumed as eateries.
11 Based on online directory: http:// .... last retrieved 4th June 2014.

characteristics of competitors and factors which drive the market's competitiveness or collusiveness are necessary for decisions on investment. This also requires an evaluation of relevant actors' pricing and distribution strategies. Thus, this sub-chapter focuses on the assessment of the market structure of alternative energy markets in Bangalore, India, with the goal of evaluating key external and internal factors which will be representative of success drivers or limiting factors to new waste-to-energy businesses, in particular, briquette businesses. The market structure assessment is based on a structure, conduct and performance (SCP) framework and assesses the implementation feasibility potential of agro-waste briquettes businesses.

3.1.2.2 Research Methods and Data Collection

Empirical research literature on the structure, conduct and performance of firms in industries covering some of the developing countries, particularly African economies reveal that market structures of commodities and therefore industries differ leading to different kinds of behavior or conduct of participant firms and thereby resulting in different kinds of performance. However, these studies once again substantiate the influential relationship of structure with conduct and conduct with performance of firms in an industry. Broadly, the market structure of industries is examined in terms of number and size of firms. Accordingly, researchers have measured market concentration ratios of the leading firms. Alternatively, HHI has been calculated to throw light on the degree of concentration prevailing in an industry. By and large, the larger the number of firms in an industry lower the concentration and more competition among the participant firms. In such cases, firms resort to different kinds of pricing and non-pricing, particularly advertising strategies. However, where entry barriers are high, such industries are characterized by oligopolistic markets with high concentration ratios. But wherever entry barriers are low, more number of firms has entered the market provided, (I) existing firms are performing well, and (ii) market has grown due to growth in consumer demand. While oligopolistic markets have always facilitated higher price of the products leading to better performance of the existing firms to the disadvantage of consumers, competitive markets have favored the consumers with more alternatives (in terms of products and quality) at competitive prices.

However, the performance of firms did not rely exclusively on structure and conduct of firms. It depended on other economic factors such availability and prices of inputs, as well as innovation capability of firms. If high quality raw materials are not readily available, and as a result if their prices are high and thereby accounting for a larger share of the total cost, even an oligopolistic market may not ensure higher profitability. This is particularly true when total market in terms of consumer demand is small and it includes largely low-income consumers. On the other hand, if consumer demand is growing and market is competitive where innovations emerge, firms stand to gain and perform better. Given the above issues, it is appropriate to understand the number and size of existing RRR product sellers, extent of current market demand for RRR products, future market potential, number firms it can accommodate, the conduct of existing firms in terms of pricing and non-pricing strategies, and the performance of existing firms in terms of sales revenue growth, profit margins, ROI, etc.

Given that the briquette industry is fairly nascent, the respective markets of alternative fuels were considered for the market structure assessment as these are representative of the direct competitors to new briquette businesses. The following aspects were evaluated as follows: a) the supply chain analysis was analyzed via the identification of main actors along the value chain, their behavior and roles, product flows along the supply chain and quality; regulatory and policy environment which affect performances of the supply chain; b) performance of the supply chain actors was assessed based on their profit margins and average profits. Data was obtained from primary and secondary sources, Indian organizational reports and websites on the Indian energy market. The goal of the

assessment was to be conducted from a city perspective, however given data limitations and the sector (energy) under consideration, parts of the analysis was conducted using national level data where there was limited city-level data.

- **Analytical framework**

A market structure analysis depends on quantitatively and qualitatively understanding the three broad aspects of the market, namely the market structure, market conduct and the performance. New RRR businesses will have to enter markets that are already well established in most cases and their conduct will at a minimum be influenced by the behavior of the already established businesses. Hence the market structure is something that is already existent and will influence the entry of new businesses and their conduct. This will eventually dictate the overall performance of the businesses in these markets. Figure 1 gives the overall analytical framework for the SCP analysis as applied to the energy market.

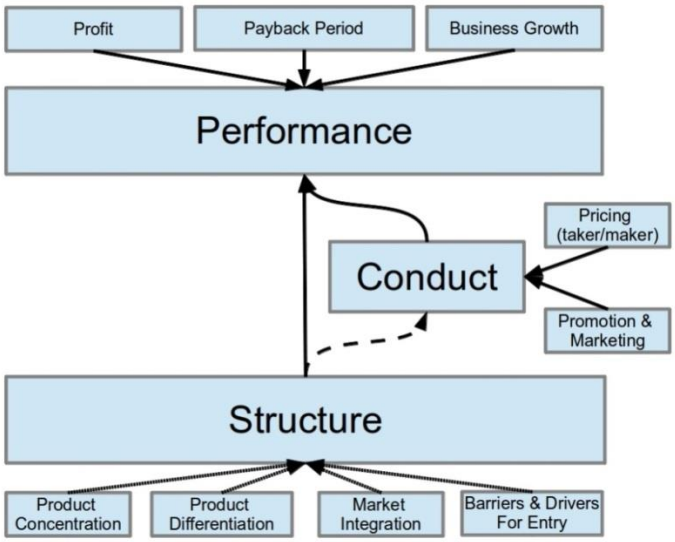

Figure 1: Analytical framework for SCP

Market Structure: The market structure is typically studied by the amount of market concentration among the players. A market in which a few players tend to dominate will have weak competition in comparison with a market in which a large number of players participate equally. This level of market concentration is measured in terms of the *number of players and their market shares*. This information is used to compute the *Herfindahl index.* In addition to market concentration the other dimensions studied are product and service differentiation, flow of resource, information and finance, and barriers to entry in the market. The product/service differentiation is essential to understand as the RRR products will have to be appropriately positioned and marketed to the appropriate consumer. A product such as briquette which competes with firewood is more energy efficient and easy to handle. However the social stigma associated with briquettes from waste makes it highly challenging to be marketed to some segments of the firewood consumers such as households and restaurants. The other major factor in defining the market structure is the flow of material, information and finance. For instance in the case of MSW briquettes, the availability of segregated raw material is rather very limited and hence the quality (calorific value) of the final product can be compromised. This leads to a situation where MSW briquettes may not be able to effectively compete with coal and heating oil. Finally the enablers and barriers to market entry complete our understanding of the market structure. Some government policies such as tax breaks and land use regulation may have an impact on the new market entrants.

Market Conduct: The conduct of the players is studied by their price setting behaviour. Specifically their independence in pricing decisions, amount of price mark-up, and their marketing and promotion activities were studied. The price setting behaviour of market players is crucial for new RRR businesses as it has a direct impact on their revenues and the eventual survival of the business. A market in which a lead player dictates the price of the product could be very challenging for new RRR businesses to sustain their business in the long run. Also a market where some players/competing products get government subsidies would be difficult to compete with based on the price of the product. Clearly in such situations the price of the competing products do not factor in the whole of their cost involved in the production and distribution and hence would have a significant price advantage.

Market Performance: The performance of the market players is measured using their profitability, payback period, business growth, and sales turnover figures. The attractiveness of a RRR business to a future entrepreneur is influenced by its potential profitability. All things remaining the same, a market where the competing products are highly profitable would be highly attractive for a potential entrepreneur. Clearly the cost structure of a RRR business need not be the same as the competing products. However this provides a yardstick to measure the attractiveness of the business potential. The market performance variables try to measure this aspect of the market.

- **Study area**

The study was conducted in and around the city of Bangalore (Figure 2). Bangalore is the principal administrative, cultural, commercial, industrial, and knowledge capital of the state of Karnataka, with a population approaching 9 million. The city is geographically located at 12.95º N latitude and 77.57º E longitude and situated on the Deccan plateau, at an altitude of 920 meters above mean sea level (msl). Bangalore is a fast growing incipient megapolis, with an increase in population from 163,091 during 1901 to 8,499,399 as per the 2011 Census (Census of India, 2011). With the advantages of booming economic activity, availability of land for expansion, and the city's year-round favorable climate due to its location at a higher elevation, population growth, migration and expansion have been extensive, leading to urban sprawl and landscape fragmentation in and around Bangalore (Sudhira et al., 2007, Nagendra et al., 2012). The city of Bangalore, despite the success stories of growth on the one hand, faces challenges in managing resources in general and wastes in particular similar to most Indian cities on the other. The rapid growth of population in Bangalore metropolitan area and changing lifestyles has resulted in increased waste generation (BBMP, 2013). Consequently, waste management has become a key issue garnering attention. The various waste streams include municipal solid waste (households, commercial establishments), bio medical waste (Hospital, dispensaries), and industrial waste (industries) and electronic waste (discards from electronic equipment including PCs). Most of the study reports suggest waste generation rate of 0.4 to 0.6 kg per capita per day. Based on this per capita consumption of 0.5 kg per capita per day is proposed as the waste generation pattern for Bangalore city.

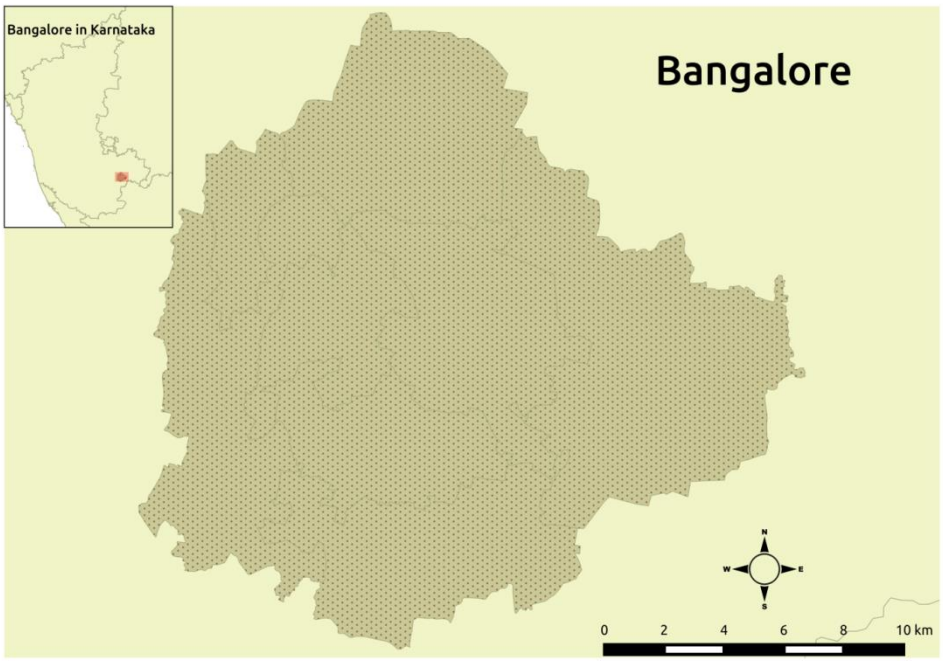

Figure 2: Location of Bangalore in Karnataka state

- **Sampling strategy**

The analysis used both primary and secondary data. A survey method was used to collect information from key players in the supply chain of the competing products listed in Table 17. The sampling units were the organizations which participate in their supply chain. The competing products such as LPG, kerosene and state electricity corporations are heavily regulated and monopolized by state agencies. Hence all the required data were collected from secondary sources. For the other products a convenience sampling[12] based formal survey was conducted. The following table indicates the target respondents for the competing traditional product for the key RRR products considered.

Table 17: Competing traditional products and targeted respondents

No.	Competing traditional product	Respondents
1	Firewood	Informal firewood collectors and distributors
2	Briquettes from agro-waste	Existing Agro waste briquette manufacturers
3	Liquefied petroleum gas (LPG)	Retail outlets of State-run LPG distributors
4	Kerosene	State-run Kerosene distributors

A scoping study for the different markets was conducted to understand the different players. In places where the number of formal players was limited and the variability in the expected outcomes was marginal the sample size was restricted to a small number. For example, in the case of the firewood market the product was almost entirely sourced from government forest department and distributed through their depots in different areas around the state. The retail outlets source their products typically from these depots.

[12]Since many of the respondents were not willing to share information on their business practices convenience sampling strategy had to be adopted.

3.1.2.3 Results and Discussion

- **Overview of the energy market**

In the overall purview of the energy market, for the purposes of this study firewood, briquette and electricity are relevant. However, the energy market (power generation, supply and distribution; Kerosene distribution and LPG distribution) is very well regulated by the state with mostly state-run enterprises managing them. Private participation is permitted only on certain aspects of power generation, though the pricing for the same is something the private entrepreneurs have to negotiate with the respective electricity reforms commission. Hence, in this scenario, we have not attempted a detailed analysis for electricity, Kerosene and LPG segments. The analysis for firewood and briquette are presented below.

- **Firewood**

The secondary data gathered on the competing products for the RRR products have revealed that the use of firewood for household heating and in enterprises has been in the market for a long time now. Based on the recent NSSO statistics (NSSO, 2014: 68th round), the percentage of households reporting use of firewood and chips remained as high as 83.5% in rural areas and 23% in urban areas. Further the monthly per capita rural consumption of firewood and chips was estimated at about 19 kg and its value (including imputed value of free collection and home-grown stock) at Rs.48.20 (42% of fuel expenditure). At the national scale, the consumption of fuel wood by industries and construction is rather decreasing as per the United Nations statistics (UN, 2014).

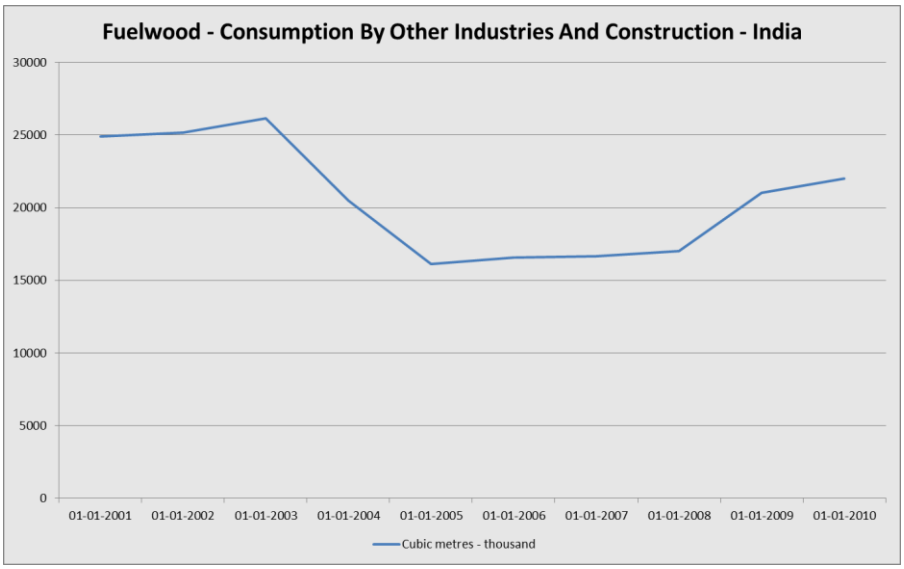

Figure 3: Fuel wood consumption in India

Source: United Nations statistics (UN, 2014)

Swaminathan and Varadharaj (2001) have studied the status of firewood in India. Accordingly, they note that the firewood production mainly comes from forest areas (51 per cent) while the remaining balance of 49 per cent comes from outside forest areas amounting to about 26.7 million hectares). They report that the mean annual production of firewood was 211 million cubic meters with an annual demand of 212 million cubic meters (m. cu. m). Their study of annual firewood production from 1970 to 1998 suggests that there is an annual increase of 2.02 per cent. They further report that the demand for firewood by small restaurants, cottage industries and religious rituals including cremation were 10, 25 and 4 million tons, respectively. It is noted that the overall demand for firewood is expected to increase from 274.34 m. cu. m in 1998 to about 347 m. cu. m. by 2010. However, they conclude that

the effect of future increases in income and on the demand of firewood is difficult to predict, since the increase in income may result in the increase in demand for more refined fuel such as LPG, Kerosene, etc. (Swaminathan and Varadharaj, 2001). Although firewood has been the one of the primary source of fuel for households' for decades, with the advent of LPG, its usage has reduced significantly in the urban households, and rather disappeared from upper and middle income households and even for enterprises. Therefore, the product is in the stage of maturity with still marginal demand. In addition, the recent regulation of not allowing the transport of firewood into the city limits resulting in their limited availability has hastened its decline. If its usage is prevailing in the city, then it is largely confined to low income households, and micro and small enterprises.

- **Agro-waste briquette**

Secondary data also revealed that the agro-waste or biomass briquette industry is another competing product, which has emerged only in the last couple of decades. ICLEI (2007) notes that biomass contributes to about 14 per cent of the total energy supply worldwide and further about 38 per cent of this energy is consumed in developing countries, predominantly in the rural and traditional sectors of the economy. In India, under the active support of Ministry of New and Renewable Energy, Government of India is indeed receiving a significant thrust through policy measures and incentives[13]. The study by ICLEI (2007) report estimated the availability of biomass in India at about 120-150 million MT/annum covering agricultural and forestry residues corresponding to a potential of 16,000 MW. It noted that plantations on wastelands also provide significant opportunity by about 62,000 MW for grid-interactive power and another 15,000 MW for off-grid applications. The cumulative installed capacity of grid interactive and bagasse cogeneration power projects up to 31.12.2006 was 912 MW (ICLEI, 2007). However, as per the latest data[14] the installed capacities in MW of biomass power and gasification under grid interactive power is 1365.2 MW and off-grid captive power under rural is 17.48 MW_{eq} and industrial is 147.2 MW_{eq}. Thus, indicating that the sector is steadily growing. Therefore, this product can be considered to be in its growth stage.

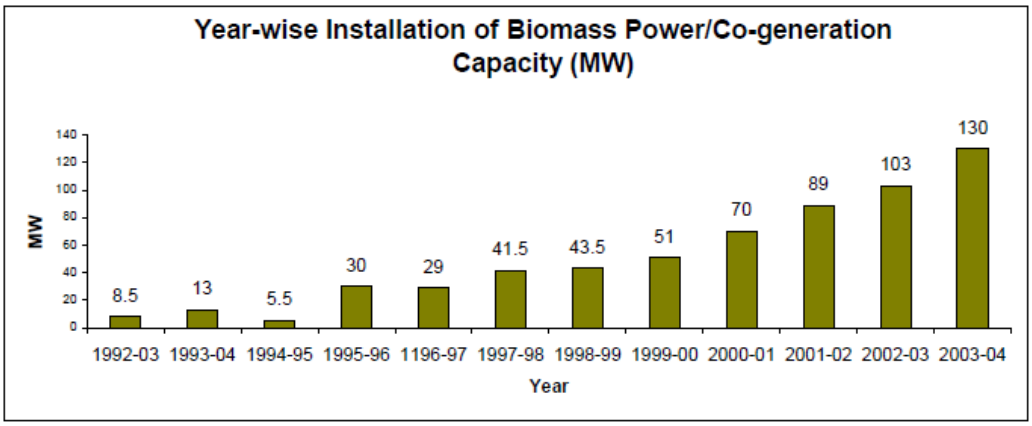

Figure 4: Growth in installation of Biomass Power/Co generation Capacity

(Source: MNRE Annual Report 2003-04)

- **LPG and Kerosene**

The LPG and Kerosene are the other two competing products to agro-based briquettes. The quantity and price of both are regulated by the government. They have been in the market, particularly kerosene for decades now. Recent NSSO results show that nearly 71% households in urban areas and

[13] http://mnre.gov.in

[14] http://www.mnre.gov.in/mission-and-vision-2/achievements/ last accessed: 9th July 2014.

over 21% in rural areas reported consumption of LPG for household use during the last 30 days (NSSO, 2014). According to NSSO, between 2004-05 and 2011-12, the rural sector showed an increase of 83% in the proportion of LPG-consuming households and an increase of 75% in the quantity of LPG consumption per person. The urban sector showed a rise of 20% both in the proportion of LPG-consuming households and in the quantity of LPG consumption per person (NSSO, 2014). Thus, LPG is indeed in the growth stage given its growing penetration into the rural areas with almost complete penetration in the urban centres. In regards to kerosene, their quantities of consumption are marginal in comparison with other fuel sources thus indicating a decline in their consumption (Table 18). Although kerosene has significantly penetrated rural markets, where it is one of the primary sources of fuel, its use is limited by the quantity supplied by the government. Further, because it is subsidized and its sale is only through regulated fair price shops of the government, its supply leads to pilferage, which is subsequently available for sale (at a higher price) in grey markets. Overall, it is considered to be in saturation stage with no growth prospects as most existing users prefer to shift to other energy carriers.

Table 18: Details of consumption of selected energy items, all-India

fuel	qty. of consn. per person in 30 days (2011-12)		value of consumption in 30 days								% (2011-12) of consuming hhs (in 30 days)	
			per capita (Rs.) (2011-12)		as % of all fuel							
					R			U				
	R	U	R	U	*68^*	*66^*	*61^*	*68^*	*66^*	*61^*	R	U
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
firewood and chips (kg)	19.04	4.29	48.20	13.17	42	47	42	8	9	9	83.5	22.9
electricity (kwh)	8.9	25.8	25.11	87.20	22	22	20	50	51	46	74.2	96.0
kerosene - PDS (litre)	0.431	0.230	6.78	3.50	6	6	9	2	2	3	75.6	30.0
kerosene - other sources (litre)	0.103	0.166	2.92	5.70	3	2	4	3	3	5	21.7	15.7
LPG (kg)	0.378	1.926	11.31	56.74	10	8	8	32	31	32	21.4	70.8
other fuel	-	-	19.79	9.55	17	14	17	5	5	5	-	-
all fuel (excl. vehicle use)	-	-	**114.11**	**175.86**		**100**			**100**		**99.8**	**99.6**

^round: *68* – 2011-12; *66* – 2009-10; *61* – 2004-05

Source: NSSO, 2014.

- **Results from assessment of market structure, conduct and performance**

  - **Firewood**

The organized market for firewood in the Bangalore Metropolitan Region Development Area (BMRDA) depends entirely on supplies imported from outside its geographical boundary. The organized firewood sector sources the firewood for sales through the firewood depots run by Karnataka State Forest Industries Corporation limited (KSFIC). The state run KSFIC maintains one firewood depots in Bangalore[15] which typically acts as the source for the firewood retailers. The supply chain of the organized firewood market in the BMRDA region is shown in Figure 5.

Market structure assessment

- **Market concentration:** The *Herfindahl index* for the firewood retailers computed from the annual turnovers of the sampled retailers is 0.2916 suggesting a highly dispersed set of players in the firewood retail trade.
- **Product differentiation:** All the retailers indicated that there is no product differentiation in the products sold by them, probably owing to the nature of the product. However, one of the retailers had information on the plant species from which the firewood was sourced. Also no additional service offering is provided by these retailers.

[15]Kamakshi Palya KSFIC depot in Bangalore (Source: http://www.ksfic.com/English/fd.htm accessed on March 3, 2014).

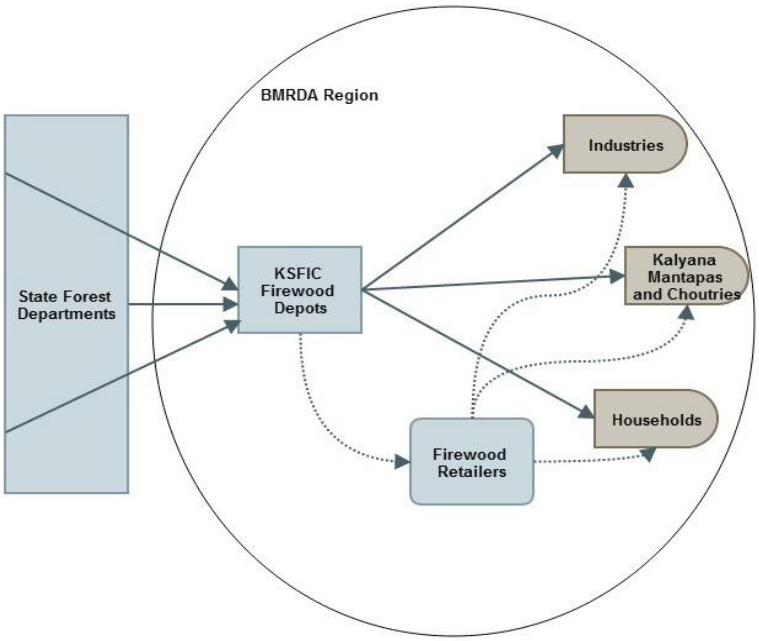

Figure 5: Firewood supply chain[16]

- **Market integration:** Tri-wheeled auto-rickshaw being the main mode of transportation for their customer delivery. None of the sampled retailers had indicated any problems related to logistics, while 75% of the sampled retailers (3 out of 4 retailers) indicated problems in lead time specification by their supplier. Telephones were the dominant mode of communication used by the retailers for their communication between themselves and their suppliers and between themselves and their consumers. The suppliers have extended terms of credit to the retailers with the option of delayed payments for the load of firewood received. Typically the end consumer of firewood does not receive any line of credit for the product purchased. They are expected to settle the outstanding when the product is purchased.
- **Barriers and drivers for entry:** Some of the key phrases used by the retailers in describing the barriers faced by them include "lack of stable and economically attractive markets, limited access to credit facilities, pricing policies, taxes, regulations", "uncertainty of the market and prices", and "difficult to obtain resources like lands, inputs, Pricing policies, taxes, regulations".

Market Conduct

- **Pricing:** All the retailers use a price mark-up strategy, although they were unwilling to provide exact details. They indicated inflexibility with respect to pricing between themselves and their suppliers and their consumers. There is no volume discount in this business.
- **Promotion and marketing:** There is no promotion and marketing activities for this product as expected.

Market Performance

- **Profitability**: As one would expect none of the businesses sampled were willing to share their financial information. However at a qualitative level all the retailers have indicated that their business is profitable (4 in a scale of 1 to 5).

[16]Dashed lines in the supply chain diagram indicate weak links indicating the relatively small amount of impact the players have on the operation of the supply chain

- **Payback period**: The firewood businesses recover their investment in a period of about 1 to 2 years.
- **Business growth**: The sampled firewood businesses were not willing to share this information.

➢ **Briquette**

The briquette market is characterized by the manufacturer acting as the point of contact for the end users there by eliminating the intermediaries. This could be due to the relatively low penetration of the product in the market. A briquette manufacturer typically sources the raw materials from farmers or brokers who act as the intermediary between the farmers and the manufacturers. The source of raw materials is typically agro-waste like groundnut husk or coffee husk or paddy husk or other husks also called as dry bio-mass. The manufactured briquette is then sold directly to the final consumer (industries/choultries). The primary data collected from the manufacturers indicates that the role of retailers and other intermediaries such as distributor for the final product is rather very limited or negligible. The household is the prospective end-user in the structure; however they are not significant at this point of time. The supply chain of the briquette market is shown in Figure 6.

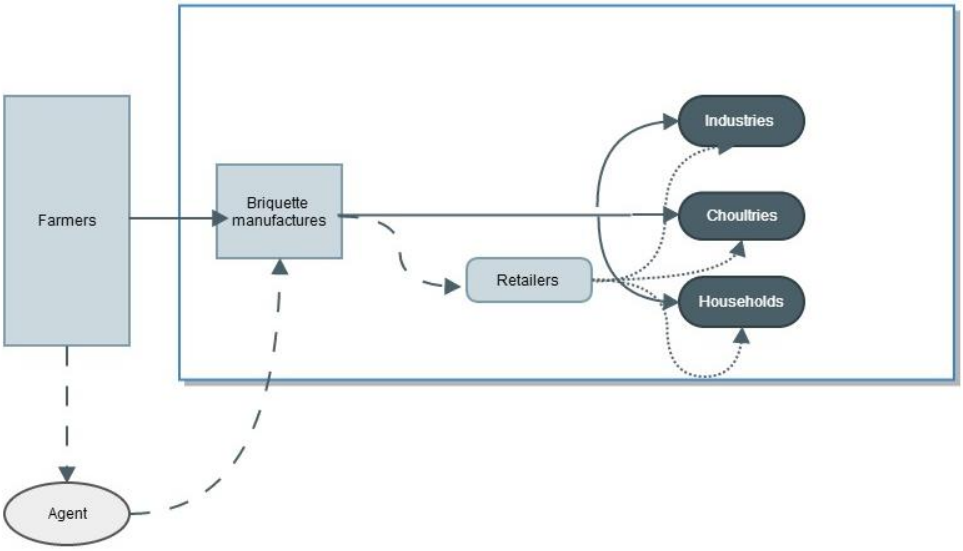

Figure 6: Supply chain of the briquette market in the BMRDA region

Market structure

- **Market concentration:** The briquette manufacturing sector seems to have a relatively long history in Bangalore region with one manufacturer in the sample having established his business nearly 15 years ago. The *Herfindahl index* for *the* briquette manufacturers/retailers is 0.36 indicating that the market is highly dispersed and that there is no one dominant player in the market. This is especially important in this context as the sample had manufacturers who have been in business for as long as 15 years and other who are recent entrants (1 to 2 years).
- **Product differentiation:** There is no product differentiation in the briquette industry. Also there are no value added services that are provided by the briquette manufacturers.
- **Market integration:** Trucks are the main mode of transportation used in this industry. Telephones are mostly used for communicating between the suppliers, manufacturers and customers. Manufacturers have indicated that the shortage of raw materials is the main problem they currently face. This has been mostly attributed to the seasonal nature of the source from which the raw materials are procured. MSW-based briquettes, on the other hand, will not have this seasonality problem and hence could leverage this to their advantage. Supplier lead times are typically dependable and do not seem to create any uncertainty. Some

manufacturers have indicated the availability of NET-D[17] payment terms. The capital for these enterprises is typically self-arranged and there do not seem to be any special institutional arrangement for this business.

- **Barriers and drivers for entry:** The need for large capital investment has been cited as the major entry barrier. One of the manufacturers has cited the presence of a 5 year tax break for this business as a major enabler. However, this information does not seem to be widely known and taken advantage of. These businesses require a trade license and all the sampled responses have indicated the easy availability of such a license.

Market conduct

- Pricing: The dominant pricing strategy in this market is based on set profit margins. There are no price negotiations between the manufacturer and the customers. Also the price of raw materials supplied to the manufacturer is fixed and there is no scope for negotiation. There are no volume based discounts in this market.
- Promotion and marketing: The role of promotion and marketing is nil.

Market performance

- **Profitability**: All the sample respondents have indicated that their business is profitable. Although they were unwilling to share their exact profit margins all of them have indicated that their business is highly profitable (4 and 5 on a scale of 1 through 5).
- **Payback period**: Typically these businesses have paid back the initial investment in a very short period of 1 to 2 years.
- **Business growth**: The briquette manufacturers were not willing to share any information in this regards.

- **Implications of results for the implementation of new briquette businesses**

The implications of the above analysis of competing products for agro-waste briquette with respect to the level of differentiation of the competing products in the context of the stages of their product life cycle are briefly presented in Table 19 below. Firewood and agro-waste briquette can be considered relatively close substitutes and therefore low level of differentiation with respect to agro-waste briquette. On the other hand, electricity, LPG and Kerosene are highly differentiated and therefore remote substitutes for agro-waste briquette. Given the level of product differentiation, both firewood and agro-waste briquette will pose stiff resistance to the entry of agro-waste briquette into the market. This will hold good, in the context of LIG households and informal sector enterprises in rural as well as urban India. However, the fact that the usage of firewood is in its declining phase would mean that the competition emerging from it, will tend to decline in the future, though slowly and steadily. However, the scenario w.r.t. electricity and LPG will be entirely different. Although both are highly differentiated from agro-waste briquette they will still pose a stiff resistance to the entry of agro-waste briquette particularly in view of the convenience in their supply and easy accessibility. Further, since both of them are in their growth phase an increase in the level of income will only make both of them more attractive for multiple users in middle and upper income households and restaurants. Kerosene although a highly differentiated product is primarily used by LIG households and informal sector enterprises in urban and rural India. Though kerosene is in the declining phase of its PLC, so far as the government policy of subsidization continues it will continue to pose a stiff competition to the RRR product, particularly in the context of LIG households. If and when subsidies are phased out, its usage will see a sharp decline.

[17]A NET-D term of payment term is a form of trade credit where the net payable is expected to be settled in D days.

The introduction of agro-waste briquette in the market could impact the existing firewood business. A key change would be that it may tend to formalize the current firewood business once they shift/start to selling briquettes instead. With the restrictions on transporting firewood into the city, the market is facing challenges with respect to availability and consequently its impact on customer expectations and loyalty. However, the same may not be applicable to briquettes and so the present firewood sellers and distributors would be more impacted with the increased availability and acceptance of briquettes. The introduction of agro-waste briquette in the market would impact the agro-waste briquette industry. Briquette manufacturers would then prefer municipal solid waste over agro-waste, as the raw material in the case of the former would cost almost nil except bearing its transportation costs. This would also bring stability to the rather volatile agro-waste market. Further, it may also affect the pricing of briquettes based on market demand. However the new agro-waste briquette industry needs to accommodate the customer expectations in terms of credit, delivery, and near nil expenditure for marketing by the current market players.

Table 19 : Implications of RRR Product: MSW Briquette

Competing Products	**Level of Differentiation**	**Implications of Differentiation**	**Implications of the Stages of PLC of Competing Products**
1. Firewood	Low (close substitute)	Highly competitive in rural areas as well as urban areas with respect to LIG households and informal sector enterprises.	Competition is likely to decline in the future.
2. Electricity	High (remote substitute)	Highly competitive in rural as well as urban areas w.r.t. middle and upper income groups and restaurants.	Competition is likely to grow stronger.
3. Agro-waste Briquette	Low (close substitute)	Highly competitive for LIG groups and informal enterprises.	Competition is likely to remain steady.
4. LPG	High (remote substitute)	Highly competitive in rural as well as urban areas w.r.t. middle and upper income groups, informal sector enterprises and restaurants.	Competition is likely to increase in the future.
5. Kerosene	High (remote substitute)	Highly competitive in rural areas as well as urban areas with respect to LIG households and informal sector enterprises.	Competition is likely to decline in the future.

3.1.3 Market Outlook

3.1.3.1 Background and Justification

Market forecasting is a projection of demand levels in the future, based on current or past evolutions. The role of market or demand forecasting is to aid businesses in planning for the future. Because investment toward an uncertain future is very difficult and risky, market forecasting tools have been developed to alleviate the risk and to obtain more accurate or reliable information. The most fundamental variable in determining an appropriate business strategy is the stage of the product life cycle (Hofer, 1975; Anderson and Zeithaml, 1984). The product life-cycle management is the succession of strategies used by businesses as a product goes through its life-cycle. The condition of the market in which a product is sold changes over time and business strategies must be managed as it moves through its succession of stages. The goals of product life cycle management are to reduce time to market, improve product quality, reduce prototyping costs, identify potential sales

opportunities and revenue contributions, and reduce environmental impacts at end-of-life. To create successful new products the product manufacturing company must understand its customers, markets and competitors.

3.1.3.2 Research Methods and Data Collection

Given the limited data on the proposed RRR products, the Bass model (1969) was used to assess the market outlook for briquettes. The model took into consideration the probability of purchase given that no previous purchases were made and the total number of potential buyers as parameters reflecting the rate of diffusion and the initial probability of first-time purchases (Proctor, 2000). A variant of the discrete time bass model function was applied. Satoh (2001) justified the adoption of the discrete time model when data used is discrete, as the Bass model is a continuous-time model. Satoh (2001) further noted that the discrete Bass model conserves the characteristics of the Bass model because the difference equation has an exact solution. Therefore, the discrete Bass model enables us to forecast the innovation diffusion of products and services without a continuous-time Bass model.

$$f(t) = \frac{\frac{(p+q)^2}{p} e^{-(p+q)t}}{\left(1 + \frac{q}{p} e^{-(p+q)t}\right)^2}$$

$$F(t) = \sum_{i=0}^{t} f(i)$$

$$A(t) = M\ F(t) \text{ and } a(t) = M\ f(t)$$

The optimal time to peak sales is given by:

$$\frac{\ln\left(\frac{q}{p}\right)}{p+q}$$

Other variables in the Bass Model calculated from M, p, q and t, are:

f(t): the portion of M that adopts at time t.
F(t): the portion of M that have adopted by time t,
a(t): adopters (or adoptions) at t and
A(t): cumulative adopters (or adoptions) at t.

The most critical determinants of the model are the innovation and imitation coefficients p and q and the potential market size (M) of the briquette market. In the absence of data on p and q estimated for the briquette product, the study used an average estimation of those coefficients as per the findings of Sultan at al. (1990). Accordingly, the assumed estimate of p used was 0.04 and q, 0.5. Low diffusion rates were assumed due to the strong habitual behaviour of consumers of current fuel products (low switching behaviour) in the absence of strong alternative products in the market. Additionally, the total (p+q) is assumed to lie between 0.3 and 0.7. The potential market size is estimated at 1.275 million tons based on the WTP assessment.

3.1.3.3 Results and Discussion

Figure 7 and Figure **8** show the behavior of new and cumulative product sales over the years with the value of p assumed at 0.04 and q at 0.5. The probability of market adoptions and the cumulative

adoptions are obtained as indicated in the figures below. The results suggest a peak of adoptions between 4-5 years and a new business would eventually take between 12 - 13 years to capture the market in totality. The model outcomes suggest that everything else remaining the same, the probability of market adoptions will gradually peak at 4-5 years and has a very long span for the market. Given the prospects of a longer horizon, the first five to six years need a greater push for the product to mature and achieve the maturity stage. Although the model indicates a decline in terms of adoptions post reaching its peak, effective marketing strategies employed during the introduction stage of the product can ensure a longer maturity phase and gain a significant share of the market[18].

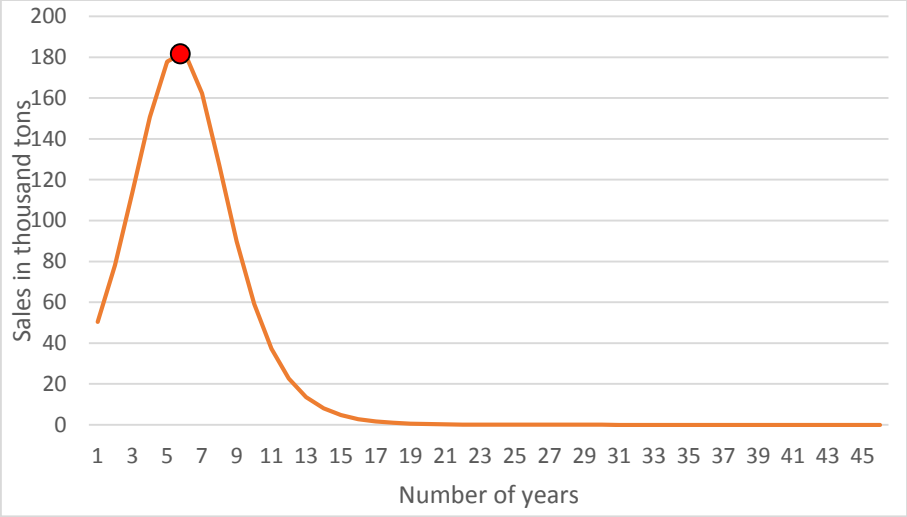

Figure 7: Probability of market adoptions for briquettes

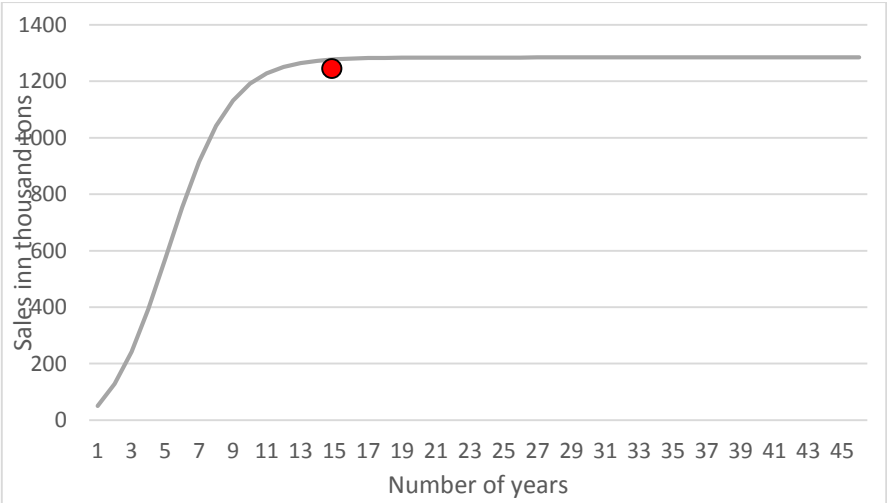

Figure 8: Cumulative adoptions of briquettes

3.1.4 Conclusions

The results indicate that there is a fair market demand for agro-waste briquettes in Bangalore, although not substantial. Among the surveyed households (both urban and rural), none were currently

[18] The bass model relies on number of users and may not be a good one to estimate the quantity *per se*. Hence, we have only estimated the number of potential users.

noted to be using briquettes. Furthermore, the estimated supply of agro-waste for the generation of briquettes and the estimated demand for briquettes from the identified segments of the economy broadly reveal that there is no significant demand supply gap for briquettes, although the estimated demand exceeds estimated supply. This suggest that an appropriate planning and marketing strategy will be required for new briquette businesses to gain a share of the market. New briquette businesses also will need to accommodate customer expectations in terms of credit, delivery, and near nil expenditure for marketing by the current market players. Differential pricing can help in gaining market share, although its implementation needs to be studied in greater detail. Across all the studied markets product promotion and marketing is close to nil. New briquette businesses would need to invest in R&D in order to mitigate the effects of high social barriers. This would place them at a competitive disadvantage compared to their competitors.

There are also both policy induced factors and environmental factors that are representative of entry barriers for briquettes to penetrate the household sector. Government subsidies for existing competing products in the energy market (LPG and Kerosene) can pose a challenge to new briquette businesses, and thus appropriate product positioning and customer targeting would be very essential to overcome the challenges posed by the subsidy. Additionally, the extensive established network of LPG has improved the product's accessibility not only in urban areas but also in rural areas - thus a significant competitor for briquettes. Similarly, the steady improvement of electrification has resulted in households relying on electricity at least for lighting. In addition, urban low income households have the access to kerosene both through public distribution system and open markets; and in the rural areas, households have the luxury of collecting firewood free of cost.

3.2 Model 4: Onsite energy generation by sanitation service providers (faecal sludge to energy) and Model 6: Power capture model (Livestock waste to energy)

The electricity market is heavily regulated and monopolized by state agencies. Private participation although present is very limited and permitted only for certain aspects of power generation. Pricing of electricity is negotiated between the private entrepreneurs and the respective electricity reforms commission. As private electricity suppliers do not supply directly supply to households but rather to the national grid, the only direct market/ consumer is with the latter. In that regard, a willingness-to-pay assessment was not conducted for business models 4 and 6. An assessment of the market structure and outlook is provided in detail in the 'Institutional analysis' report.

3.3 Model 8: Phyto-remediative wastewater treatment and fish production

3.3.1 Willingness-to-pay and Market Estimation

3.3.1.1 Background and Justification

With the increasing global climate challenges, many policy makers are seeking for alternative options to mitigate both the direct and indirect impacts on society. Concurrently water, which is an essential input of life, is decreasing at an alarming rate and many developing countries are considered to be water stress or water scarce countries. To effectively reduce the impacts of water scarcity, many policy makers have opted for the use of wastewater for multiple uses in our societies. Wastewater use for aquaculture is becoming a common practice in Africa and Latin America while households in Asia have been using wastewater for decades (Edwards, 1992). Specific examples of this practice can be found in China, India, Indonesia and Vietnam. There are multiple benefits associated with the use of wastewater for aquaculture, especially in water scarce countries. Households are able to secure relatively cheaper water for farming, obtain fresh fish at an affordable price and the cost of agricultural production could be reduced significantly.

Given the benefits associated with wastewater use for aquaculture, many international organizations including the World Health Organization (WHO), International Water Management Institutes (IWMI) and World Fish Centre, recommend that wastewater reuse should be considered as an option in schemes to improve sanitation in developing countries. In reality, however, a few wastewater-fed aquaculture systems have been implemented recently (i.e., Agriquatics in Bangladesh, Terraqua in Peru, Waste Enterprisers in Ghana). These examples represent opportunities for cost-recovery for these wastewater treatment systems. The undertaking and sustainability of a business component to wastewater reuse requires an assessment of the market in its entirety to include an evaluation of market demand of wastewater-fed fish. This is crucial, particularly, given that in areas where wastewater-fed aquaculture exists, the practice is threatened or in decline for diverse reasons. In spite of current technological advancement, there are still health issues associated with the wastewater-fed aquaculture. Households and policy makers are still reluctant to consume fish raised with wastewater because of perceived negative health risks. Marketing of fish from wastewater is a major issue for the households or business owners. Thus, an assessment of the market demand and potential size is crucial prior to implementing such an operation and to understand the existing level of demand and driving factors of demand for wastewater-fed fish.

Traditionally contingent valuation approach is used to estimate the demand for a product without existing or historical market price. This approach has the ability to assess both the direct and indirect benefits of the product and to provide market information for potential investors. Many resource economists prefer stated preference approaches with either open-ended or closed-ended questions to elicit respondents' willingness to pay (WTP). However in recent years, the use of choice experiment is becoming a common practice to assess the demand for a new product because of its ability to overcome hypothetical bias. Also, this approach considers trade-off analysis and provides WTP for different attributes of the products. Previous studies have applied the choice experiment (CE) approach to assess different economic policies in both the developed and developing word. For instance, Lim et al. (2013) apply the CE to assess the economic value of country-of-origin considerations in beef steak products in the US, other have use the approach to assess demand for fair trade coffee in Canada (Arnot et al. 2006); economic value of river improvement in Durham, England (Hanley et al. 2006) and Ndunda and Mungatana (2013) apply the method to estimate welfare benefits of improving wastewater treatment options in Nairobi, Kenya. In general, these studies show that the CE approach has the ability to demonstrate incentive compatibility for the choice alternative

presented to the respondents. This analysis thus sought to evaluate the following research questions using a choice experiment approach:

1. Assess the perceptions of households and businesses of wastewater-fed fish;
2. Estimate households' and businesses' WTP for wastewater-fed fish;
3. Estimate households' and businesses' WTP for attributes of wastewater-fed fish;

In this context, our main hypothesis is to evaluate if households' and businesses' demand for wastewater-fed fish would increase under two conditions; (a) if wastewater-fed fish are certified by a trusted government agency and (b) if full information is provided to the households and businesses about the source of water used to raise the fish? The subsequent sub-sections outline the research methods, data collection and analytical assumptions, results and finally the policy implications of the assessment.

3.3.1.2 Research Methods and Data Collection

Theoretical Framework: Choice Experiment

According to Lancaster (1966), the demand for a product is influenced by attributes rather than the product itself. The Choice Experiment (CE) has its theoretical foundation from the Lancaster's consumer choice theory, but also from the random utility theory developed by McFadden in 1974. Thus, in any CE, households are asked to select an alternative option from many choices, which are provided according to their characteristics and the levels they take. According to random utility theory, a utility function comprise of a deterministic and a random component (McFadden, 1974; Arnot et al. 2006; Ndunda and Mungatana, 2013). In most cases, the researcher is able to observe the deterministic factors but the unobservable factors are captured in the random component of the utility function. Thus, the utility U associated with individual n whose choice is alternative i is given by:

$$U_{in} = V(Z_{in}) + \varepsilon(Z_{in}) \qquad (1)$$

where $V(.)$ is the deterministic component and $\varepsilon(.)$ is the error component in the utility function. The probability of individual n choosing alternative i from a set of alternatives J can be estimated using conditional logit model (CL) (Greene, 2002; McFadden, 1974; Maddala, 1999) and specify as:

$$\Pr(Y_i = n) = \frac{\exp[V(Z_{in})]}{\sum_{j=1}^{J} \exp[V(Z_{jn})]} \qquad (2)$$

If $V(.)$ is taken to be a linear function of specific characteristics whose random error term is identically and independently distributed (IID) with a type 1 extreme value (Gumbel) distribution, the conditional indirect utility function becomes (Ndunda and Mungatana, 2013; McFadden, 1974; Arnot et al. 2006):

$$V_{jn} = \delta_j + \sum \beta_{jk} Z_{jk} + \sum \alpha_{jn} (M_n . \delta_j) \qquad (3)$$

Where δ_j is an alternative specific constant, Z_{jk} is the k characteristic value of the choice j; β_{jk} is the parameter allied to the k characteristic, M_n is the socio-economic characteristic vector of individual n and α_{jn} is the vector of the coefficients related to the individual socio-economic characteristics.

The Choice Experiment Design

This study assessed the households' preferences towards diverse characteristics of fish reared with different sources of water, including wastewater. The primary step of the research was to select applicable attributes, which was based on a literature review and in collaboration with local partners. Given the difficulties associated with the exact changes in the attributes' features, the levels of choices were qualitatively presented. The price levels used for the choice experiment were provided by the local partners and based on current market prices. Table 20 presents all the possible combinations considered for the choice experiment. Considering a fractional-factorial design 21 choices were generated (of the full-factorial choices 3*4*2 = 24) which were further classified into choice sets having three alternatives from the choices designed and another alternative as '*opt-out*'.

Table 20: Selected attributes for the compost choice experiment

Attributes	**Number of Levels**	**Description**
1. Price (INR/kg)	3 [120, 250, 350]	Price of fish per kg
2. Source information of product (SOURCE)	4 [none-N; farmed freshwater fish-FFF; wastewater fed-fish-WWF; wild fish-WF]	Product carries information regarding its origin (production system)
3. Certification for quality (CERT)	2 [yes, no]	Product carries a label issued by a third party assuring that the product was inspected throughout the production process for safety and quality.
*The levels are indicated in the parenthesis.		

An experimental design technique was used for the final design (Louviere et al. 2000) and implemented with the SAS software. Pair-wise combinations of attributes were randomly blocked to six groups of six choices using a blocking factor. Therefore, each of the randomly selected household was presented with a six choice set, as shown in the example of choice set (Table 21). The respondents were required to indicate their preferred choice on each choice set, which contained alternatives A, B, C and D (status quo) "no change" option. The respondents were provided with a detailed description of the wastewater-fed fish and benefits of purchasing this type of fish for household consumption.

Table 21: Example of choice set presented to households and businesses

Fish Attributes	**A**	**B**	**C**	**D**
Price (INR/kg)	250 INR/kg	120INR/kg	10INR/kg	If options A, B and C were all that was available at my local market I would not purchase any of them
Source	Farmed Freshwater Fish	None	Wastewater fed-fish	
Certification	Certified	Not certified	Certified	
I would choose	o	o	o	o

The choice experiment survey was conducted in 2013 in Bangalore among 93 households randomly selected in various locations of the city. To iterate, although a sample of 93 households were interviewed in Bangalore for the final data analysis 89 households were selected since 4 of the households were found to have inconsistent choices or protest bids. Therefore, the total valid observations that were generated for the choice model estimation was 2492 (28*89). Sixty (60) businesses were also interviewed and their WTP elicited via the same methodological approach.

3.3.1.3 Results and Discussion

This section presents the results of the analyses, providing background information of the respondents, their perceptions and knowledge on the wastewater reuse for aquaculture and their evaluation of potential health and environmental impacts of wastewater-based aquaculture. Subsequently, the choice experiment results are presented with a focus on estimating the willingness to pay (WTP) for two main attributes wastewater-fed fish - Tilapia. Subsequently, results from the regression analyses used to evaluate factors that influence households' fish purchasing decisions are presented.

- **Socio-economic characteristics of households and businesses**

Households: In this sub-section, we present a brief background of households in the study area. The aim of this sub-section is to highlight the socio-economic backgrounds of the households, but this information would be useful for the subsequent sections, especially when reporting about WTP and the influence of these variables on the mean WTP. The average age of the respondents was 42 years ranging from a minimum of 22 years to a maximum of 96 years. The majority of respondents were males (71%). The average household size was 3.7 persons. The average annual income from farming activities was Rs.49227/- while the average annual income from non-farming activities Rs.800444/-. Then the average annual income from both farming and non-farming activities was Rs.664134/-.

Table 22: Socio-economic characteristics of households

	Urban high-income household	Urban low-income household	Rural household
Average household size	3.75		3.86
Average annual income (Rs./year)	885366.67		86655.17
Average fish consumption (kg) per year	0.95	1.75	9
Average total expenditure (Rs.) per year each house	1465	401	219.6

Businesses: The number of enterprises respondents was 60. The enterprises mainly comprised of fish markets, hotels and other markets. Most enterprises interviewed were on an average more than two decades old. Only 27% were marketing their fish product through posters and about 8% through word of mouth, while the rest did not use any method for marketing their products. About 83% were not contracting out the supply of inputs to the fish farmers and only the remaining 17% were doing so. Almost 80% operated with a license to sell fish. However about 97% were not interested to get a license to certify that the fish they sell or use was safe and of a high quality.

- **Households' and businesses' fish preferences and consumption patterns**

Households: The households sampled for the study were interviewed only if they consumed fish. In regard to the prevalent consumption patterns, no household (urban or rural) was currently consuming wastewater-fed fish. About 91% respondents were consuming fish with *Rohu* and *Catla* being the most popular fish varieties consumed. Almost 68% were not concerned about the source (medium in which the fish was raised in) of the fish. About 55% believed they knew the source or rearing technique of the fish they consumed. Of this, 85% noted that these were farmed fish while 15% thought these were wild fish. Almost 98% of them stated that they were unaware of any labelling or quality of fish they purchased. To further assess the confidence of the households in the quality of the fish purchased and their perception about comfort from different sources, the respondents were asked to rank the sources. The following tables (Table 23 and Table 24 respectively) shows the ranking of the households for different sources based on their perception about the quality of the fish and how much are they comfortable purchasing from those sources. The tables indicate that while the households are more

comfortable in purchasing fishes across different sources, they are confident in the quality of the fish when purchased from fish farmer, mobile vendor or the open market (34-35% of the respondents ranked these sources comparatively higher than the other sources). The respondents were asked to rank their preference given the location or the source of fish purchased. Of this about 62% were not willing to buy from the fish farmer while only about 32% preferred buying directly from the fish farmer. Further, about 50% preferred buying from wholesalers, with 40% did not and the remaining 10% undecided. For purchasing from the mobile vendors, 62% were in favor of this option whilst 30% were not. About 60% were in favor of purchasing from open markets.

Table 23: Household's preferences for sources in terms of their confidence on quality

	Respondents' evaluation of statements (ranking: 1 - mostly disagree to 10 - mostly agree)								
	1	2	3	4	5	6	7	8	9
Location/source	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**
Fish farmer	11.8	4.3	7.5	3.2	6.5	2.2	10.8	6.5	34.4
Wholesaler	11.8	4.3	6.5	5.4	8.6	4.3	10.8	7.5	28.0
Mobile Vendor	4.3	11.8	5.4	2.2	7.5	7.5	6.5	7.5	34.4
Open market	6.5	7.5	4.3	3.2	6.5	5.4	9.7	6.5	35.5
Other	14.0	-	-	2.2	5.4	1.1	1.1	5.4	30.1

Table 24: Household's preferences for source/location for purchasing fish

Location/source	**Respondents' evaluation of statements (ranking: 1 - mostly disagree to 10 - mostly agree)**								
	1	2	3	4	5	6	7	8	9
	% of surveyed respondents	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**
Fish farmer	3.2	2.2	2.2	1.1	1.1	-	2.2	1.1	17.2
Wholesaler	2.2	1.1	3.2	-	2.2	1.1	2.2	-	14.0
Mobile Vendor	2.2	3.2	2.2	1.1	-	1.1	-	2.2	14.0
Open market	2.2	3.2	2.2	-	-	-	1.1	3.2	14.0
Other	4.3	-	-	1.1	-	-	1.1	5.4	14.0

Businesses: Of the total respondents, 77% had consumed or used fish in the past. About 39% each stated that they typically used the fish in raw and fried forms. Almost 55% of the respondents said they knew the sources of the fish they consumed and most of them said they were wild fish. Almost all the respondents stated that the fish they purchased did not have any labelling or certification in any form to indicate its quality. In regards to location/source of purchase of fish, the respondents were asked to rank their level of confidence across different choices. Among these, most respondents preferred to buy directly from the fish mobile vendors (75%), and from farmers (61%). However, lower preferences (in terms of percentage) were attributed to wholesalers and open market. Additionally, when asked about whom they would prefer purchasing treated wastewater fed fish from, there were only a few responses. In general there was a clear reluctance on buying wastewater-fed fish. Of the

factors influencing purchasing decisions, 66% were neutral on pricing and 52% neutral on convenient location to buy, but 74% agreed on type of fish species and 46 % agreed on packaging. 79 % strongly agreed for quality/safety of fish product is very important. However, the proposal for labelling or certifying the fish (either from a government or a private agency) for purchasing did not incentivize significant interest from them.

A majority of the respondents (about 69%) strongly disagreed that they could distinguish between the different types of farmed fish from appearance while almost every respondent (100%) was unsure (neutral) that they could distinguish between different types of farmed fish by taste. All respondents were uncertain (neutral) about the fact that wild caught fish tasted better than farmed fish. The respondents largely remained uncertain (neutral) on fish species knowledge, fish product procession, and trust in retailer as the relevant for choice between wastewater fed fish, freshwater fed fish and wild fish, respectively. About 70% strongly agreed that freshwater fed fish was safer than wastewater-fed fish, while they were unsure (neutral) whether wild fish was safer than either wastewater-fed or freshwater-fed fish. A majority of the respondents had no appropriate information or opinion (remained neutral) on the fact that fish sold in the markets were all free from chemical preservatives (65%), fish sold in the markets were all cultured in toxin free environment (100%), that fish sold in the markets were all free from additives and colours (97%), that trust information that one received about fish from the government more than other sources (80%), and that farmed fish was better for fish conservation (85%).

However, about 36% disagreed and 10% strongly disagreed that they were worried that one could lose business if customers or other fish retailers found that they used or sold wastewater fed fish even if it was safe and of high quality. Thus, suggesting that the enterprises did not perceive a threat to their current business from the sale or use wastewater fed fish. Broadly, the enterprises too in general, evoked responses indicating that they were unsure (neutral) on many aspects with respect to their business (fish) while still being able to sell them. This suggests the need for better awareness of the products that these enterprises would sell. The enterprises revealed that only 3% of the respondents had any kind of bad experience in consuming fish, in the past. Further, they had not received any complaint from any of their consumers from the consumption of fish or foods prepared from the fish they purchased.

- **Knowledge, Attitude and Perceptions about fish and product information**

Households: This analysis utilized fourteen questions and asked the respondents to rank these statements according to their preferences. About 75% (considering respondents who agrees and strongly agrees) of the respondents believed farmed freshwater fish to be much safer than wastewater-fed fish. The respondents were found to be neutral on aspects related to wild-fish. The respondents were not aware whether wild fish tasted better or was safer than farmed fish (i.e. wastewater-fed fish, freshwater-fed fish). About 65% of the respondents reported that they are unable to distinguish between fish species and 50% of the respondents were unable to distinguish them by taste. However, more than 40% of the respondents felt that fish sold in the markets are not free from chemical preservatives or cultured in toxin free environment. Similarly 30% of the respondents noted concerns related to diseases from fish. Overall, although the respondents were found to have lower awareness in most of the aspects evoking mixed results. These findings emphasized the need for a better awareness for the consumer on a variety of these aspects.

Table 25: Attitude, knowledge and perception of households regarding fish and fish products

Statement	**Respondents' evaluation of statements (ranking)**				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

	% of surveyed respondents	% of surveyed respondents	% of surveyed respondents	% of surveyed respondents	% of surveyed respondents
I can distinguish between different types of farmed fish from the look	45.2	20.4	14.0	8.6	2.2
I can distinguish between different types of farmed fish by taste	31.2	19.4	17.2	20.4	2.2
Wild-caught fish taste better that farmed fish (i.e. wastewater-fed fish, freshwater-fed fish)	8.6	16.1	47.3	16.1	2.2
Fish species knowledge is relevant for choice between wastewater-fed fish, freshwater-fed fish and wild fish	8.6	18.3	45.2	12.9	5.4
Fish product processing is relevant for choice between wastewater-fed fish, freshwater-fed fish and wild fish	5.4	19.4	43.0	19.4	3.2
I think that freshwater-fed fish is safer than wastewater-fed fish	0.0	3.2	16.1	28.0	43.0
I think that wild-fish is safer than either wastewater-fed or freshwater-fed fish	0.0	11.8	47.3	20.4	9.7
I believe that fish sold in the markets are all free from chemical preservatives	3.2	41.9	31.2	12.9	1.1
I believe that fish sold in the markets are all cultured in toxin free environment	2.2	40.9	33.3	14.0	0.0
I believe that fish sold in the markets are all free from additives and colors	0.0	32.3	41.9	15.1	1.1
I am worried about the current level of risk for food-borne diseases from fish	1.1	15.1	38.7	29.0	6.5
Trust in retailer is relevant for choice between wastewater-fed fish, freshwater-fed fish and wild fish	1.1	7.5	47.3	28.0	6.5
I trust information that I receive about fish from the government more than other sources (e.g. private certification)	0.0	9.7	44.1	25.8	9.7
Farmed fish (wastewater-fed and freshwater-fed fish) is better for fish resources conservation	0.0	5.4	52.7	23.7	6.5

Businesses: The only unanimous result from the KAP analysis is that the respondents preferred freshwater farmed fish over wastewater and wild fish. Nearly 70% revealed that they are unable in distinguishing different types of farmed fish from its look and most of the respondents were not worried about the current level of risk for food-borne diseases from fish (73%). However, about 26% disagreed that all fishes sold in the market are free from chemical fertilizers. The respondents were mostly indifferent over the different issues implying a lower awareness among them.

Table 26: Knowledge, Attitude and practices of the enterprises

Statement	Respondents' evaluation of statements (ranking)				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	% of surveyed respondents	% of surveyed respondents	% of surveyed respondents	% of surveyed respondents	% of surveyed respondents
I can distinguish between different types of farmed fish from the look	68.9	6.6	-	24.6	-
I can distinguish between different types of farmed fish by taste	-	-	98.4	-	-
Wild-caught fish taste better that farmed fish (i.e. wastewater-fed fish, freshwater-fed fish)	-	-	98.4	-	-
Fish species knowledge is relevant for choice between wastewater-fed fish, freshwater-fed fish and wild fish	-	-	98.4	-	-
Fish product processing is relevant for choice between wastewater-fed fish, freshwater-fed fish and wild fish	-	-	96.7	-	3.3
I think that freshwater-fed fish is safer than wastewater-fed fish	-	-	6.6	23.0	70.5
I think that wild-fish is safer than either wastewater-fed or freshwater-fed fish	1.6	1.6	96.7	-	-
I believe that fish sold in the markets are all free from chemical preservatives	8.2	26.2	63.9	-	-
I believe that fish sold in the markets are all cultured in toxin free environment	-	-	98.4	-	-
I believe that fish sold in the markets are all free from additives and colors	1.6	1.6	96.7	-	-
I am worried about the current level of risk for food-borne diseases from fish	18.0	73.8	6.6	-	-
Trust in retailer is relevant for choice between wastewater-fed fish, freshwater-fed fish and wild fish	-	11.5	85.2	3.3	-
I trust information that I receive about fish from the government more than other sources (e.g. private certification)	1.6	14.8	80.3	3.3	-
Farmed fish (wastewater-fed and freshwater-fed fish) is better for fish resources conservation	-	4.9	83.6	9.8	-

- **Factors influencing fish purchasing decisions**

Households: The households were asked to rank factors like price, type of fish, quality of fish, certificate label by government/private party, packaging and convenient location for purchase. Table 27 illustrates that quality is an important factor influencing the purchase decision (57% respondents ranked it highest) of the households followed by price (about 37% respondents ranked it highest). Forty percent (40%) respondents strongly agreed that price was the most important factor with only 7% strongly disagreed. About 42% were neutral on the type of fish as the most important characteristic, while only 19% strongly agreed as this was an important factor. Sixty-three percent (63%) strongly agreed that quality or safety of the fish product was the most important characteristic with 27% agreed to the same. About 46% were neutral when asked about the need for a label indicating the product certification by the government as the most important characteristic. Further, 49% remained neutral on product certification by third party (private) entities as the important characteristic. With regard to packaging as the important characteristic, 40% remained neutral, 26% agreed and only 10% strongly agreed that this was an important one. About 40% were unsure (neutral)

in asserting the location to buy the product while, about 33% agreed and only 19% strongly agreed that this is the most important characteristic.

Table 27: Ranking of factors that could affect households' purchasing decisions

	Respondents' evaluation of statements (ranking)				
Statement	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	% of surveyed respondents	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**	**% of surveyed respondents**
Price is the most important factor	6.5	10.8	17.2	19.4	36.6
Type of fish species is one of the most important characteristic	2.2	10.8	36.6	21.5	16.1
Quality/safety of the fish product is the most important characteristic	1.1	1.1	6.5	24.7	57.0
A label indicating that the product is certified by the government is the most important characteristic	5.4	9.7	41.9	18.3	15.1
A label indicating that the product is certified by a third party (private) is the most important characteristic	7.5	25.8	44.1	10.8	2.2
Packaging is the most important characteristic	8.6	12.9	36.6	23.7	8.6
A convenient location to buy the product is the most important characteristic	2.2	4.3	36.6	30.1	17.2

Businesses: Contrary to the belief that price would be one of the important factor influencing purchasing decisions, only 27.9% agreed to the fact while 78.7% strongly agreed that the quality of the fish is the most important characteristic followed by packaging (27%). Seventy-four percent (74%) of respondents agree that the type of fish species is important although not the most important characteristic influencing fish purchasing decisions. The respondents disagreed that a label from the government or the third party/private company to certify the product is important (44 and 60% respectively). Regarding location for purchases, about 50% of the enterprises were indifferent leading to mixed responses among them.

Table 28: Ranking of factors that affect purchasing decisions of the enterprises

Statement	**Respondents' evaluation of statements**				
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
	%	**%**	**%**	**%**	**%**
Price is the most important factor	3.3	3.3	67.2	27.9	--
Type of fish species is one of the most important characteristic		6.6	16.4	73.8	3.3

Quality/safety of the fish product is the most important characteristic	-	-	3.3	18.0	78.7
A label indicating that the product is certified by the government is the most important characteristic	19.7	44.3	16.4	19.7	-
A label indicating that the product is certified by a third party (private) is the most important characteristic	8.2	60.7	31.1	-	-
Packaging is the most important characteristic	1.6	1.6	27.9	45.9	23.0
A convenient location to buy the product is the most important characteristic	1.6	16.4	50.8	18.0	11.5

- **Willingness-to-pay (WTP) of households and businesses for wastewater-fed**

This section deals with the results of the choice experiments. A conditional logit (CL) model was used to capture the effect of various attributes selected for the model. Two models are presented in this section. The first model deals with the impact of the attributes on choice and the second one incorporates interactions between attributes and selected socio-economic variables as well as perceptions variables. The first model shows the importance of the attributes in explaining respondents' choices across four different options in a choice set. The second model is an extended model which includes the socio-economic variables interacting with the attributes. The dependent variable in the CL is choice of wastewater-fed fish. Respondents were given three packages of fish, with different prices, production and quality attributes and asked to choose one option. In total, we had 6 choice sets for each respondent. The key attributes selected for the CL model are: price, source and certification. It is hypothesized that the types of media used to rear fish, product certification and price will affect the demand for fish. The indirect utility from the proposed fish options with quality improvement would take the following form:

$$V_i = \beta + \beta price + \beta Source + \beta Cert$$

where V_i is the indirect utility for four alternatives; β refers to the alternatives specific constants and $\beta price$, $\beta Source$ and $\beta Cert$ are the coefficients associated with the attributes payment for quality fish with information on source and certification.

The second model utilizes interactions to get an idea about the variables which influences the decisions while the consumers make a choice. At the same time, socio-economic variables could not be introduced alone into the model since Hessian singularities could be encountered in model simulation (Bennett and Blamey, 2001). In this study, the socio-economic variable that have been used is the size of the household which is being interacted with the price attribute. This is considered as a proxy variable to consumption expenditure since data on expenditure was not available. It was shown in the previous section that there were mixed responses for the perceptions and awareness of the respondents and hence interactions with these variables were hypothesized could lead to further insights about the interactions between the perceptions and decisions. However, while estimating the conditional logit models we do not consider the alternative specific constant which is more appropriate for labelled choice experiments (the design of the choice experiment used for the study shows that it is unlabelled)

The indirect utility function in this case takes the following form.

$$\begin{aligned} V_i = \ & \beta + \beta price + \beta source + \beta cert + b1\ (source * fishspecies) \\ & + b2\ (source * concernaboutquality) + b3\ (price * certification) \\ & + b4(price * sizeofthehousehold) + b5(price * knowledgeaboutsource) \\ & + b6(price * priceasanimportantdecisionvariable) \end{aligned}$$

where source is classified into three sources – wastewater fed fish, wild fish and farmed freshwater fish and certification is further categorized as private and government certification (this is guided by preferences of the consumers towards certification which would influence their purchasing decisions). Having these additive forms of indirect utility specification, the CL model is estimated for the above. Table 29 presents variable, summary statistics and their respective definitions.

Table 29: Summary statistics of key variables in the conditional logit model

Variable	Definition
Source (s_fff, s_wwf, s_wf)	We considered that 'none'/no information accompanying the product as the base case and modeled the three sources. This would help in the derivation of the marginal values (utilities) derived from each of the sources given that they are provided with information. Therefore we estimate the coefficients for each of the three sources in the same equation.
fs * fff fs*wwf fs*wf	These variables are used as interaction variables where the knowledge of the households about the fish species is interacted with the three levels of the 'source' attribute.
qs_fff, qs_wwf, qs_wf	These variables are used as interaction variables where the quality of fish (perception variable governing purchase decisions of individuals) is interacted with the three levels of the 'source' attribute.
Cert_g_p Cert_p_p	The respondents were asked about whether they feel that a certification of the product is important for purchasing decisions. The variable of certification from government (cert_g) and the private party (cert_p) was interacted with the prices provided in the choice sets.
size_p	Interaction variable between the price vector and the size of the household
kn_sr_p	This variable was obtained through the interaction of the knowledge of the households about the fish sources with the prices
p_p	This variable was obtained by interacting the price variable with the perception variable of whether price is an important variable for influencing purchasing decision.

- **Households**

Table 30 provides the base and full CL model results. It has been explained before that there are 2492 observations which are being used for the estimation of the conditional logit models. The base model deals with only the attributes of product (along with its information) and certification while the full model considers both the attributes and their interaction variables. The table shows that the model estimated along with the interactions performs better in terms of goodness-of-fit as indicated by log-likelihood and McFadden-R^2 measures[19]. The comparison of the McFadden R^2 and the log-likelihood scores reveal that in both cases, model 2 is superior in explanatory power than model 1. In the CL for model 1, we record McFadden R^2 of 0.121 for model 1 compared to 0.2246 of model 2. In addition the log-likelihood value also decreases which points to the improvement of the model. The coefficient of price is negative and highly significant (p=0.000), in both the models which holds with prior expectations that price and probability of fish purchase would be negatively correlated. This result is consistent across all two models (Table 30). The negative sign of the payment coefficient indicates that the effect on utility of choosing a choice set with a higher payment is negative. In other words, scenario improvements with 'cheaper' alternatives are preferred to 'expensive' alternatives. All the coefficients of the attributes are significant at 1% level and the signs of attributes are as expected.

With the base model for freshwater fish, households appreciate farmed freshwater fish along with its origin being mentioned and also have a positive willingness to pay for certification. However, the consumers are not willing to pay for wastewater-fed or wild fish having the information of the source. This is confirmed by the sign of the coefficients and all these variables are highly significant. Similarly in

[19]As a rule of thumb usually McFadden R^2 value for an estimated model is considered better if it is between 0.2 and 0.4.

the second model, the coefficients of the attributes have the same signs and are significant excepting that of the wastewater fed fish. The negative signs for the wastewater-fed fish and that of wild fish reflects that consumers were concerned about the health concerns that might arise from consuming wild or wastewater-fed fish when making a choice. The negative signs of the wastewater-fed and wild fish is carried forward to the interaction variables. The knowledge of the fish species interacted with the wastewater and wild fish comes to be negative as well as quality of the fish implying the consumers who are aware about the fish species they consume or are conscious about quality are not willing to pay for wastewater fed fish or wild fish. We observe that the consumers are willing to pay for certification of the fish in both the models. However, as had been previously explained that consumers are more inclined in certifications obtained through the government, it is also confirmed through the models estimated. The second model shows that the coefficient of the certification from the private party has a negative coefficient implying lower preferences compared to the government certification.

In addition the results also revealed from the interaction model that if the consumers are aware about the sources they are willing to pay lower prices for the products. Similarly as the size of the family increases and there are higher consumption expenditures incurred, respondents have a lower WTP as also the consumers who feel that price is an important variable for making any purchasing decisions.

Table 30: Conditional logit model for wastewater-fed fish

Base model1			**Full model2**	
Variables	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
Price	-0.0031***	0.004	-0.0026**	0.001
s_fff	0.965***	0.083	0.578***	0.115
s_wwf	- 0.7094***	0.148	- 0.292	0.182
s_wf	- 0.866***	0.138	- 0.668***	0.180
cert	0.293***	0.091	0.363***	0.097
fs_fff			1.124***	0.180
fs_wwf			-1.506***	0.463
fs_wf			- 0.216	0.349
qs_fff			0.281	0.184
qs_wwf			-0.390	0.360
qs_wf			- 0.254	0.342
Cert_g_p			0.009***	0.001
Cert_p_p			-0.004***	0. .001
kn_sr_p			-0.0016**	0.001
size_p			- 0.0004	0.0002
p_p			- 0.003***	0.0007
Log-likelihood		-759.037	Log-likelihood	-669.706
McFadden R^2		0.1211	McFadden R^2	0.2246
LR chi^2 (5)		209.25	LR chi^2 (16)	387.91
Prob. > Chi^2		0.000	Prob. > Chi^2	0.000
Number of obs.		2492	Number of obs.	2492

- **Marginal willingness to pay for different attributes of fish**

The results from the CL models were used to estimate the rate at which consumers are willing to trade-off one attribute for the other (Table 31). In the CL model, there are monetary considerations for the scarified attributes and the trade-off estimated is known as marginal willingness to pay for the attribute in question (Bennett and Blamey, 2001; Agimass and Mekonnen, 2011). It indicates the amount of money households are willing to pay for an improvement in the environmental attribute. It is important to know that marginal willingness to pay analysis could play a significant role in business decision making and policy making as well. Basically, the comparison of the marginal WTP of different attributes provide some understanding of the relative importance of attributes. With this type of information, decision makers will be better placed to design resource use alternatives (Agimass and Mekonnen, 2011).

In Table 31 below, the WTP is calculated as the negative ratio between the coefficients of an attribute to the price coefficient. On average, households are willing to pay more for freshwater fish than other sources. Also households are also willing to pay more for certified fish. The table below considers both the model to estimate the WTP of the attributes and the levels. The second model corrects the WTP values of the levels of the source attribute which is overestimated in the first model. However, since we consider the second model a better fit, the WTP for certification should be considered form the second model. From the primary data it is observed that urban households buy the following freshwater and wild fishes at the following prices (Table 32). Although estimation of the WTPs for wastewater-fed fish and the wild fish is negative and has no economic meaning excepting the fact that there exists a negative utility form the consumption of these fishes, we would utilize the values in the following to estimate the actual WTP for the species later.

Table 31: Marginal WTP estimates for fish attributes

Payments for different attributes of Fish by the households	**Model 1**	**Model 2**
Willingness to pay source_freshwater fed fish (INR)	305.81	217.25
Willingness to pay source_wastewater fed fish	- 224.74	- 109.63
Willingness to pay source_wild fish	- 274.54	- 250.97
Willingness to pay certification (INR)	92.82	136.35

In the table below, the WTPs for different prices given the market prices of the fish species and also the WTPs form the household survey were also calculated. The results show the market price faced by the consumers for freshwater and wild fishes. The results are combined with the results from the choice experiments to obtain prices for information and at the same time total payments for fish with information and certification is estimated. We derived the price of information for the fish product as Rs.37.25, which is obtained from the fact the households are willing to pay Rs. 217.25 for fish with information and the present price revealed is Rs. 180 for farmed species. Hence the difference provides an estimate of the marginal utility (price payable) for information. The choice experiment results show that the consumers are willing to pay Rs. 136.36 for certification. Thus the total payment offered by the consumers for fish which is farmed and is provided with information and certification is Rs. 353.60/Kg.

The choice experiment results show that consumers derive a negative utility from wastewater-fed fish and wild fish in terms that consumers perceive about health problems in consuming the fish. However, since the choice experiment with different fish sources was conducted on the same sample, we can approximate the WTP obtained for information as Rs37.25 is homogenous across the individuals. The primary survey shows that wastewater fish is presently not being consumed by the households. In absence

of the revealed preference data an approximate price of wastewater fed fish with information about the source and certification is Rs 173.6/Kg (which considers only the information price and certification price). The negative utility and its valuations needs to be considered here i.e. (-) Rs.109.63. The actual payment for wastewater-fed fish among the consumers would thus be Rs. 63.97/Kg. (173.6-109.63) making adjustments for their perceptions about health concerns. Similarly, in the above table we make the adjustments for calculating the WTP for different wild species. The prices reflect the revealed prices along with the information and certification costs attached to it.

Table 32: Marginal WTP estimates for fish attributes

Fish Species	Market Price (INR/Kg)	WTP along with information (INR/Kg)
Freshwater fish		
Rohu	180	The WTP for farmed fish with information is Rs. 217.25. The WTP for information is Rs.37.25. Total price for farmed freshwater fish with information and certification is Rs. 353.60 (217.25+136.35).
Katla	180	
Wild fishes		
Angel	600	523.6
Bangda	140	63.6
Prawns	800	723.6
Seer	1000	923.6
Promphet	800	723.6
Mullet	420	343.6
Surmi	600	523.6

Overall, it is quite evident that consumers prefer farmed freshwater fish rather than wastewater-fed fish and wild fish. In fact, households are reluctant to totally substitute farmed fish for wild fish or wastewater fish as they perceive that continued consumption might lead to health issues. The primary survey reveals that consumers do consume wild fish but consumption is relatively lower than farmed freshwater fish. The consumers reveal that if they have to substitute freshwater fish for wild fish or wastewater-fed fish, the payments for information and certification although being positive will definitely result in a lower price (whether there exists market price or not as shown in Table 32 and explained above).

- **Businesses**

In this section we estimated the willingness to pay of the enterprises for fish from different sources and that they have the information about the source and that they are certified. We derived the prices based on the percentages of the choices for a particular attribute and its level in the choice set. The percentages of the choices were considered as the weight (probability) of that choice and the estimated (average) value was obtained by multiplying the prices with the probabilities. Subsequently, the maximum prices were considered which reflects the maximum change in utility and hence maximum payment for an attribute.

Table 33: Marginal WTP estimates for fish attributes by businesses

Attributes with different level combination	WTP (Rs/Kg.)
Farmed freshwater fish with information and which is certified	237.3
Farmed freshwater fish with information but not certified	117.96
Fish with no information on source but certified	94.85

The above table shows that the estimated price of the farmed freshwater with information about source and certification is Rs. 237.3/Kg. This is lower than that elicited by the households (Rs. 353.6/Kg). The enterprises have a WTP of Rs.94.85 – Rs.119.34 for certification. Thus the value for certification for the two segments is similar (considering the maximum value) which makes it one of the reason to utilize the other WTPs from the household survey as a WTP for the enterprises. To iterate, the choice experiment with the enterprises reveals that business selected options with farmed freshwater fish and discarded wild and wastewater fed fish. This leads to a similar conclusion as that of the households. However, it cannot be stated with certainty about the magnitude of the negative disutility for wastewater and wild fish among the enterprises. The present study therefore proposes the values determined from the household survey as the WTP for wastewater and wild fish species for the enterprises. It is hypothesized that since the households and the enterprises face similar market situations, such WTPs are comparable across the two market segments. Two important reasons to make such a hypothesis about the two market segment is because -

- **Market prices for freshwater fish** - The primary data reveals that both these groups face similar market prices for farmed freshwater fishes (and for same species) within a range of Rs.150-200. This implies that the existing market structure is similar and results from the above table also closely resembles that of the household survey.
- **Tastes and preferences** - The enterprises do not consume wastewater-fed fish and relatively more enterprises have selected farmed freshwater fish as an option over wastewater and wild fish which is also similar to the household preferences. The hotels and eateries cater to the customers who in turn are the households and we assume a representative sample (of household) had been considered for the study. Therefore the decision of the households also gets reflected when we are analyzing choices of the enterprises.

Thus the prices for the wastewater fish (as derived for households) is Rs. 63.97/Kg. The price for different wild fish species would be as those obtained for households.

- **Estimated market demand for wastewater-fed fish by households and food service businesses**

The total number of households in Bangalore is estimated at approximately 2.1 million. Assuming an estimate of 98% of urban households and 3.5% of rural households are willing to consume wastewater-fed fish, the total potential market size is estimated at 13, 275 tons/year. A key aspect here is the very high willingness to use wastewater-fed fish by the urban compared to the rural households. The lower willingness by rural households is attributable to the fact that the majority of the fish they consume is harvested in the neighbouring tanks that they are familiar with. However for the urban dwellers, they are not aware where the fish is harvested. Thus, if a proper marketing strategy is developed based on the WTU and WTP results, focusing on the appropriate segments of households, the market demand for fish harvested from treated wastewater can be met reasonably. The composition of the total estimated demand reveals that a substantial chunk of the demand would emerge from urban households and the rest is accounted by rural households, which constituted a very negligible share. Given these, it may be appropriate to target this RRR product primarily at urban households.

Table 34: Potential demand for wastewater fed fish from households and businesses in Bangalore

	Percentage of respondents willing to consume and pay for wastewater-fed fish	Total number of households[20]/ businesses[21]	Number of potential households/ businesses	Average consumption kg/year[22]	Total market size tons/year
Urban households (low-, middle- and high income)	0.98	1,814,433	1,778,144	31.00	55122.46
Rural households	0.035	339,157	11,701	9.00	105.31
Businesses	-	15,636	-	-	
					55227.77

3.3.2 Market Structure

3.3.2.1 Background and Justification

As with the market structure assessment of the other business models, the sustainability of any entity engaged in wastewater reuse requires it to understand the market in which it operates. In the case of wastewater use for aquaculture, the fish (freshwater fish)market was evaluated to understand the characteristics of the market structure (i.e. level of competition in the market, characteristics of competitors and factors driving market competitiveness and collusiveness) in order to guide potential investors' decisions. The business model considered here has the key end-product of wastewater-fed aquaculture; and the analysis is conducted from that perspective. It assesses the market structure of the fish market, in light of identifying key external (market) and internal factors which will drive the sustainability of wastewater-fed fish businesses. It is important to note that the analysis is limited in its assessment due to data limitation which resulted in the assessment been done from a national perspective rather than that of the city. The key findings are however applicable to Bangalore as the majority of wastewater reuse in any form will most likely occur in the wastewater treatments.

3.3.2.2 Research Methods and Data Collection

Similar to the other business models, the structure-conduct-performance (SCP) approach was used in this assessment with a focus on the fish (freshwater) market. Details of the approach are outlined in the methodology section in chapter 2. The SCP approach typically measures how the market structure of industries vary, how different market structures influence the market conduct of firms and how their conduct influence their market performance. As per the objective of the study, inferences will be drawn to describe the potential feasibility of wastewater-fed fish (WWF) businesses in Bangalore, India. The SCP approach measures the structure of the market, the conduct and performance (profitability) of the relevant economic actors through the use of different indicators.

[20] Based on 2011 Census, Primary Census Abstract. Households in Bangalore Rural and Bangalore Urban district.
[21] Based on District at a Glance, Govt. of Karnataka.
[22] Market Survey,2014

- **Structure:** The market structure of the fish market is assessed based on the level of market concentration in the industry, for which data were extracted from already published findings due to unavailability of data on market share of different actors. Additional market dimensions, such as barriers to market entry and exit were also evaluated.
- **Conduct:** The conduct of the players is assessed by their price setting behaviour, factors or determinants of pricing of the water market, buying and selling practices and distribution strategies of actors.
- **Performance:** The performance along the supply chain was evaluated, via the assessment of indicators such as revenue generation, service cost coverage of service providers.

The study reported in this report used both primary and secondary data. Survey method was used to collect information from key players in the supply chain of the competing products listed in Table 35. The sampling units were the organizations which participate in their supply chain. For the other products a convenience sampling[23] based formal survey was conducted. The following table indicates the target respondents for the competing traditional product for the key RRR products considered.

Table 35: Competing traditional products and targeted respondents

Competing traditional product	Respondents
Fish in the market	Fish sellers; Supermarkets; Fish harvesters

A scoping study for the different markets was conducted to understand the different players. In places where the number of formal players was limited and the variability in the expected outcomes was marginal the sample size was restricted to a small number. The fish market is quite diverse and the market players are quite large in number. The sample size was set such that the variability in the market could be captured. A sample of a total of 30 fish sellers, producers and supermarkets were interviewed for the market structure assessment.

3.3.2.3 Results and Discussion

- **Assessment of the Market Structure, Conduct and Performance**

The fisheries market in Bangalore has always been a simple demand-supply driven market. There seems to be a two stage supply chain (wholesaler and retailer) in the fish business in the study area, although the distinction between the two stages are at times not very well defined. Bangalore imports fish from various coastal parts of India such as Mangalore, Chennai, Orissa, and Visakhapatnam. There are two major customer segments, namely the households and the hotels and restaurant businesses. Many of the fish retail shops source their produce from Shivaji Nagar fish market in Bangalore; and some of the retailers source their produce directly from outside distributors. The supply chain of this market is as shown in Figure 9 below:

[23]Since many of the respondents were not willing to share information on their business practices convenience sampling strategy had to be adopted.

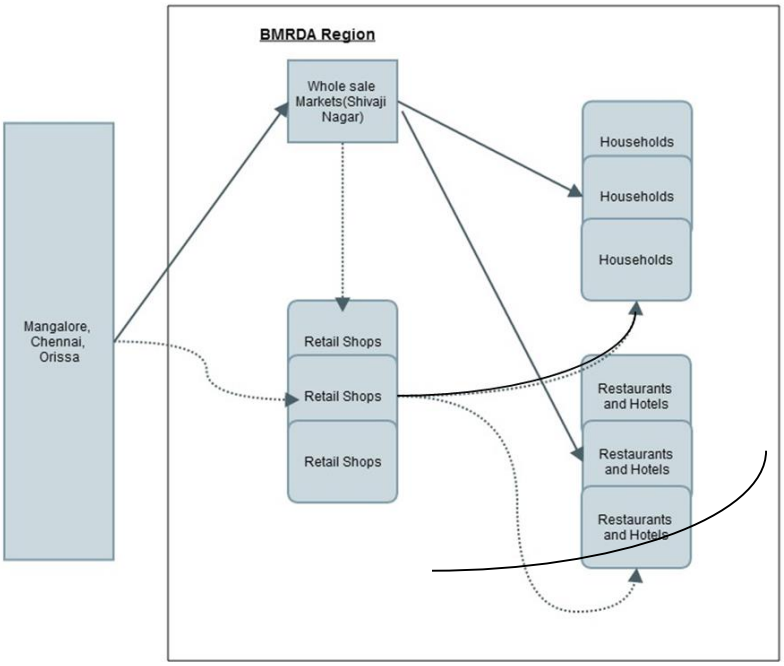

Figure 9: Supply Chain of the Fish Market in BMRDA region

➢ Market structure

- **Market concentration:** The approach to selling fish in the market seems to be segmented into the organized retailers at established multiproduct retail outlets and the more unorganized retailers. The organized retail outlets such as METRO and HyperCITY differentiate themselves by getting the HACCP (Hazard analysis and critical control points) certification. All the retailers tend to provide additional service by way of home delivery, cutting & cleaning and guaranteed replacement for stale items. The *Herfindahl index for* the fish retailers is 0.12 indicating that no player has a significant market power.
- **Product differentiation:** The product is differentiated based on the water in which they are bred (sea water vs. fresh water) and also the fish species. From the service perspective the fish retailers differentiate themselves based on value-added services such as SMS service, home delivery, and purported freshness of the fish being sold. Some of the retailers replace the fish sold if found to be of bad quality.
- **Market integration:** Four-wheelers are the main mode of transportation used in this market, while two wheelers are used for home deliveries. Delayed supply and disposal of waste are the major issues faced by the market players. The main mode of communication used by the market players are telephone, though a select few also use e-mails. Some of the retailers have faced issues with the delivery lead times. There is some scope for price negotiation and NET-D terms of payment are sometime extended. The perishable nature of the product can create problems for the retailers. This issue has been specifically indicated by some of sampled respondent.
- **Barriers and drivers for entry:** Most of the retailers used their own funds in starting their fish retail business. The respondents did not explicitly identify any unique entry barriers for this business. However there is a government regulation against the sale of any meat and fish on Gandhi Jayanthi and Sivaratri days. A trade license issued by the government is required for this business with nearly 40% of the sampled respondent indicating the difficulty and complications involved in acquiring this license. Almost all the respondents were not aware about any subsidies being given by the

government although the Department of Fisheries, Karnataka offers subsidies for reconstruction of fish markets, purchase of inputs for marketing fish and various welfare schemes. Increasing number of malls and established retail stores have been cited as a major threat to small and unorganized retailers.

- **Market Conduct**

- **Pricing**: Most of the retailers and wholesalers follow the market price in pricing their fish produce. One of the retailers sampled gives a 10% to 15% discount to penetrate the market. Bargaining seems to be a very common practice in this business.
- **Promotion and Marketing:** The fishing industry in Karnataka is very fragmented on production and supply side though there is large demand for the fish in the state. Around 50% of the sampled respondents indicate that they have a marketing and promotion budget. Some of the respondents noted providing price breaks during weekends as the sale increases during the weekends.

- **Market Performance**

- **Profitability**: All the respondents indicated that their business has been profitable ((4 in a scale of 1 to 5). Exact number on profit margins was not revealed by the respondents.
- **Payback period**: The initial investments were recovered in a period of about 2 to 4 years. Others could not be persuaded to respond to this question.
- **Business growth**: Data on business growth was not available.

- **Implications for wastewater-fed fish businesses**

The introduction of wastewater-fed fish in the market would affect existing fish businesses based on its pricing and acceptance of this fish by the consumers. Although there are no major entry barriers, if introduced through penetrative pricing, the market for fresh water fish could be affected and depending on how the market matures, local fish sellers would prefer wastewater-fed fish over freshwater fish that needs to be obtained from the neighbouring places/tanks over locally available wastewater-fed fish. Although the fish bred in wastewater ponds are already in the market in select areas, customers seemed to resist the idea when explicitly stated. The market is highly dispersed with no clear leader indicating the possibility of making space for them if the perception roadblock could be addressed.

3.3.3 Market Outlook

Similar to the market structure assessment, the market outlook analyses for wastewater-fed fish will be conducted from the freshwater fish perspective.

3.3.3.1 Background and Justification

This sub-chapter presents the results of the market outlook assessment of the wastewater-fed fish (WWF) business model. The assessment is viewed from the end-product, fish, and uses the freshwater fish sector as the base. The forecasting of WWF demand is a projection of demand levels in the future, based on current or past evolutions. The role of market or demand forecasting will aid business development management in planning into the future. Because investment toward an uncertain future is very difficult and risky, market forecasting will help alleviate the risk and obtain more accurate or reliable information. Market forecasting will be helpful for future investors in wastewater reuse for aquaculture in making

strategic decisions on product pricing, future capacity requirements, and implementation of other innovative business strategies, etc. An assessment of the market outlook and trend will provide greater clarity on anticipated market growth and will better inform investors on which strategic investment decisions to make. Thus, the key objective of this analysis is to assess the market potential for wastewater-fed fish demand by forecasting future demand, identifying possible gaps in supply and policy opportunities in Bangalore, India. As with the market structure assessment, it is important to note that the analysis is limited in its assessment due to data limitation.

3.3.3.2 Research Methods and Data Collection

As with the other business models, the Bass model (1969) was used to assess the market outlook for wastewater-fed fish given data limitation. The model took into consideration the probability of purchase given that no previous purchases were made and the total number of potential buyers as parameters reflecting the rate of diffusion and the initial probability of first-time purchases (Proctor, 2000). A variant of the discrete time bass model function was applied. Satoh (2001) justified the adoption of the discrete time model when data used is discrete, as the Bass model is a continuous-time model. Satoh (2001) further noted that the discrete Bass model conserves the characteristics of the Bass model because the difference equation has an exact solution. Therefore, the discrete Bass model enables us to forecast the innovation diffusion of products and services without a continuous-time Bass model.

$$f(t) = \frac{\frac{(p+q)^2}{p} e^{-(p+q)t}}{\left(1 + \frac{q}{p} e^{-(p+q)t}\right)^2}$$

$$F(t) = \sum_{i=0}^{t} f(i)$$

$$A(t) = M\ F(t) \text{ and } a(t) = M\ f(t)$$

The optimal time to peak sales is given by:

$$\frac{\ln\left(\frac{q}{p}\right)}{p+q}$$

Other variables in the Bass Model which are calculated from M, p, q and t, are:

f(t): the portion of M that adopts at time t.
F(t): the portion of M that have adopted by time t,
a(t): adopters (or adoptions) at t and
A(t): cumulative adopters (or adoptions) at t.

The most critical determinants of the model are innovation and imitation coefficients p and q and the potential market size of the market for wastewater-fed fish. In the absence of already available data on the p and q for this product, the study made use of an average estimation of those coefficients as per the findings of Sultan at al. (1990). Low diffusion rates (low switching behaviour) were assumed because although the Bangalore population is unaware of the source (medium in which fish was reared) of the fish they consume, they may be initially hesitant to consume wastewater-fed fish. Accordingly, the assumed estimate of p used was 0.003 and q, 0.5. Additionally, the total (p + q) is assumed to lie between 0.3 and

0.7.There exists scarce data on fish consumption in Bangalore city. The freshwater fish market was used as a reference for the market of wastewater-fed fish.

3.3.3.3 Results and Discussion

The estimated market size, M is 55,227 tons/ year based on the WTP assessment. The value of p is assumed to be 0.003 and q as 0.5. The values of innovation and imitation are much lower than that of other considered RRR products (e.g. briquette and compost) as there is little scope for innovation or modification of the product. Given that their imitation or adoption would be a function of how everybody resorts to the consumption of treated wastewater-fed fish, this will take a very long time especially if the prospective consumers are made to perceive that the fish is obtained from treated wastewater. This is particularly true due to the perception of the consumers more than the competition likely to emerge from either freshwater or sea water fish, as elicited from willingness to use/pay analysis. In other words, the entry barriers for treated wastewater-fed fish is likely to be much more than that of both briquettes and compost since the former involves human consumption whereas the latter are used as intermediates for the production process either as a source of fuel or as soil input. This can be primarily attributed to the health concerns that emerge immediately in the minds of prospective consumers with respect to wastewater treated fish. In contrast, briquette is used as a source of fuel and compost as a farm input, where they do not pose any direct health risk either to the user directly or through the end product indirectly. As a result, the growth phase for market adoption of wastewater-fed fish will be comparatively much longer than that of compost and briquette as noted in the Figure 10 Figure 11 below. Based on this, the peak is going to be 10.17 years and would eventually take almost 23-24 years to capture the market in totality.

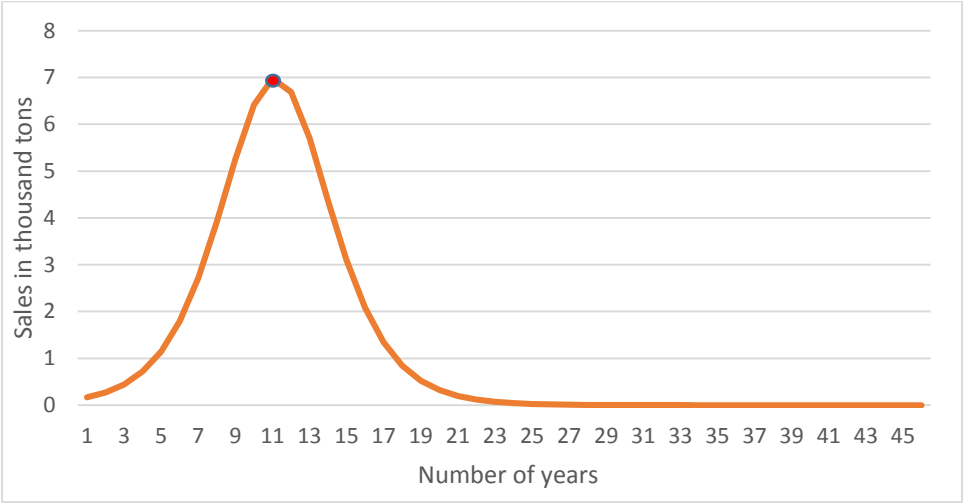

Figure 10: Probability of market adoptions for wastewater-fed fish

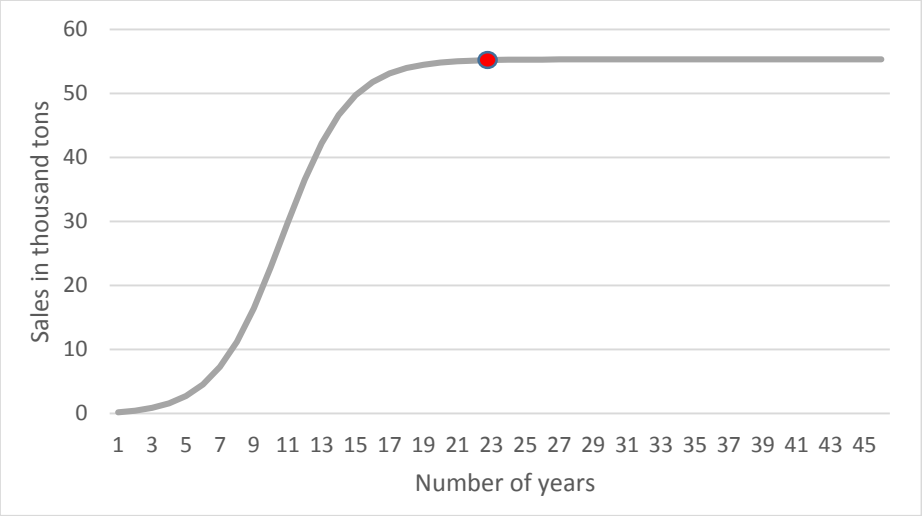

Figure 11: Cumulative adoptions of wastewater-fed fish

3.3.4 Conclusions

The market prospect for wastewater-fed fish looks promising in the initial years although a related business will reach the point of saturation and stability followed by a sharp decline in the market. This will however depend on the marketing strategies including pricing and product promotion strategies that the businesses adopt for market penetration and growth. It is suggested that food products made from fish harvested in treated wastewater must be priced differentially lower than that of food products of freshwater fish, in order to capture a share of the market. An aggressive marketing strategy for the promotion of treated wastewater fish is also recommended. Overall, wastewater-fed fish has a good market outlook but will have to compete aggressively with their alternative products to sustain in the market eventually. Freshwater fish is a very a close substitute for fish from treated wastewater. Therefore, this product will offer a high degree of competition to the RRR product. With an ever-expanding cultivation of freshwater fish and with an ever increasing level of income and population, the demand for freshwater fish will grow steadily. However, if proper labelling is done by appropriate regulatory authorities to educate the prospective consumers that the consumption of fish reared from treated wastewater will not pose any health risks, and if it is sold at a competitive price, it will find its way into the market, though gradually and steadily.

3.4 Model 9, 10, 11 & 12: Cost savings and Recovery - Treated wastewater for irrigation/fertilizer/energy

3.4.1 Willingness-to-pay and Market Estimation

3.4.1.1 Background and Justification

With ever growing population and rise in living standards, urbanization and industrialization, the demand for water has increased rapidly. The total supply of fresh water is itself limited by the nature and at the same time, drought, depletion of aquifers, deforestation and pollution have reduced the availability of good water. On the contrary, providing safe and sufficient drinking water and proper sewerage system remain as the challenging tasks for many developing countries particularly so, in urban areas. With this background using treated waste water for potable and non-potable purposes is being actively considered by many regions around the world to tide over the fresh water availability gap. For example, about 90% of the waste water generated by the City of Phoenix in United States is being treated and recycled for uses such as crops, power generation and turf irrigation[24]. Similarly Singapore which is heavily dependent on water imported from Malaysia introduced the concept of NEWater that is a highly purified form of waste water for use by industries. It is also mixed with "nutrient-rich" reservoir water, purified and filled up in bottles for potable use[25]. Wastewater treatment forms part of these new challenges. At the global level, the treatment of wastewater is one of the key aspects of protecting water resources. It presents a dual public health and environmental protection challenge for emerging and developed countries. The treatment of wastewater and its reuse has two advantages: it not only avoids drawing on natural resources, but also enables a significant reduction in the amount of wastewater discharged into the natural environment. In fact, given the population explosion and ever-increasing water requirements, these new techniques, which are known as reuse, offer genuine solutions. Once it has been treated, wastewater can also be used for various purposes where drinking water quality is not mandatory, including agricultural irrigation, the cleaning of industrial equipment, the watering of green spaces, and street maintenance, etc. Of late, reuse has become essential in all areas in the world that suffer from water shortages, like in the United States (especially California), Mexico, Australia, and Asia, as well as in the Persian Gulf countries.[26]

In Bangalore, fresh water scarcity has engendered development, and use of alternative sources of water like treated waste water (TWW) therefore becomes pertinent. The total water demand as estimated by the Bangalore Water Supply and Sewerage Board (BWSSB) is around 1125 MLD and it is expected to grow to around 2000 MLD by 2020. However Bangalore which is heavily dependent on surface water (around 90%) has almost reached its maximum water drawing rights of 1470 MLD from Cauvery as awarded by The Cauvery River Water Disputes Tribunal. Hence recycled water gains importance to bridge this gap. The use of recycled water is not only a technological issue, but to a significant extent has operational challenges and societal stigma to overcome. The acceptability of recycled water by the society needs to be studied to be able to identify the challenges and devise strategies to overcome them. To overcome the consequences of water scarcity, the concept of wastewater reuse is thought of as a solution besides rainwater harvesting and other conservation methods. Reuse of wastewater through treatment yields

[24] http://phoenix.gov/waterservices/ourservices/facts/ (accessed on 19/6/2014)
[25] http://www.dw.de/water-scarcity-in-singapore-pushes-toilet-to-tap-concept/a-16904636 (accessed on 19/6/2014)
[26] http://www.emag.suez-environnement.com/en/wastewater-treatment-aims-challenges-11037

major results economically and in small time frame. Hence treatment of wastewater should be given priority by increasing the capacity of the existing treatment plants and to find out innovative options and cost effective measures for wastewater treatment. By reusing the wastewater we find that the city not only meets the supply and demand gap but also reduces pressure on ground water draft.

The undertaking and sustainability of a business component to wastewater reuse requires an assessment of the market in its entirety to include an evaluation of market demand of wastewater, in particular, for irrigation and multiple uses. Thus, an assessment of market demand and potential size is crucial prior to implementing such an operation and to understand the existing level of demand and driving factors of demand for treated wastewater products. It is possible that farmers may already have access to freshwater or are using untreated wastewater for free, making the implementation of such an initiative infeasible. Kakembo (2012) notes that one of the conditions necessary, as requested by farmers, for turning wastewater into a valued commodity is the existence of private service providers where their services are delivered through public-private-partnerships. It is important to note that the main end-product considered in this analysis is treated wastewater for irrigation and other uses. The other end-products: energy generation and compost production are covered in the other business models [i.e. BM 4]. Two key customer groups were considered for wastewater use: a) businesses and b) households. Thus, the objectives of this analysis are to use a choice experiment approach to:

1. Estimate farmers' and businesses WTP for treated wastewater;
2. Estimate farmers' and businesses WTP for attributes of treated wastewater;
3. Estimate the potential market demand for treated wastewater.

The subsequent sub-sections outline the research methods, data collection and analytical assumptions, results and finally the policy implications of the assessment.

3.4.1.2 Research Methods and Data Collection

Theoretical Framework

The market size for recycled wastewater will be entirely based on the demand emanating from the three economic sectors, viz. agriculture, industry and services. However, which of these economic sectors and sub-sectors in each of these sectors as well as which of the households in each category of the income groups in rural as well as urban segments will be covered for the study would be primarily based on three factors: 1) prices and availability of alternative products, 2) awareness of RRR products, and 3) policy intervention made by the government, from time to time or on a consistent basis. Other things remaining the same, empirical literature (Shekar, 2011) reveals that demand for RRR products (fish and wastewater in the present case) is likely to emerge from rural farmers, low-income households in both rural and urban segments, and water intensive industries. The willingness to use the RRR products by these identified groups would depend on the proposed three possible influential factors. Similarly, willingness to pay will depend on the three influential factors. However, it is important to note that only those farmers, households and industrial/service enterprises who are willing to use the RRR product will only be willing to pay. Further, the larger the number of farmers, households and enterprises willing to use the RRR product, greater the scope for willingness to pay. The larger the willingness to use and the higher the willingness to pay, the greater the size of potential market and vice-versa. This implies that the size of the potential market for a RRR product would directly depend on the number of enterprises and households which are willing to use and how much are they willing to pay?

A scoping study was conducted by interacting with different potential customer segments such as households (rural and urban households) and enterprises (Kalyana mantapas, water intensive industries,

car washing services, and darshinis) to ascertain the prospective customer segments for wastewater related business models. For the households, it was apparent that rural farming households would be keen on any additional water supply for farming. This practice is already in vogue in a very limited number of areca-nut farms around the Bangalore city. Hence the rural households were considered one of the key customer segments. Although urban households could benefit from recycled water for non-potable consumption, the absence of separate plumbing in-house along with storage mechanism is a major barrier. However some urban households were found to be open to fishes reared in recycled water. In fact a couple of tanks holding recycled water (eg. Jakkur, Nagawara) have been already leased out for fish farming and are available in market. It is important to note here that such fishes are rarely labelled and hence from a vast majority of the consumer perspective this issue is non-existent. The enterprises in the city are always looking for any additional sources of water. Along with the major water-intensive industries some of the other non-traditional enterprises such as hotel, kalyana mantapas, dhobis, and car washing enterprises were also considered. The scoping study considered these customer segments and the short listed ones for the different business models are listed below (Table 36).

Table 36: Wastewater based business models and respective customer segments

No	Business model	Customer segments
1	Treated wastewater for irrigation / fertilizer / energy - Cost recovery	Farm households; Dhobis; Kalyana mantapas; Water intensive industries; Darshini's; Car Washing Enterprises;
2	Wastewater & drinking water exchange (water exchange – irrigation and drinking water)	Only institutional analysis (BWSSB and Irrigation department)

Thus, the analysis focused on rural farming households in the periphery of Bangalore city, and water-intensive industrial and service enterprises in Bangalore. Additionally, the urban households were considered for recycled water reared fish. By adopting a random sampling, data were gathered from the households in urban and rural areas. In Bangalore city, based on researchers' knowledge, the income-based household localities were identified and a stratified random sampling was adopted to gather responses.

Data and Study Area

In order to assess the willingness to pay and estimate the market size, questionnaires were designed to elicit responses from different customer segments identified above. The questionnaires were administered to a sample size of each above mentioned customer segment for data collection. Primary data was collected from the targeted households and enterprises by personally visiting them and interacting with them with the help of the predesigned questionnaire, during November 2013 - February 2014.

Table 37: Description of the sample size of farming households and enterprises

Households		***Enterprises***	
Region	Number of observations	Type of enterprises	Number of observations
Rural farming households	30	Dhobis; Kalyana mantapas; Water intensive industries; Darshini's; Car washing enterprises;	158

3.3.1.4 Results and Discussion

- **Characteristics of farming households and business entities**

a) Businesses: A total of 158 enterprises were surveyed. On an average, the enterprises consume about 10,266 litres of water per day including both for human and industrial consumptions. About 91% of the respondents' operations were centralized in Bangalore. Only 1% knew what a carbon foot print was but did not know what their carbon foot print was. Almost 99% said that their clients were not interested in having a smaller footprint. Given the low awareness on carbon footprint itself, almost all (100%) responded negatively to have ever hired any consultants to evaluate their carbon footprint or whether they would consider hiring one. On the presence of treatment plants only 14 of the sampled enterprises had them. Of this, they stated to be recovering only a little less than 2% of the water. The type of industries interviewed was primarily:

a) Dhobis (Washers/Laundry)
b) Kalyana mantapas (Marriage Halls)
c) Water intensive industries
d) Darshinis (Small eateries)
e) Car Washing Enterprises

The average number of people employed in the enterprises was 127 ranging from as low as 2 employees to 1500 in some cases. The average of total revenues from the sample was Rs.1067877/- per year. Most of them (87%) managed to get funds from personal sources than relying on financial institutions for credit. About 61% of the respondents rated themselves as 'good' on the strategies put in place to reduce environmental pollution with 46% remaining 'neutral' and about 8 % giving themselves a rating of 'very good'. Of those sampled, about 58% were small-scale enterprises, followed by 38% medium scale enterprises and only 3% was large scale enterprises, as stated by the respondents. Some enterprises responded positively to the question on corporate social responsibility program and most of them were related to health care activities like blood donation camp. Of the respondent sampled, only 2% (3 respondents) had a waste management plan. However, 95% of the respondents stated that the current waste management practices in Bangalore were inadequate.

b) Farming households: The average age of the respondents was 46 years; most of them were males (97%) and married (86%). About 55% respondents had completed secondary schooling while 34% of them had no formal education, only 1% each had completed primary schooling, technical training and university education. On an average, the respondents had been involved in farming for 27 years. As stated by the respondents, the annual gross household income was Rs.27200/-. About 21% of them stated to have been pursuing off-farm work like poultry farming, besides working as daily wage labourers in brick kilns and others. The annual off-farm gross income was Rs.34167/-. About 83% lived in mud houses followed by 17% in concrete structures. In terms of land holding for farming, all of them (nearly 100%) stated to own the current land in which they farmed. Only one of the respondents was farming on leased land. The average input cost per season was about Rs.24286/- and the average income per season was Rs.30760/-. About 15 respondents resorted to farm activities by resorting to borrowing from formal/informal credit agencies, while only about three of the rest borrowed from their family and friends. Higher interest rates were an impediment in accessing institutional/informal credit. The primary crop grow in the region was finger millet (*Ragi*) followed by vegetables (cabbage, beans, tomato, etc.), other millets, paddy, coconut, wheat, areca and flowers. Of this, almost 37% of them grew Ragi followed by beans (11%). About 6% each

grew corn, flowers and wheat, while 5% each grew paddy rice, pigeon pea, and tomato. Most of these are sold in the local markets.

- **Water sources and use**

a) Businesses: About 50% of the respondents used water for washing, production activities (water as input) and for sanitation purposes (19%). About 9% of this was used in production – water as a medium, 3% for cooling and 1% for dilution. About 46% of them obtained water from private water tankers / trucks followed by 38% from connections and the remaining 16% from other sources (bore-wells). Almost 99% of them were satisfied with the quality of water they were using, and 98% of them were satisfied with the existing supply of water (quantity).

Table 38: Sources of water

Type of Source	% of surveyed respondents
Connection (BWSSB)	38%
River	0%
Truck (Private Supply)	46%
Other sources	16%

Most of them paid for the water charges via cash payment based on a monthly bill from the water supply agency (BWSSB in Bangalore). The other respondents paid water tanker suppliers via cash on delivery of water. On average, the respondents spend Rs.4093/- per month for water. About 70 respondents stated that the quality of water they used did not affect them nor their employees' health and the quality of product. Almost 92% stated that they were not willing to pay more than they were paying for reliable treated wastewater services when supplied to their operations. However, about 91% of the respondents preferred to be charged for any improvements to the water supply service.

Table 39: Preferences for water supply service

Preference to be charged for these improvements to the water supply service	% of surveyed respondents
Current way, through the bill for the water utility services	91%
Through increases in the taxes paid by each farmer	5%
Through business association	5%
Other	0%

Almost 98% of the respondents did not trust the city to do the necessary improvements to guarantee the supply of water or improved quality to their operations. About 75% of the respondents stated that the municipality should be managing the wastewater treatment plant followed by 11% who wanted some business association to discharge that responsibility, 8% by NGOs and 3% by a water utility company like BWSSB, 1% by farmers association and 1% by others.

Table 40: Managing wastewater treatment plant

Who should be managing the wastewater treatment plant?	% of surveyed respondents
Municipality	75%
Business association	11%

Farmers association	1%
NGO	8%
Water utility company	3%
Other	1%

The respondents were asked whether they would consider shifting to the use of treated / partially treated waste water due to seasonality factors that affect water availability for: irrigation, cooking/drinking; bathing/toilet; cleaning/mopping; gardening; and car/bike washing. In response, with regard to the end-use in cooking/drinking, there was a negative response by over 80% of the respondents who were unwilling to consider this option. However, for the end-use in bathing and toilet, there was a positive response by almost 82% and 67% to consider the usage during summer and winter months, respectively. While during monsoon, almost all responded negatively to using treated wastewater for bathing or toilet. Further, with regard to the end-use in cleaning and mopping, there was a positive response to consider using treated wastewater during summer by about 81%. But there was minimal positive response to consider use during monsoon and winter months. Interestingly, only 56% preferred considering this for use in gardening during summer, with most of them responding negatively for its usage during monsoon and winter months. For the end-use in bike/car washing, there was a higher preference with 89% and 77% during summer and winter months, respectively to consider using this. However, there were almost completely negative responses for considering to use this during monsoon. The end-use in irrigation was not applicable and hence the option was discarded. In summary, there was a willingness to use treated wastewater during summers for most non-cooking or potable purposes, while there is not much of willingness to use treated wastewater for other purposes during non-summer seasons especially monsoon. This suggests that it is the relative availability of water as perceived by the respondents in different seasons and the purpose for which water is used, which would determine the willingness of enterprises to use treated/partially treated wastewater.

b) Farming households: The number of farming households interviewed was 30. In regard to the main source of water for irrigation almost 62% was rain-fed with 38% using bore wells. About 67% was indeed satisfied, while about 33% was not satisfied with the water they were using due to anticipated health risks. About 77% was not satisfied with the existing supply (quantity) of water with only 23% satisfied with the quantity of water. The characteristics of the water that made the quality unsatisfactory were notably lack of bore holes, electric pumps and rivers or streams nearby. The farmers were asked to respond to whether they would consider shifting to treated/ partially treated wastewater due to seasonality based on different end uses for: irrigation, cooking/drinking; bathing/toilet; cleaning/mopping; gardening; and car/bike washing. In response to this, for the end-use in irrigation during summer months, about 93% respondents were affirmative while only 7% responded negatively. About 63% were affirmative while 30% responded negatively and 7% were uncertain / partially willing, for its use during the monsoon period. About 82% were affirmative while 14% responded negatively and 4% were uncertain / partially willing, for its use during winter.

For the end-use in cooking/drinking during summer, almost all the respondents (100%) answered negatively as far as using the treated wastewater for cooking or drinking purposes was concerned. For its use during monsoon as well as winter months, all the respondents answered negatively for using the treated wastewater for cooking or drinking purposes. Surprisingly, almost all the respondents (100%) answered negatively to the use of treated wastewater for bathing/toilet during the summer. Their answers were the same for monsoon and winter months. The results were no different for using treated wastewater for cleaning/mopping, gardening or even vehicle washing, for any of the seasons

- **Willingness-to-pay (WTP) for treated wastewater**

a) Willingness to pay for treated wastewater among enterprises

To estimate the willingness to pay for treated wastewater among businesses, the respondents were provided with alternative scenarios of water availability and were asked about their willingness to pay. The different scenarios presented to them were as follows –

- Scenario 1: If the cost of water goes up by 10%
- Scenario 2: If the cost of water goes up by 25%
- Scenario 3: If the cost of water goes up by 100%
- Scenario 4: If the availability of water comes down by 10%
- Scenario 5: If the availability of water comes down by 25%
- Scenario 6: If the availability of water comes down by 50%

While the first three scenarios are related to the increment in the cost of water, the later three scenarios dealt with the scarcity of water. Analysis of the primary data shows that on an average of 84% of these enterprises were willing to pay for using treated wastewater for irrigation. The average payment that enterprises were willing to render was Rs.455/- per tanker of treated/partially treated wastewater. However, among the larger enterprise respondents, they were willing to pay on an average of Rs.1160/- per 8000 litre tanker. Figure 12 below illustrates the willingness to pay of the enterprises given the base situation of being provided with treated/partially treated wastewater for irrigation. The figure clearly indicates that the enterprises value relatively higher the increment in cost of water supply than scarcity of water. However, the bid offered by the enterprises for a higher increase in the cost of the water (from 25 to 50%) is lower than the other scenarios. This implies that for the initial increases in the cost of procuring water, the enterprises are willing to cover the increased costs. Further increases in cost up to 100% is perceived to be significantly high and they expect the local government to step in and provide subsidies and partly cover the increase in the prices.

Considering the other scenarios centred on scarcity of water, it is found that the payments offered by the enterprises are relatively lower. In fact even with a 10% scarcity of water, business enterprises are willing to pay about the same charges as in the business as usual condition. Another important consideration is that while for the first 15% increase in scarcity of water the WTP for treated wastewater (a substitute) rises by Rs.50 (a rise of 10%) and for the next 75% increase in scarcity of water, the WTP rises by about Rs. 141 (about 28%). Thus the changes in the WTP, move in an opposite direction (as availability decreases, WTP rises) although not proportional to the change in the scarcity of water (which would become dearer which scarcity of water). This implies that the enterprises do consider wastewater as a substitute to water although not a perfect substitute.

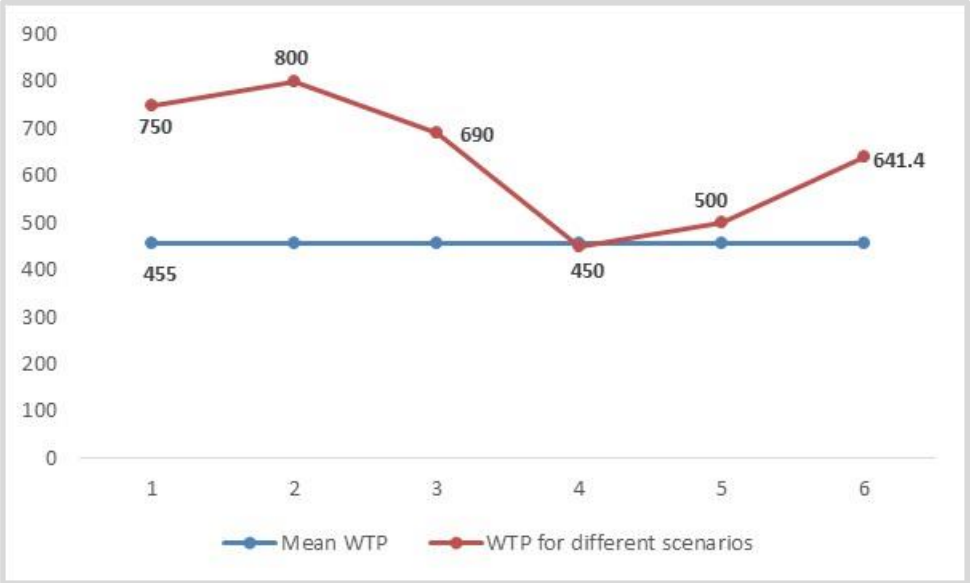

Figure 12: Comparison of the mean WTP of the industries for wastewater with the different scenarios

- **Willingness to pay by scale, water consumption, expenditure towards water**

Table 41 below shows that on average the difference between the WTP of medium and small scale enterprises is about Rs. 300, whereas if we classify the enterprises on the basis of water consumption there is a substantial difference between the payments. Similar observations were found when enterprises were classified in terms of unit price of water and the total expenditure on water. While there is a marginal difference in the WTP when enterprises are classified according to the price paid for water in the present situation, there is a marked difference in the WTP between enterprises with higher expenditures of water than with enterprises incurring lower expenditure.

The enterprises included in the survey comprised of institutional houses (*Kalynmantapas*), hotels, car services, washer-man and industries (like brick manufactures, chemicals and garments). Except for the industries, it was found that other businesses incur water costs less than Rs.5000 and hence have lower payments for wastewater as can be seen from the above table. Similarly, the consumption of these businesses are lower than that of the industries and hence have lower preference for WTP for treated wastewater. These smaller (and some medium) enterprises thus have a lower substitutability for treated wastewater rather than the larger industries and hence their demand curves are more inelastic to price changes of water.

Table 41: Willingness to pay of the business enterprises based on their scale, consumption and expenditure of water

WTP based on the scale on the enterprise			WTP based on water consumption		
Medium scale	Mean	2919.23	> 10,000 Liters	Mean	4420
	Maximum	20000.00		Maximum	20000
	Minimum	300.00		Minimum	300
	STD	5454.76		STD	8710.52
Small	Mean	2640.00	<10,000 Liters	Mean	1140
	Maximum	20000.00		Maximum	5000
	Minimum	450.00		Minimum	450
	STD	5102.70		STD	1349.04
WTP based on unit price of water			**WTP based on expenditure on water**		
<1000 Rs/liter	Mean	2785.71	< Rs. 5000	Mean	3006.25
	Maximum	20000.00		Maximum	20000
	Minimum	450.00		Minimum	300
	STD	5262.84		STD	6867.59
>1000 Rs/liter	Mean	2792.86	> Rs. 5000	Mean	1325
	Maximum	20000.00		Maximum	5000
	Minimum	450.00		Minimum	450
	STD	5259.56		STD	1567.52

b) Willingness to pay for treated wastewater among farming households

To estimate the willingness to pay for treated waste water in agriculture, the farming households were provided with alternative scenarios of water availability and were asked about their willingness to pay. The different scenarios presented to them are as follows –

- Scenario 1: If the cost of water goes up by 10%
- Scenario 2: If the cost of water goes up by 25%
- Scenario 3: If the cost of water goes up by 100%
- Scenario 4: If the availability of water comes down by 10%
- Scenario 5: If the availability of water comes down by 25%
- Scenario 6: If the availability of water comes down by 50%

While the first three scenarios are related to the increment cost of water, the later three scenarios deals with the scarcity of water. Analysis of the primary data shows that on an average 89% of these farmers were willing to pay for using treated wastewater for irrigation. On an average the farmers were willing to pay Rs.482/- per 10000 litres (10 m^3) of treated/partially treated wastewater. The following figure (Figure 13) illustrates the willingness to pay of the farmers given the base situation of being provided with treated/partially treated wastewater for irrigation.

The figure clearly shows that the farmers have valued scarcity of water relatively higher than any increment in cost of water supply. The open-ended bids offered by the farmers towards scarcity of water

also increases at an increasing rate compared to that of the increases in the cost of supply of water. The bids offered by the farmers for an increase in cost of water at the initial levels (10% to 25%) are similar in terms of the average value (Rs. 315.38). This increases marginally by Rs 66 when an option of 100% cost increment is faced by the farmers. In comparison, the marginal change in the bid offered when scarcity of water increases from 25% to 50% is about Rs. 210 per 100m^3 which is 3 times the increase in the bid offered for cost changes. The higher open bids by the farmers with increases in cost implies perception of the farmers that would prefer the government to provide subsidised irrigation when the cost of water supply increases. However, with higher increments in costs, the farmers were noted to prefer to bear some of the costs with higher increases in water supply costs. This thus implies that when the cost of water supply increases or if there is water scarcity, the demand curve shifts parallel to the initial demand curve but the magnitude is lesser compared to higher changes in both these parameters.

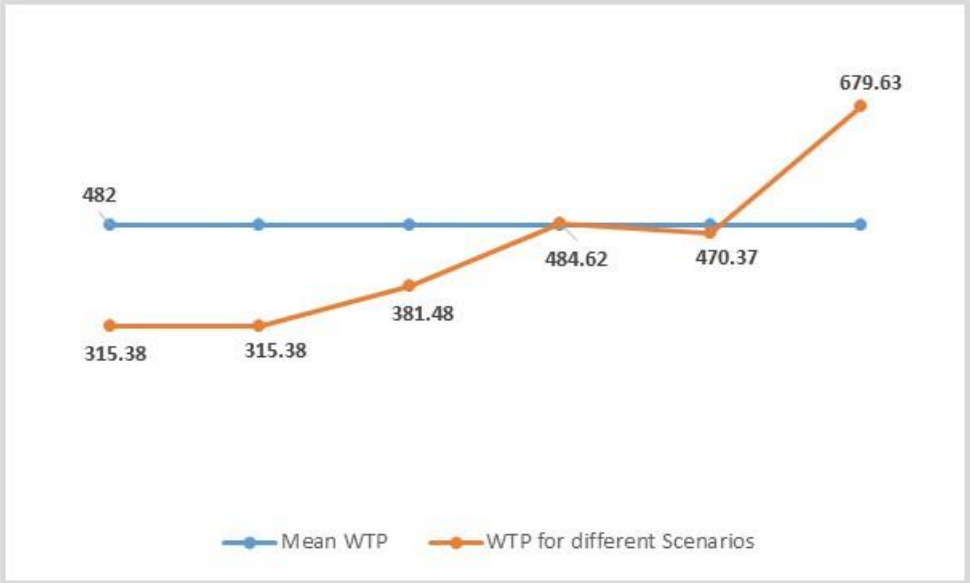

Figure 13: Comparison of the open-bids in comparison to the mean WTP for the farmers

- **Willingness to pay: a classification based on the socio-economic profile of farmers**

This section focuses on the willingness to pay of the farmers for wastewater irrigation based on their socio-economic profile. The analysis of the open-ended WTP bids of the farmers shows that farmers with more experience are willing to pay a relatively higher fee than the other groups. However, it is also noted that the standard deviation for these farmers is also higher in comparison to the groups. This points to the heterogeneity in the willingness to pay among these farmers who are most experienced. The analysis of the WTP data based on the source of irrigation indicates that farmers dependent on rain for irrigation are willing to pay higher for wastewater irrigation than farmers utilising groundwater. This might be due to the fact that farmers practising rain-fed farming are willing to hedge the risk of vagaries of rainfall and hence have a higher willingness to pay. The farmers dependent on groundwater markets pay high price for water[27] and do not consider treated wastewater as a substitute with the assured water supply they

[27] Gowda U.R.C et. al. (2012) "Economics of Peri-Urban Agriculture: Case of Magadi off Bangalore"; Economic & Political Weekly June 16, 2012 Vol xlvii no 24. This study reveals that there exists informal water markets for irrigation. The farmers close to urban areas pay Rs.3441 per acre per year while farmers in peri-urban areas with lower urban influence pay around Rs. 8000 for an acre per year.

presently receive. Another reason for lower preference for payments is due to the fact that farmers who have already invested for groundwater are reluctant to phase it out completely since it entails a higher establishment cost. Usually, in the peri-urban areas, the large farmers play an important role in making the initial investments for groundwater exploration and the smaller farmers are water buyers. This is also confirmed by the fact that smaller farmers are willing to pay higher for the wastewater which they consider as a substitute for groundwater compared to the medium and large farmers. Table 42 reveals that farmers with higher household incomes are willing to pay higher than the lower income household. However, a standard deviation of the open-bids shows that there is preference heterogeneity for payments among the bigger farmers which is quite consistent among the smaller farmers (with lower household income).

Table 42: Classification of the open-bids by different socio-economic profile of the farmers

WTP by years of farming (INR)			**WTP by source of irrigation (INR)**		
> 40 Farming experience (years)	Mean	925.00	Pump	Mean	416.67
	Maximum	2000.00		Maximum	600.00
	Minimum	200.00		Minimum	200.00
	STD	788.99		STD	204.12
20-40 Farming experience (years)	Mean	480.00	Rain	Mean	578.95
	Maximum	1200.00		Maximum	2000.00
	Minimum	200.00		Minimum	0.00
	STD	332.67		STD	462.58
< 20 Farming experience (years)	Mean	616.67			
	Maximum	800.00			
	Minimum	400.00			
	STD	160.21			
WTP by income class of the farmers (INR)			**WTP by land holding (INR)**		
>10,000 Annual income	Mean	978.50	< 3 acre	Mean	369.23
	Maximum	2000.00		Maximum	600.00
	Minimum	200.00		Minimum	200.00
	STD	750.18		STD	179.74
< 10,000 Annual income	Mean	523.69	> 3 acre	Mean	790.91
	Maximum	1200.00		Maximum	2000.00
	Minimum	160.21		Minimum	200.00
	STD	344.96		STD	492.86

c) Potential market demand for treated wastewater among the farming households and businesses

The total number of agricultural households in the urban and the peri-urban areas of Bangalore, India was estimated at approximately 231,377. Assuming an estimate of 83% of farmers are willing to use treated wastewater, the demand for treated wastewater for agricultural production is estimated at 1,430 million m^3/yr. Whilst the estimated demand from businesses is noted to be marginal, it is important to note that the businesses considered in the analysis was incomplete due to data limitations. This suggests that the overall demand for treated wastewater can be substantially higher than that presented here, although it is the lack of infrastructure for water delivery may limit the actual quantity of treated wastewater supplied/ made available to farmers.

Table 43: Potential Market Demand for wastewater use by farming households and businesses

	Total number of households/ businesses	Probability of adoption	Potential number of households/ businesses willing to adopt wastewater use	Consumption rate (m^3/year)	Total market size (m^3)	Total market size (in million m^3/yr)
Farming households	259482	0.83	215370.06	7450.00[28] (per ha)	1,430,719,680[29]	1,430.72
Dhobis (Washers/Laundry)	500	0.19	95	8925.35	847,908	0.85
Kalyana mantapas (Marriage Halls)	500	0.69	345	3163.75	1,091,494	1.09
Water intensive industries	3,299	0.17	561	2000.00	1,121,660	1.12
Darshini's (small eateries)	10,000	0.69	6,900	729.90	5,036,310	5.04
Car washing enterprises	1,000	0.34	340	880.20	299,268	0.30
					Total	1,439.12

3.4.2 Market Structure and Outlook

3.4.2.1 Background and Justification

As with the market structure assessment of the other business models, the sustainability of any entity engaged in wastewater reuse require it to understand the market in which it operates. In the case of the wastewater business models, the water market was evaluated to understand the characteristics of the market structure (i.e. level of competition in the market, characteristics of competitors and factors driving market competitiveness and collusiveness) in order to guide potential investors' decisions. The business models considered here have the key end-product of treated wastewater for irrigation in agriculture; and the analysis is conducted from that perspective. It assesses the market structure of the irrigation water market, in light of identifying key external (market) and internal factors which will drive the sustainability of wastewater treatment and reuse (WtR) businesses. It is important to note that the analysis is limited in its assessment due to data limitation which resulted in the assessment been done from a national perspective rather than that of the city. The key findings are however applicable to Bangalore as the majority of wastewater reuse in any form will most likely occur closer to the wastewater treatments. Additionally, the market structure assessment proved to provide significant insights for the outlook of the water market. In that regard, the market structure and outlook assessment are presented together here in this sub-section.

[28] Agrinfo,2011 (http://www.agriinfo.in/?page=topic&superid=1&topicid=16) : o.745 m depth of irrigation water requirement for most prominent crops (Finger millet, paddy and maize) in Bangalore

[29] Average farm size taken as 0.892 ha based on total agricultural land area 231377 ha of Bangalore urban and rural districts

3.4.2.2 Research Methods and Data Collection

Similar to the other business models, the structure-conduct-performance (SCP) approach was used in this assessment with a focus on the sanitation/wastewater management and irrigation service sector in Bangalore, India. Details of the approach are outlined in the methodology section in chapter 2. The SCP approach typically measures how the market structure of industries vary, how different market structures influence the market conduct of firms and how their conduct influence their market performance. As per the objective of the study, inferences will be drawn to describe the potential feasibility of WtR businesses in Bangalore, India. The SCP approach measures the structure of the market, the conduct and performance (profitability) of the relevant economic actors through the use of different indicators.

- **Structure:** The market structure of the water market is assessed based on the level of market concentration in the industry, for which data were extracted from already published findings due to unavailability of data on market share of different actors. Additional market dimensions, such as barriers to market entry and exit were also evaluated.
- **Conduct:** The conduct of the players is assessed by their price setting behaviour, factors or determinants of pricing of the water market, buying and selling practices and distribution strategies of actors.
- **Performance:** The performance along the supply chain was evaluated, via the assessment of indicators such as revenue generation, service cost coverage of service providers.

The market structure of the wastewater management and irrigation management sector was assessed primarily via the wastewater and irrigation service supply structure and institutional structure. The assessment used data and information obtained from existing secondary literature, organizational reports and websites on the wastewater and irrigation service sectors sector. Information on the structure of the market, sales shares, pricing behaviour indicators and prevailing pricing policies were obtained from the state instructional reports.

3.4.2.3 Results and Discussion

Water is used for a variety of purposes and is one of the most essential resources for human life. Water for irrigation has been a key sector garnering attention and importance by both state and central (federal) governments in India. India with 2.4% of the world's total area has 16% of the world's population; but has only 4% of the total available fresh water (Planning Commission, 2012). This clearly indicates the need for water resource development, conservation, and optimum use. The ultimate irrigation potential of India has been estimated to be 139.5 million Ha, comprising 58.5 million Ha from major and medium schemes, 15 million Ha from minor irrigation schemes and 66 million Ha from groundwater exploitation. India's irrigation potential has increased from 22.6 million Ha in 1951 to about 90 million Ha at the end of 1995. It is estimated that even after achieving the full irrigation potential, nearly 50 per cent of the total cultivated area will remain rain-fed (Dehadrai, 2003). The National Institute of Hydrology has estimated the annual water requirements for the country scale. Accordingly, the total annual requirement of fresh water for the country from various sectors including irrigation, domestic, industrial, hydropower and other uses is estimated to be about 694 to 710, 784 to 850 and 973 to 1,180 km^3 by the years 2010, 2025 and 2050 respectively depending on the low and high demand scenarios.

Table 44: Annual Water requirement for different uses[30] (in km^3)

Uses	Year 1997-98	Year 2010			Year 2025			Year 2050		
		Low	High	%	Low	High	%	Low	High	%
Surface Water										
Irrigation	318	330	339	48	325	366	43	375	463	39
Domestic	17	23	24	3	30	36	5	48	65	6
Industries	21	26	26	4	47	47	6	57	57	5
Power	7	14	15	2	25	26	3	50	56	5
Inland Navigation		7	7	1	10	10	1	15	15	1
Flood Control		-	-	0	-	-	0	-	-	0
Environment (1) Afforestation		-	-	0	-	-	0	-	-	0
Environment (2) Ecology		5	5	1	10	10	1	20	20	2
Evaporation Losses	36	42	42	6	50	50	6	76	76	6
Total	399	447	458	65	497	545	65	641	752	64
Ground Water										
Irrigation	206	213	218	31	236	245	29	253	344	29
Domestic	13	19	19	2	25	26	3	42	46	4
Industries	9	11	11	1	20	20	2	24	24	2
Power	2	4	4	1	6	7	1	13	14	1
Total	230	247	252	35	287	298	35	332	428	36
Total Water Use										
Irrigation	524	543	557	78	561	611	72	628	807	68
Domestic	30	42	43	6	55	62	7	90	111	9
Industries	30	37	37	5	67	67	8	81	81	7
Power	9	18	19	3	31	33	4	63	70	6
Inland Navigation	0	7	7	1	10	10	1	15	15	1
Flood Control	0	0	0	0	0	0	0	0	0	0
Environment (1) Afforestation	0	0	0	0	0	0	0	0	0	0
Environment (2) Ecology	0	5	5	1	10	10	1	20	20	2
Evaporation Losses	36	42	42	6	50	50	6	76	76	7
Total	629	694	710	100	784	843	100			

The extent of the expected increase in demand represents a challenging task that needs to be met. Additionally, water scarcity in urban areas is a well-known phenomenon all around the world and Bangalore is no exception. With the ever growing population in cities like Bangalore, provision of potable water has been a major challenge to the civic authorities. BWSSB currently supplies approximately 900 million litres (238 million gallons) of water to the city per day, despite a municipal demand of 1.3 billion litres. The need for water emerges from all sections of the society in Bangalore – residential, commercial, industrial, and for peri-urban agriculture. Water has multiple uses across several sectors. Its high

30 http://www.nih.ernet.in/rbis/india_information/AnnualWaterRequirements.htm Last accessed 9th July 2014.

functionality and expected increase in demand mainly from the agricultural and industrial sectors, suggests it to be a high penetrative market product – currently in a growth stage.

In the case of the water market, the recovery and reuse of wastewater as treated/partially treated water for irrigation and other purposes, harvesting fish in treated/partially treated wastewater and water exchange for drinking/irrigation are applicable. However, similar to the energy market, fresh water, as a natural resource is a well regulated market segment. Typically, it is the respective civic agencies which have the onus on water supply and distribution; collection and treatment of wastewater. In the case of Bangalore, it is BWSSB that manages these activities. At the scale of the city, it has setup centralized treatment plants that are responsible for treatment of wastewater from which treated/partially treated wastewater could be reused. However, the government is currently making it mandatory for several independent apartment complexes and housing layouts to setup with their own treatment plants in-situ. The onus of water supply for irrigation remains with the Irrigation Department. It is however not apparent as to how private players with often lesser quantities of treated wastewater can link to tanks managed by the irrigation department. Yet, given the limited players and government monopoly in general, this segment is not analyzed but only an institutional analysis is presented.

As shown in Table 45 below, freshwater is a competing product for treated wastewater. Given that freshwater is a product with limited differentiation, the competition for the entry of treated wastewater is likely to be high. Additionally, if facilities for these storage and supply of freshwater through irrigation dams and canals improve steadily, the demand for treated wastewater may not increase substantially. This will also depend on the quantity of rainfall water during the monsoon which is the primary source of freshwater in India. However, the demand for treated wastewater can at least be seasonal. In the summer months, in particular, when the supply of freshwater declines and becomes unsteady, treated wastewater can be an effective alternative for agricultural purposes as well as non-edible uses in rural India and for all non-edible uses in urban India.

Table 45: Market structure - treated wastewater

Competing Products	**Level of Differentiation**	**Implications of Differentiation**	**Implications of the Stages of PLC of Competing Products**
Fresh water	Low (close substitute)	It will offer high resistance particularly in rural areas.	Competition is likely to continue in the future.

3.4.3 Conclusions

The results from the WTP assessment show that the majority of farming households (93% of surveyed respondents) are willing to use and pay for treated wastewater for irrigation purposes, especially during the drier seasons (summer months). A lower percentage (63%) were however noted to be willing to pay for treated wastewater during the monsoon season. On average, 89% of these farmers were willing to pay for using treated wastewater for irrigation. The farmers were willing to pay Rs.482/- per 10000 litres (10 m^3) of treated/partially treated wastewater. The results also showed that the farmers placed a higher value on treated wastewater under a scenario of 'increased water scarcity' compared to any increment in cost of water supply. The bids offered by the farmers for an increase in cost of water at the initial levels (10% to 25%) are similar in terms of the average value (Rs.315.38). This increases marginally by Rs 66

when an option of 100% cost increment is faced by the farmers. In comparison, the marginal change in the bid offered when scarcity of water increases from 25% to 50% is about Rs. 210 per 100m^3 which is 3 times the increase in the bid offered for cost changes. The results also showed that farmers with more farming experience were willing to pay a relatively higher fee than the other groups. It is however important to note that the standard deviation for these farmers was also higher in comparison to the groups. Additionally, farmers dependent on rainwater for irrigation were willing to pay a higher fee for wastewater for irrigation than farmers utilizing groundwater. This might be due to the fact that farmers practising rain-fed farming are willing to hedge the risk of vagaries of rainfall and hence have a higher willingness to pay. The farmers dependent on groundwater pay a relatively higher price for water compared to the other group of farmers and may not consider treated wastewater a substitute with the assured water supply they presently receive. Another reason for lower preference for payments is due to the fact that farmers who have already invested for groundwater are reluctant to phase it out completely since it entails a higher establishment cost.

In regards to the businesses, the results showed that on average of 84% of the surveyed enterprises were willing to pay for treated wastewater. The average WTP value was Rs.455/- per tanker of treated/partially treated wastewater. However, among the larger enterprise respondents, they were willing to pay on an average of Rs.1160/- per 8000 litre tanker. The results also indicated that the enterprises value treated wastewater relatively higher under the scenarios of 'increment in cost of water supply' than that of 'water. Under the water scarcity scenario, it was found that the payments offered by the enterprises were relatively lower. In fact even with a 10% scarcity of water, the enterprises were willing to pay about the same charges as when there was no water scarcity. Another important consideration is that while for the first 15% increase in scarcity of water the WTP for treated wastewater (a substitute) rises by Rs.50 (a rise of 10%) and for the next 75% increase in scarcity of water, the WTP rises by about Rs. 141 (about 28%). Thus the changes in the WTP move in an opposite direction (as availability decreases, WTP rises) although not proportional to the change in the scarcity of water (which would become dearer which scarcity of water). This implies that the enterprises do consider wastewater as a substitute to water although not a perfect substitute. The enterprises included in the survey comprised of institutional houses (*Kalynmantapas*), hotels, car services, washer-man and industries (like brick manufactures, chemicals and garments). Except for the industries, it was found that other businesses incur water costs less than Rs.5000 and hence have lower payments for wastewater as can be seen from the above table. Similarly, the consumption of these businesses are lower than that of the industries and hence have lower preference for WTP for treated wastewater. These smaller (and some medium) enterprises thus have a lower substitutability for treated wastewater rather than the larger industries and hence their demand curves are more inelastic to price changes of water.

It is clear that there is a fair demand for treated wastewater. In particular, the demand is higher among farmers but characterized by a WTP lower during the monsoon seasons that the summer season. Demand for treated wastewater among businesses was found to be specific to the enterprise type and use. Demand for water is expected to grow exponentially in the future particularly in the agricultural and industrial sectors. In terms of the structure of the water market, it is a well-regulated market and it is foreseen that the supply and distribution of wastewater and the related market structure will most likely follow a similar pattern.

3.5 Nutrient Business Models

The organizational structure of this sub-chapter differs from the other sub-chapters on energy and wastewater. The willingness-to-pay and market size estimation results are presented first for 3 business models, noting that models 15 and 16 have the same end-product (MSW-based compost) and model 17 is faecal sludge-based organic fertilizer *(termed here as Fortifer).* Whilst model 20 has a similar end-product to model 17, it is quite different in terms of the quality and safety assurance of the product. Given data limitations and the fact that Fortifer does not as yet have an established market in the fertilizer market/industry, the market structure assessment is conducted from the perspective of the key competing market - chemical fertilizer market for both end-products. A subsequent section is also presented for the market outlook assessment with respective sub-sections for the two products.

A. Model 15: Large-Scale Composting for Revenue Generation (MSW to Compost)

Bangalore is a fast-growing city in India with a population of some 8.5 million, according to the 2011 census. The sole authority responsible for the management of sewerage and sullage in the city is the Bengaluru Water Supply and Sewerage Board (BWSSB). In February 2011, the Comptroller and Auditor-General (CAG) of India reported that the sewage network in Bengaluru served only about 40% of the total 800 km^2 of the city (The Hindu, 2011). This implies that only 3.4 million of the 8.5 million is being served, while the remaining 60% of the city, or 5.1 million people, rely on on-site sanitation with off-site disposal, or are forced to defecate in the open. In Bangalore, on-site sanitation systems typically consist of septic tanks receiving waste water from toilets, kitchens and showers that are constructed adjacent to, or have some distance from, individual houses. The septic tanks are emptied by informal, private operators, dubbed 'honey-suckers'. Recently BWSSB brought in a system whereby honey suckers can dispose of their contents in designated sewage plants, though a protocol is yet to be developed. How well this mechanism is working today is yet unclear. This mechanism has profound effect on two business models (Faecal sludge-based organic fertilizer and Informal reuse of faecal sludge for agricultural production) developed around the faecal sludge. If the mechanism is efficient, it will enhance the production of faecal sludge based organic fertilizer or else it will support the informal reuse of faecal sludge for agriculture production.

Utilization of both municipal solid waste (MSW) and faecal sludge (FS) is important to curb the ever rising demand of scarce land for its disposal. Changing life style patterns, particularly in urban areas, has led to an increase in the generation of MSW. The recent Indian waste regulation encourages some small-scale Indian entrepreneurs to consider organic waste treatment as a new business opportunity and compost as an increasingly marketable product. These enterprises are clearly profit-oriented and also concentrate on the production and sale of compost, as well as on providing consulting services in the field of composting. The success of new organic fertilizer (compost and Fortifer) will be hinged on a strong market assessment, resulting in implementation of appropriate pricing, distribution and marketing strategies, given past research has shown business failure to be attributable to limited market research. Thus, similar to the previous business models, the introduction of a compost product in the fertilizer market will require an assessment of the consumers' WTP and the potential market size. This will serve to better inform future investors on the appropriate pricing and marketing strategies to implement and also the optimal production capacity at which to operate.

3.5.1 Willingness-to-pay and Market Estimation

3.5.1.1 Background and Justification

This study seeks to estimate the demand for compost in Bangalore, India. Farmers in Bangalore are aware of the benefits and costs of chemical fertilizers and other farming inputs. But the use of compost made from organic waste and faecal sludge is new to the farmers. In this regard, the use of contingent valuation (CV) approach is appropriate to assess farmers demand for compost. The application of this approach can be found in Danso et al. (2006), who use CV to assess farmer demand for compost in Ghana; Dadson Awunyo et al. (2013) use the approach to assess farmers willingness to pay for improved sanitation in Kumasi Metropolis, Ghana; Agyekum et al. (2014) apply the approach to estimate the demand for faecal compost by farmers in southern Ghana; Palatnik et al. (2005) estimate the demand for waste recycling in Israel; Arene and Mbata (2008) use the approach to estimate profitability and WTP for waste use in Abuja, Nigeria; and Valerian et al. (2011) use the approach to estimate farmers WTP for organic products in Morogoro municipality, Tanzania. All these studies use stated preference approach with either open-ended or closed-ended questionnaires to elicit respondents WTP for an improvement in waste recycling services. This approach has issues such as hypothetical bias, cultural bias and starting point bias. To avoid these issues, the choice experiment (CE) approach is used in this study. It has the ability to avoid hypothetical bias and the choices given to respondents are incentive-compatible. Karousakis and Birol (2006) use CE approach to estimate farmers demand for recycling services in London and worldwide applications can be found in Hanley et al.(2006); Ndunda and Mungatana (2013); Lim et al.(2013) and Agimass and Mekonnen (2011). According to the literature review conducted, this is the first study to apply CE approach in Bangalore, India. The aim is to use the CE approach to:

1. Estimate farmers' WTP for MSW-based compost;
2. Estimate farmers' WTP for attributes of MSW-based compost;
3. Estimate the potential market demand for MSW-based compost.

The next section deals with the research methods and assumptions used to implement the study. The subsequent sections present the results and discussions of the study. The last section focuses on policy implications and recommendations for businesses and future research on this topic.

3.5.1.2 Research Methods and Data Collection

Theoretical Framework

According to Lancaster (1966), the demand for a product is influenced by its attributes rather than the product itself. The theoretical foundation of the Choice Experiment (CE) is based on Lancaster's consumer choice theory, but also from the random utility theory developed by McFadden in 1974. Thus, it is assumed that in any CE, farmers will select an option from many choices, provided the selected option has attributes that provide them with the maximum utility. According to the random utility theory, a utility function comprises of a deterministic and a random component (McFadden, 1974; Arnot et al. 2006; Ndunda and Mungatana, 2013). In most cases, the researcher is able to observe the deterministic factors but the unobservable factors are captured in the random component of the utility function. Hence, the utility U associated with individual n whose choice is alternative i is given by:

$$U_{in} = V(Z_{in}) + \varepsilon(Z_{in}) \qquad (1)$$

where $V(.)$ is the deterministic component and $\varepsilon(.)$ is the error component in the utility function. The probability of an individual n choosing alternative i from a set of alternatives J can be estimated using a conditional logit model (CL) (Greene, 2002; McFadden, 1974; Maddala, 1999) and specified as:

$$\Pr(Y_i = n) = \frac{\exp[V(Z_{in})]}{\sum_{j=1}^{J} \exp[V(Z_{jn})]} \quad (2)$$

If $V(.)$ is taken to be a linear function of specific characteristics whose random error term is identically and independently distributed (IID) with a type 1 extreme value (Gumbel) distribution, the conditional indirect utility function becomes (Ndunda and Mungatana, 2013; McFadden, 1974; Arnot et al. 2006):

$$V_{jn} = \delta_j + \sum \beta_{jk} Z_{jk} + \sum \alpha_{jn} (M_n . \delta_j) \quad (3)$$

Where δ_j is an alternative specific constant, Z_{jk} is the k characteristic value of the choice j; β_{jk} is the parameter allied to the k characteristic, M_n is the socio-economic characteristic vector of individual n and α_{jn} is the vector of the coefficients related to the individual socio-economic characteristics.

The Choice Experiment Design

This study aimed at identifying farmers' preferences towards diverse characteristics of compost produced from organic waste and faecal sludge. Thus, the primary step of the research was to select applicable attributes. The primary step of the research was to select applicable attributes, which was based on a literature review and in collaboration with local partners. Given the difficulties associated with the exact changes in the attributes' features, the levels of choices were qualitatively presented. The price levels used for the choice experiment were provided by the local partners and based on current market prices. Table 46 presents all the possible combinations considered for the choice experiment. Taking the full factorial design for three alternatives (A, B, C and D), each with two attributes with two levels, one attribute with three levels, one with four levels, we obtain ($4x3x2^2)^4$ different treatment combinations.

Table 46: Selected attributes for the choice experiment

Attributes	Levels	Description of the levels
Price(INR)	4	10, 20, 40, 60
Source	3	MSW, Faecal Sludge, Both (MSW + FS)
Certification	2	Yes, No
Pelletization	2	Yes, No

An experimental design technique was used for the final design (Louviere et al. 2000) and implemented with the SAS software. Pair-wise combinations of attributes were randomly blocked to eight groups of eight choices using a blocking factor. Therefore, each of the randomly selected farmers was presented with eight choice set, as shown in the example of choice set (Table 47). The respondents were required to indicate their preferred choice on each choice set, which contained alternatives A, B, C, D and E (status quo) "no change" option. The respondents were provided with detailed description of the benefits and costs of compost made from organic waste.

Table 47: An example of a choice set presented to the respondents

Compost Attributes	A	B	C	D	E
Price (INR/kg.)	20INR/kg	40INR/kg	10INR/kg	60INR/kg	If options A, B, C and D were all that was available at my local farm input shop I would not purchase compost from that shop.
Source	Faecal Sludge	Both	MSW	Faecal Sludge	
Pelletization	Yes Pellet	No Pellet	Yes Pellet	No Pellet	
Certification	Not certified	Certified	Certified	Not certified	
I would choose. .	○	○	○	○	○

The choice experiment survey was conducted in 2013 in Bangalore. Respondents for this study were randomly sampled from farmers in various locations. The farm household heads in the selected sample were provided with different composts as explained in Table 47 above, and the respective attributes were clearly explained to them before any interview. A sample of 52 farmers were interviewed in Bangalore for the study. However, from the total sample surveyed, only one respondent provided a protest response and hence refused to respond to the CE sets for compost, and there were no respondents with zero WTP by constantly selecting the status quo option in all the 8 choice sets presented. Therefore, a total of 51 farmers fully completed the survey, which included either option A, B, C, D or option E, and thus provided a total of 408 (51*8) valid observations for choice model estimation.

3.5.1.3 Results and Discussion

- **Socio-economic characteristics of farming households**

The survey results show that the farmers interviewed were from all age groups and have at least some basic education with about 6% having a university degree. Also most of the farmers are from a large household and have an annual income between 1,000-10,000 rupees[31]. Table 48 presents the full socio-economic characteristics of the farmers.

Table 48: Socio-economic characteristics of farmers

Variables	Description	Frequency	%
Education	No formal education	27	41.0
	Primary school	9	13.6
	Secondary School	24	36.4
	Technical/training college	2	3.0
	University	4	6.1
Age	less 35	11	16.7
	36-45	14	21.2
	46-55	14	21.2
	56+	27	40.9
	between 2-4	26	39.4

[31] This was noted to be unusually low. This result may be biased as the respondents were in general reluctant to reveal their income.

household size	between 5-8	35	53.0
	8+	3	4.5
Income	1000-10000	21	61.8
	10000-20000	7	20.6
	20000+	6	17.6
farming experience	between 5-15	8	12.1
	between 16-30	24	38.7
	between 31-45	24	38.7
	45+	6	9.1
Housing type	Adobe house	2	3.0
	Brick house	46	75.4
	Concrete house	13	21.3

- **Current use of organic fertilizers**

Most of the farmers were noted to currently use chemical fertilizer, cow manure and compost. The farmers use these inputs mainly to improve soil quality, increase crop yields and to maintain the soil for agricultural productivity. The survey results also showed that most of the farmers use these inputs annually and about 12 farmers apply these inputs either twice or three times per year. Retailers are the major inputs suppliers for the farmers and as expected 75% of the farmers do not care about the source of these inputs. It is interesting to note that 70% of the farmers prefer Indian inputs and these farmers indicate that it would be beneficial if local inputs are used to manufacture the appropriate soil inputs. However, the demand for the Indian soil inputs would be constrained by either low quality product (66.7%) or high prices (75.8%). Farmers were more concerned about the price of soil inputs because 63% have observed that over the least five years, input prices have been increasing and this has affected their farming activities. In addition, the survey results showed that about 33% of the farmers have currently use/ have used compost before while most farmers have not. For the users, compost was obtained from either retailers or from their own farm. Of the 33% of the farmers, most of them do not use enough compost while 28% of them obtained enough compost for their farming activities. However, no farmer has being able to sell compost in the study area.

As expected, chemical fertilizer is the main soil input for farmers. Several attributes were used to evaluate farmers' preferences when purchasing chemical fertilizer. These attributes were ranked from 1 being the lowest to 5 with the highest value. The survey results revealed that farmers valued all these attributes but price, sources and type of fertilizers were the main attributes that influenced their decisions (Table 49). These results suggested that these attributes were relevant for policies and investment decisions on a new product such as compost. The ability to incorporate these attributes into the development of compost for the market is essential.

Table 49: Farmers preferences for fertilizers

Attributes	Ranking (Lowest to Highest)						
	3		4		5		
	Freq.	%	Freq.	%	Freq.	%	Total
Price	2	3.85	35	67.31	15	28.85	52
N-P-K content	27	55.10	16	32.65	6	12.24	49

Source of water/material used	7	13.46	41	83.67	4	8.16	52
Sanitary certification	28	53.85	15	30.61	9	18.37	52
Type(organic/inorganic)	15	28.85	33	67.35	4	8.16	52
Origin	24	46.15	22	44.90	6	12.24	52

- **Factors influencing consumers' purchasing behaviour**

The preceding section shows that farmers' value attributes such as price, sources of the product and type of fertilizers, and whether it is organic or inorganic. The section also seeks to evaluate the factors that drive farmers' decisions when purchasing these inputs. In this regard, several questions were used to analyze farmers' decision making in purchasing fertilizers for farming activities. Contrary to expectations, the survey results revealed that most of the farmers were uncertain as to how these factors affected their purchasing decisions. About 94% of the farmers indicated that suitable credit is not a significant variable in their decision making. This result tends to confirm the lack of credit systems for agricultural activities in the study area. Intuitively, this result suggests that farmers mostly rely on their own financial sources or obtain financial support from relatives. Thus, this factor is not a significant variable in their decision making processes. However, farmers were able to confirm that price, nutrient contents, safety, organic matter contents, brand name and packaging certainly influence their purchasing decisions (Table 50).

Table 50: Ranking of factors that could affect farmers purchasing decisions

Questions	Ranking (lowest to highest)						
	3		4		5		
	Freq.	%	Freq.	%	Freq.	%	Total
Price is the most important characteristic			4	8	46	92	50
Nutrient content is the most important characteristic	2	3.92	1	1.96	48	94.12	51
Organic matter which enhances soil quality is the most important characteristic	14	27.45	16	31.37	21	41.18	51
Carbon content and water holding capacity are the most important characteristics	30	61.22	16	32.65	3	6.12	49
Safety is the most important characteristic	13	25.00	3	5.77	36	69.23	52
Packaging is the most important characteristic	19	37.25	15	29.41	17	33.33	51
A label showing the fertilizer is certified by relevant authorities (specify) is the most important characteristic	36	70.59	14	27.45	1	1.96	51
Brand name is the most important characteristic	26	50.00	13	25.00	13	25.00	52
Suitable credit offer is the most important characteristic	49	94.23	3	5.77	0	0	52
A convenient location to buy the product is the most important characteristic	51	98.08	1	1.92		0	52
Volumes to apply are my main concern	50	96.15	2	3.85		0	52
Application method is the most important	51	98.08	1	1.92		0	52
Recommended by sources I trust	52	100.00		0		0	52
I know someone who has used it	52	100.00		0		0	52

- **Knowledge, attitude and perceptions of farmers towards compost**

Previous studies have also shown that farmers' perceptions positively influence their willingness to pay for compost (Danso et al., 2006). To assess the perception of farmers, a rating scale from 1 to 5 was adopted. Overall, 15 questions were used and farmers had the option to agree or disagree with any of the statements based on their knowledge, attitudes and perceptions about soil inputs. The analysis was conducted in the frame that farmers' demand for soil inputs could be affected by how they perceived the benefits and costs of the product. The survey results show that most of the farmers could evaluate the benefits and costs of these products with these questions. Some farmers had limited to no preference for compost made from faecal sludge and to increase their demand, it would be necessary for the product to be certified by an appropriate government authority. Farmers also indicate that they would avoid compost made from faecal sludge even if it is pelletized (Table 51). Conversely, farmers reveal that pelletized compost is preferred to powdered form of any compost. Overall, these results tend to suggest that farmers value compost as an organic input for farming. The results show that farmers are aware of the health risks associated with the use of faecal sludge for compost and some actually prefer to pay less for this product. This result is evident, when farmers try to avoid the product even when it is pelletized. Conversely, faecal sludge compost that is pelletized and certified by a trusted government agency is more likely to be purchased by farmers compared to compost without these attributes.

Table 51: Farmers' knowledge, attitude and perception of compost

	Ranking (lowest to highest)					
Evaluation questions	1	2	3	4	5	Total
	%	%	%	%	%	
Benefits and costs of using compost derived from faecal sludge	1.96	0	62.75	5.88	29.41	51
Benefits and costs of using compost derived from MSW	3.85	1.92	63.46	0.00	30.77	52
No reservation for accepting and using compost from faecal sludge	2.08	0.00	58.33	0.00	39.58	48
No reservation for accepting and using compost derived from MSW	4.08	4.08	51.02	26.53	14.29	49
Compost with Faecal sludge should be certified by relevant authorities	5.77	7.69	75.00	9.62	1.92	52
Compost derived from MSW should be certified by relevant authorities	1.92	1.92	69.23	21.15	5.77	52
faecal sludge certified by the relevant authorities ,it can be trusted	1.96	1.96	88.24	7.84	0.00	51
MSW is certified by the relevant authorities ,it can be trusted	1.52	1.52	75.76	21.21	0.00	66
Compost can be pelletized	0.00	0.00	88.46	9.62	1.92	52
Any pelletized soil input is better	1.92	1.92	94.23	1.92	0.00	52
buy compost made with MSW and FS if it was 20% cheaper than other	1.92	3.85	94.23	0.00	0.00	52
I buy compost made with MSW and FS if it was 10% cheaper than other	1.92	1.92	96.15	0.00	0.00	52
Regardless of price ,I try to avoid pellets derived from faecal sludge	1.92	1.92	71.15	0.00	25.00	52
compost which contributes to reduction of environmental degradation	1.92	3.85	94.23	0.00	0.00	52
I would prefer the pellet form over the powder form for any compost	0.00	40.00	60.00	0.00	0.00	5

- **Willingness-to-pay (WTP) for MSW-based compost**

This section presents the results of the choice experiments. A conditional logit (CL) model was used to capture the effect of various attributes. Two models are presented in this section. The first model deals with the impact of the attributes on choice and the second one incorporates interactions between the attributes and selected socio-economic variables as well as perception variables. The first model shows the importance of the attributes in explaining respondents' choices across five different options in a choice set. The second model is an extended model which includes the socio-economic variables interacted with the attribute variables. The dependent variable in the CL is the choice of compost from faecal sludge. Respondents were given four packages of compost, with different prices, production and quality attributes and asked to choose one option. In total, there were 8 choice sets for each respondent. The key attributes selected for the CL model were: price, source, pelletization and certification. The basic model focuses on these three attributes. The indirect utility from the proposed compost options with quality improvement would take the following form:

$$V_i = \beta + \beta price + \beta source + \beta pellet + \beta cert \qquad (1)$$

where V_i is the indirect utility for five alternatives; β refers to the alternatives specific constants and $\beta price$, $\beta source$, $\beta pellet$ and $\beta cert$ are the coefficients associated with the attributes payment for quality compost with information on source, pelletization and certification. The definitions of these variables are provided in Table 52. In the basic model, the homogeneity of preferences of individuals is assumed. However, preferences may in fact be heterogeneous. Thus, to have unbiased estimates of individual preferences, the heterogeneity was accounted for (Birol et al. 2005). In this study, an interaction of the socio-economic variables was used to correct this issue. To avoid multicollinerity issues, there is no need to interact these variables with the alternative specific constant terms, thus $\beta = 0$. The socio-economic variables could not be introduced alone into the model since Hessian singularities would be encountered in model simulation (Bennett and Blamey, 2001). In this study, the socio-economic variables such as education, and income were interacted with attributes in the choice set. The indirect utility function in this case takes the following form:

$$\begin{aligned} V_i = {} & \beta + \beta price + \beta source + \beta pellet + \beta cert + b1(source * educa) + b2(source * income) + \\ & b3(source * per1F) + b4(source * pp1F) + b5(pellet * educa) + b6(pellet * income) + \\ & b7(pellet * per1F) + b8(pellet * pp1F) \end{aligned} \qquad (2)$$

where i =1,2,3,4 and 5 for the five scenario options; 0 for the status quo and 1 for all other options. Having these additive forms of indirect utility specification, the CL model is estimated for equation 1 and 2. Table 52 presents the variables, summary statistics and their respective definitions. A reliability test is performed on the perception variable to determine the alpha value before including it in the CL model. The test shows an alpha value of 0.839 and 0.845, which indicates that the variables used to measure perception are reliable. Subsequently, a principal component analysis (PCA) was used to extract the key questions that measure perception better. The PCA resulted in four components but only significant ones were used in the CL model.

Table 52: Summary statistics of key socio-economic variables in the conditional logit model

Variable	**Definition**
Education	Education of the farmers and interactions with pelletization (educaP) and source(educaS) attributes

Age	Age of the farmer in years and interactions with pelletization (AgeP) and source(AgeS) attribute
Hhsize	Household size categorized as large (1) and small (0)
Purchasing factors	Factors affecting farmers purchasing decisions. Final values obtained from the principal component analysis (PCA): Question used is price is the most important factor. Defined as PP1F for source and PP1F1 for pellet.
Perception variables	Perception of compost with faecal sludge. Final values obtained from the principal component analysis (PCA): Question used is compost can be pelletized. Measure perception interactions with pelletization (Per1F1) and source (per1F) attributes

Table 53 presents the base and full CL model results. Using 408 observations elicited from 51 respondents, the CL model with linear specifications in attributes is estimated using LIMDEP 9.0 NLOGIT 5.0 for the basic and full models. The base model deals with only the attributes of the compost option while the full model considers both the attributes and their interactions with the socio-economic variables. Neither of these models includes a parameter to estimate the alternative specific constant term; including this term introduces high multi-collinearity into the model (Arnot et al. 2006). The specifications including the additional interaction terms conform more closely to theory and also performs better in terms of goodness-of-fit as indicated by log-likelihood and McFadden-R^2 measures (Table 53). The comparison of the McFadden R^2 and the log-likelihood scores reveal that in both cases, model 2 is superior in explanatory power than model 1. In the CL for model 1, the McFadden R^2 is 0.109 for model 1 compared to 0.148 of model 2. The coefficient on price is negative and highly significant (p=0.000), which holds with prior expectations that the price and probability of compost purchase would be negatively correlated. This result is consistent across all two models (Table 53). The negative sign of the payment coefficient indicates that the effect on utility of choosing a choice set with a higher payment is negative. In other words, scenario improvements with 'cheaper' alternatives are preferred to 'expensive' alternatives. All the coefficients of the attributes are significant at 1% level and the signs of attributes are as expected. With the base model for compost, farmers appreciate high quality compost type which is pelletized and also care about source of organic material used to produce compost. This indicates that the probability of purchasing compost is highly affected by whether it is pelletized and made with faecal sludge or not. In model 1, farmers are willing to pay more to know the source of materials used to produce compost compare to pelletized compost. Conversely, with model 2, farmers are willing to pay more for pelletized compost (Table 54).

Table 53: Conditional logit model for compost choices

	Base model 1		Full model 2	
Variables	Coefficient	Std. Error	Coefficient	Std. Error
Price	-0.049***	0.004	-0.051***	0.004
Source	0.566***	0.065	0.706***	0.204
Pellet	0.445***	0.102	0.656***	0.321
Cert	0.071	0.103	0.110	0.105
AgeS			-0.003	0.003
AgeP			0.009**	0.004
HHSizeS			-0.004	0.027
HhSizeP			0.006	0.043

EducaS		0.002	0.051
EducaP		-0.222***	0.080
Per1F		-0.158**	0.071
Per1F1		-0.033	0.113
PP1F		-0.041	0.695
PP1F1		0.293***	0.108
Log-likelihood	-489.303		-473.205
McFadden R2	0.128		0.156
AIC	986.6		974.4
Number of obs.	400		400

Since the socio-economic variables do not change over choice sets, they were interacted with alternative attributes. After several model specifications, education is found to be a significant variable for pelletized compost. This result indicates that as years of education increases, the probability of choosing high pelletized compost option decreases, *ceteris paribus*. Farmers' willingness to pay for source and pelletization attributes are highly affected by purchasing decision factors and perception variables. To validate this claim, a principal component analysis (PCA) was conducted with 15 questions to understand farmers purchasing decisions. The PCA proved that four sub-questions would be a better measure of factors affecting farmers purchasing decisions. However, only one question is significant in the CL model- that is price is the most important variable (PP1F). The CL model shows that respondents' choice decisions could be affected by the price of substitute's products as well. This result is significant only when the pelletization attribute is factored into compost production. A similar analysis was conducted for questions that seek to measure farmers' perception on compost and the PCA showed that the question on source of materials used to prepare pelletized compost was equally important (Per1F). Both purchasing decision factors and perception variables were noted to negatively affect farmers willing to pay to know the source of materials used to produce compost. These results suggest that the demand for compost is likely to decrease as farmers get to know that faecal sludge is used in producing compost for the market. This result is consistent for farmers' perceptions on pelletized compost as well. However, farmers purchasing decision factors positively affect demand for pelletized compost.

- **Estimated WTP and marginal WTP for attributes for MSW-based compost**

The results from the CL models were used to estimate the rate at which farmers are willing to trade-off one attribute for the other (Table 54). In the CL model, there are monetary considerations for the scarified attributes and the trade-off estimated is known as marginal willingness to pay for the attribute in question (Bennett and Blamey, 2001; Agimass and Mekonnen, 2011). It indicates the amount of money farmers are willing to pay for an improvement in a product attribute. It is important to note that the marginal willingness to pay analysis can play a significant role in business decision making and policy making as well. Basically, the comparison of the marginal WTP of different attributes provides some understanding of the relative importance of attributes. With this type of information, decision makers will be better placed to design resource use alternatives (Agimass and Mekonnen, 2011).

Table 54: Marginal WTP estimates for compost

Compost types		Compost	
Model		Model 1	Model 2
Willingness to pay source	(wtpS)	1.458	2.747
willingness to pay for pelletization	(wtpP)	5.359	21.859
Willingness to pay certification	(wtpC)	14.397	

In Table 55, the WTP is calculated as the negative ratio between the coefficients of an attribute to the price coefficient. The results indicate that farmers are willing to pay 1.458 INR/kg more to know the source of the waste input used to produce the compost; and an even higher premium of 5.359 INR/kg for pelletization and 14.397 INR/kg for certification. Nutrient content and quality which have direct positive effects on farm yields and profits are preferred attributes. Given these marginal estimates, the full analysis shows the estimated WTP for compost to be 61.214 INR/kg, which is significantly higher than the current market of competitive products.

Table 55: Marginal WTP estimates for compost and estimated total price of high quality compost

					Estimates from conditional logit model(INR/kg) - Model 1			
	Current market prices(INR/kg)				**Attributes**			
Soil input	Min	Max	Mean	Std. dev	Marginal WTP for source (INR/kg)	Marginal WTP for pelletization (INR/kg)	Marginal WTP for certification (INR/kg)	Total price of compost (INR/kg)
Compost	10	60	40	22.17	1.458	5.359	14.397	61.214

- **Estimated market demand for MSW-Compost**

The analysis shows that there is a significant demand for MSW compost and Fortifer. The potential market for MSW-compost is noted to be substantial with the demand estimated at 578,400 tons/year, with an adoption rate of 20% and application rate of 12.5 tons/ha/year. The total cultivated area is 231,377 ha[32]. It is important to note that MSW-based compost in considered as a complementary product to chemical fertilizer.

[32]http://agcensus.dacnet.nic.in/districtT1table1.aspx

B. Model 17: High value Fertilizer Production for Profit (Faecal sludge to compost)

This section presents the results for the WTP and market size estimation for faecal sludge-based compost (termed here as *Fortifer*). Model 17 is similar to Model 15 in concept but in addition to MSW, this business model uses faecal sludge as an input from onsite sanitation systems which is rich in nutrients. There are opportunities for pelletization and blending of faecal sludge-based compost with rock-phosphate, urea/struvite or NPK which is an additional value proposition that can be explored under this business model, allowing the product to have nutrient levels specific for target crops and soils, and a product structure improvement (pellets) to improve its competitive advantage, marketability and field use.

3.5.2 Willingness-to-pay and Market Estimation

3.5.2.1 Background and Justification

This sub-section focuses on the promotion of high quality faecal sludge-based compost in Bangalore, India. As noted in the MSW-based compost section, agricultural production contributes immensely to the livelihoods of farmers in urban and peri-urban areas in Bangalore, India. Recent changes in climate patterns has resulted in farmers facing exacerbated challenges with access to basic farming inputs such as water, land and fertilizers. Particularly, farmers have deal with increasing land degradation and related fertilizer costs. Previous research shows that the use of compost provides significant benefits to farmers and has the dual benefit of reducing public budget allocated to waste management, particularly waste collection and treatment (Danso and Drechsel, 2014). Large municipalities and towns generate vast quantities of waste that are rich in valuable resources, e.g. nutrients with great potential for agricultural production. Faecal sludge reuse, in particular, has been found to offer several benefits: a) providing options for municipalities to recover waste management costs, b) business opportunities where enterprises can produce high value organic fertilizer for sale at a profit, and c) advancing the goal of sustainably transforming agricultural production via the promotion of organic agriculture through the gradual replacement of chemical fertilizer with more sustainable and affordable options such as organic fertilizers. Like any new product, the introduction of Fortifer on the market, requires businesses to adequately assess the market so as to make strategic business decisions concerning pricing and marketing. Thus, similar to the previous business models, the introduction of Fortifer in the fertilizer market will require an assessment of the consumers' WTP and the potential market size. This will serve to better inform future investors on the appropriate pricing and marketing strategies to implement and also the optimal production capacity at which to operate. The objectives of this sub-section is to use a choice experiment (CE) approach to:

1. Estimate farmers' WTP for Fortifer;
2. Estimate farmers' WTP for attributes of Fortifer;
3. Estimate the potential market demand for Fortifer.

The subsequent sub-sections outline the research methods, data collection and analytical assumptions, results and finally the policy implications of the assessment.

3.5.2.2 Research Methods and Data Collection

The theoretical framework is as detailed out for the MSW-based compost, which uses a CE based on Lancaster's consumer choice theory and random utility theory developed by McFadden in 1974. Thus, it

is assumed that in any CE, farmers will select an option from many choices, provided the selected option has attributes that provide them with the maximum utility.

The Choice Experiment Design

In addition to the estimation of the farmers' WTP and potential demand, the analysis also evaluated farmers' preferences towards diverse attributes of Fortifer. The primary step of the research was to select applicable attributes, which was based on a literature review and in collaboration with local partners. Given the difficulties associated with the exact changes in the attributes' features, the levels of choices were qualitatively presented. The fortification attribute is defined as a co-composted product from MSW and faecal sludge blended with rock-phosphate, urea/struvite or NPK, allowing the product to have nutrient levels specific for target crops and soils. And the pelletization attribute represents a product structure improvement (pellets) to improve its competitive advantage, marketability and field use. The price levels used for the choice experiment were provided by the local partners and based on current market prices. The payments were derived using the local market prices of the chemical fertilizers. Table 56 below shows the selected attributes and their levels used in the study. Considering the attributes and their levels a full-factorial design was considered for the experiment. This yielded (4*2*2*2 = 32) 32 choices which were combined randomly into 8 blocks. Each of these 8 blocks (choice sets) thus had 4 alternatives randomly selected from the 32 designs along with an '*opt-out´* (*status-quo*) alternative. Therefore, each of the respondent were shown 8 choice sets which contained 5 alternatives each. The respondents had to make a choice from each of the 5 alternatives for each of the choice set and hence 8 choices in total form the 40 choices shown to them. An example of the choice set is shown in Table 57.

Table 56: Selected attributes for the compost choice experiment

Attribute	Levels	Description
Price (INR/kg)	4	20, 35, 50, 65
Fortification	2	Yes, No
Pelletization	2	Yes (pelletized), No (powder form)
Certification	2	Not certified, certified

Table 57: Example of choice set presented to farmers

Compost Attributes	A	B	C	D	E
Price (INR/kg)	INR65/kg	INR35/kg	INR20/kg	INR50/kg	If options A, B, C, and D were all that was available at my local farm input shop I would not purchase Fortifer
Fortification	No	Yes	Yes	No	
Pelletization	Not Pelletized	Pelletized	Pelletized	Not Pelletized	
Certification	Not certified	Certified	Certified	Not Certified	
I would choose	○	○	○	○	○

The choice experiment survey was conducted in 2013 in Bangalore. Respondents for this study were randomly sampled from farmers in various locations. The farm household heads in the selected sample were provided with different composts as explained in Table 57, and the respective attributes were clearly explained to them before any interview. A sample of 51 farmers were interviewed in Bangalore for the

study but only 48 respondents fully completed the surveys. Since each farmer was presented with 8 choices, a total of 384 (48*8) valid observations were obtained from the primary survey conducted for the choice model estimation.

3.5.2.3 Results and Discussion

- **Socio-economic characteristics of respondents**

The survey results show that the farmers interviewed were of a wide range of age groups and have at least some basic education with about 10% having a university degree. Almost 53% farmers had a farming experience between 16-30 years.

Table 58: Socio-economic characteristics of farmers

Variables	Description	Frequency	%
Education	No formal education	15	30.0
	Primary school	10	20.0
	Secondary School	15	30.0
	University	5	10.0
Age	less 35	7	14.0
	36-45	15	30.0
	46-55	9	18.0
	56+	16	32.0
Income	1000-10000	4	8.0
	10000-20000	7	14.0
	20000+	1	2.0
farming experience	between 5-15	6	12.1
	between 16-30	26	52.0
	between 31-45	8	16.0
	45+	4	8.0

- **Current use of organic fertilizers**

Most of these farmers were noted to currently use chemical fertilizer, cow manure and compost. The farmers used these inputs mainly to improve soil quality, increase crop yields and to increase/ maintain soil productivity. Chemical fertilizers - key soil input, were purchased from the retailers by the farmers. The results also showed that most of the farmers used these inputs annually and about 27% of the farmers applied these inputs either twice or three times per year. It is interesting to note that 97% of the farmers prefer Indian inputs and these farmers indicate that it would be beneficial if local inputs are used to manufacture the appropriate soil inputs. Farmers were concerned about the price of soil inputs as 54% of the respondents observed that over the least five years, input prices had continuously increased and thus

affecting their farming activities. As expected, chemical fertilizer is the main soil input for farmers. Several attributes were used to evaluate the farmers' preferences when purchasing chemical fertilizer. These attributes were ranked from 1 being the lowest to 6 with the highest value. The results revealed that farmers valued all these attributes but price and sources of fertilizers were noted to be the main attributes that influenced their decisions (Table 59). It is interesting to note that mixed responses were obtained in terms of certification of the fertilizer, nutrient content and origin of the fertilizer. The ability to incorporate these attributes into the development of compost for the market is essential. The results suggest that these attributes will be important for product development and invariably the decisions that investors make.

Table 59: Ranking of fertilizer attributes by the farmers

	Ranking (lowest to highest)					
	4		**5**		**6**	
Attribute of fertilizers	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
Price	1	2	29	58	40	20
N-P-K content	20	40	16	32	28	14
Source of waste	6	12	33	66	22	11
Certification	17	34	15	30	36	18
Type (Organic/Chemical/Mixed	10	20	32	64	16	8
Origin (Indian/Imported)	19	38	16	32	30	15

- **Factors influencing consumers' purchasing behaviour**

This section seeks to evaluate the factors that drive farmers' decisions when purchasing these inputs. In this regard, several questions were used to analyze farmers' decision-making in purchasing fertilizers. Contrary to mixed responses obtained during the ranking of the attributes, the results revealed that most of the farmers were concerned about the NPK content of the product that they purchased. The farmers also confirmed price to be an important factor in their purchasing decisions. Safety of the fertilizer products was also noted as an important attribute to the farmers as reported by 66% of the surveyed farmers. Overall, the farmers were indifferent about most of the remaining explanatory variables used to identify their purchasing decisions (Table 60).

Table 60: Ranking of factors that could affect farmers purchasing decisions

Evaluation statements	**Likert-scale ranking**		
	Neutral	**Agree**	**Strongly Agree**
	%	**%**	**%**
Price is the most important characteristic	0.0	6.0	88.0
NPK levels content is the most important characteristic	4.0	4.0	92.0
Organic matter is the most important characteristic	22.0	44.0	32.0
Carbon content and water holding capacity are the most important characteristic	40.0	50.0	4.0
Safety is the most important characteristic	20.0	14.0	66.0
Packaging is the most important characteristic	58.0	18.0	22.0

A label showing the label is certified by relevant authorities is the most important characteristic	76.0	20.0	2.0
Brand name is the most important characteristic	60.0	20.0	20.0
Suitable credit offer is the most important characteristic	66.0	6.0	28.0
A convenient location to buy the product is the most important characteristic	94.0	6.0	0.0
Volumes to apply are my main concern	94.0	6.0	0.0
Fertilizer application method is the most important	94.0	6.0	0.0
Recommended by sources I trust	96.0	4.0	0.0
I know someone who has used it	96.0	4.0	0.0

- **Knowledge, attitude and perceptions of farmers towards organic fertilizers**

Previous studies have shown that farmers' perceptions influence their willingness to pay for compost (Danso et al. 2006). To assess the perception of the farmers, a rating scale from 1 to 5 was adopted. Overall, 10 questions were used and farmers had the option to agree or disagree with any of these questions based on their knowledge, attitudes and perceptions about soil inputs. The analysis was conducted from the basis that farmers demand for soil inputs can be affected by how they perceive the benefits and costs of the soil input product they use. The results showed that most of the farmers could evaluate the benefits and costs of these products with these questions. Some of the farmers were not interested in using Fortifer (compost made from faecal sludge) but noted that their demand would change/increase if the product was certified by an appropriate government authority. The farmers also indicated that they not prefer to use compost made from faecal sludge even if it was pelletized (Table 61). Conversely, while some farmers revealed that pelletized compost was preferred to the powdered form of any compost they had a limited preference for certification. Overall, these results tend to suggest that farmers value Fortifer as an organic input for farming and are willing to buy Fortifer if it was priced close to chemical fertilizers. However, the results show that the farmers are quite concerned about the health effects from using Fortifer. This is in line with the fact that they also expressed their concern for 'safety' when they were asked to rank the fertilizer attributes.

Table 61: Farmers Attitude, knowledge and perception of compost

Statement	Five-level Likert scale				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
	% of surveyed respondents	% of surveyed respondents	% of surveyed respondents	% of surveyed respondents	% of surveyed respondents
I am aware of the advantages and disadvantages of using fertilizer derived from FS	0.0	4.0	40.0	18.0	36.0
I do not have any reservation for accepting and using fertilizer derived from FS	6.0	12.0	40.0	20.0	20.0
Fertilizer derived from FS should be certified by relevant authorities	0.0	2.0	58.0	34.0	4.0
If Fortifer is certified by authorities it can be trusted	4.0	4.0	52.0	24.0	6.0

Despite attractive appearance, it is not safe to use fertilizer pellets derived from FS	8.0	8.0	64.0	6.0	12.0
I would buy Fortifer if it was sold at the same place as chemical fertilizer	6.0	14.0	52.0	24.0	2.0
I would buy Fortifer if it was 20% cheaper than chemical fertilizer	6.0	14.0	70.0	6.0	0.0
I would buy Fortifer if it was 10% cheaper than chemical fertilizer	6.0	12.0	78.0	0.0	0.0
Regardless of price I try to avoid buying fertilizer pellets derived from FS	0.0	4.0	72.0	20.0	2.0
I would use Fortifer as it contributes to improvement in sanitation	4.0	12.0	82.0	0.0	0.0

- **Willingness-to-pay (WTP) for Fortifer**

A conditional logit model was used to estimate the farmers' preferences for different attributes of the the Fortifer product. Two different models were estimated - (i) which solely focused on the effects of the attributes on the choices of the farmers, and (ii) which included the interactions of the socio-economic variables and the perception variable of the farmers along with the attributes used in the choice experiment. The respondents were given eight choices sets each of which had five alternatives. The dependent variable used is: the choice of Fortifer attribute (like pellet form or certification). The farmers were given four options of the Fortifer with different prices and whether certified or not and in pellet form or not. The last option put forth was an opt-out (or status quo) option. Therefore, the key attributes of the choice model were: prices, fortification, pellet form and certification. It was hypothesized that all these attributes except that of the price would have a positive effect on the farmers. The basic model in terms of the attributes can be written as -

$$V_i = \beta + \beta fortifier + \beta pellet + \beta certification - \beta price \quad (1)$$

The above equation can be interpreted as:- V_i is the indirect utility function for the five alternatives, β is the alternative specific constant and other coefficients help in estimating the marginal utility/ WTP based on the price coefficient (method of estimation explained later). In the estimation however, the constant term was not included which is more applicable for the labelled design. In the second model as had been stated earlier, the socio-economic variables were interacted with the attributes of the choice experiment primarily with the intention to understand the variables which influence the choice of the attributes. In all total eight interaction variable were used for the estimation which was derived after considering different models and simultaneously checking the log-likelihood values, pseudo-R^2, AIC and BIC values. The indirect utility function of the second model can be stated as –

$$V_i = \beta + \beta fortifier + \beta pellet + \beta certification - \beta price + \beta edu * fort + \beta p\_chem\_fert * Price + \beta\ age * price + \beta\ safety * price + \beta aware\_adv\_disdv * price + \beta use * fort + \beta\ use * pel + \beta\ use * price$$

The above equation shows that only two socio-economic variables were used as interaction variables – age and education, the rest were all perception variables. The following Table 62 describes the interaction variables used in the interaction model:

Table 62: Summary statistics of key interaction variables in the conditional logit model

Variable	Definition
edu*fort	Education profile of the farmers was interacted with the Fortifer attribute. This was used to understand whether education (used a proxy towards Fortifer) leads to willingness in use of Fortifer
age*price	Age of the farmers was interacted with the price attribute. This was used to understand how farmers age played a role in willingness to pay for the Fortifer
p_chem_fert*price	Perception of the farmer to use Fortifer if price of Fortifer matches the price of chemical fertilizer is interacted with the price attribute of the choice experiment. This was used to get an understanding that if prices were set according to the market prices of the chemical fertilizers, how it affects the decision of the farmers while selecting the choices.
safety*price	Perception of the farmer regarding whether Fortifer is safe or not interacted with the price. As in the previous variable if the farmer reported as aware there might be health issues using Fortifer, does it affect their decision mainly the price attribute
aware_adv_disadv*price	Perceptions of a farmer about the advantages and disadvantages of fertilizer derived from faecal sludge was interacted with price to understand whether the awareness influences the farmer
use*fort	All of three variables were derived by interacting the farmers' decision to use fertilizer derived from faecal sludge with Fortifer, pellet forms and price. These variable would provide us an idea that if the farmers' were willing to use fertilizers obtained from faecal sludge whether they want it fortified, in pellet form and whether they were willing to pay for it.
use*pel	
use*price	

Table 63 presents the estimated conditional logit models. There was a total of 1910 valid observations. Ideally since 48 farmers fully completed the surveys and each of them presented with 8 choice sets to make a decision from 5 alternatives (in each of the choice set), the expected total number of observations was 1920 (48*8*5). However, 10 observations were dropped because of inconsistent choices. The table shows that the second model is more acceptable in terms of the log-likelihood value, pseudo-R^2, and the AIC and BIC values. A lower BIC vale along with a lower log-likelihood value and higher pseudo-R^2, implies a better fit of the model. For this reason, the second model was selected over the first model. The price variable has a negative sign in both the models and is also significant. The sign of this variable is as expected since it implies that the price of the Fortifer and probability of purchase is negatively correlated. This means that the effect on utility of choosing a choice set with a higher payment is negative. In other words, scenario improvements with 'cheaper' alternatives are preferred to 'expensive' alternatives. In model 1 all the other variables are positive except certification. This implies that while there is a preference for purchasing Fortifer in pellet form, farmers have lower valuation for certification. The certification attribute is not significant across the two models while the other attributes were considered to influence the utility of the farmers.

The results show that, when age is interacted with price - the variable has a positive sign and is significant, which implies that older farmers have a marginally higher preference for Fortifer and are interested in higher payments than their younger counterparts. When the education variable is interacted with price - the estimated coefficient has a negative sign although it is insignificant. This result suggests that farmers who are educated have a lower valuation of Fortifer. These farmers were noted to be concerned about

the potential health impact from the use of Fortifer. This result is confirmed by the fact that although farmers are aware about the advantages and disadvantages of Fortifer, they are willing to pay lesser as shown by a highly significant estimated coefficient. Farmers who were willing to substitute chemical fertilizers for Fortifer preferred cheaper alternatives than the expensive ones. This is confirmed by the results that show that the farmers who expressed that if Fortifer prices are set to market prices of the chemicals, they would consider switching over to Fortifer.

Table 63: Conditional logit model for Fortifer choices

	Base model 1		**Full model 2**	
Variables	**Coefficient**	**Std. Error**	**Coefficient**	**Std. Error**
Price	- 0.019***	0.002	- 0.034***	0.011
Pellet	0.318***	0.121	0.514***	0.151
Fortifer	0.612***	0.120	0.355	0.281
Cert	- 0.088	0.177	- 0.0267	0.122
age*price			0.0006***	0.053
p_chem_fert*price			0.010	0.006
safety*price			- 0.016**	0.007
edu*fort			- 0.084	0.094
use*fort			0.641**	0.271
use*pel			0.472*	0.258
aware_adv_disadv*price			- 0.043***	0.008
use*price			-0.004	0.009
Log-likelihood		-581.59	Log-likelihood	-486.04974
McFadden R^2		0.0540	McFadden R^2	0.1487
AIC		1171.195	AIC	1110.716
BIC		1193.415	BIC	1177.374
Number of obs		1910	Number of obs	1910

- **Estimated WTP and marginal WTP for attributes for Fortifer**

The results from the CL models were used to estimate the rate at which farmers are willing to trade-off one attribute for the other (Table 64). In the CL model, there are monetary considerations for the attributes and the trade-off estimated is known as marginal willingness to pay for the attribute in question (Bennett and Blamey, 2001; Agimass and Mekonnen, 2011). The WTP is calculated as the negative ratio between the coefficients of an attribute to the price coefficient. The interaction model estimated shows that WTP values correct the overestimation of the WTP vales calculated through the simple conditional logit model (Model 1).

The results indicate that farmers are willing to pay 10.63 INR/kg more for fortification and an even higher premium of 14.97/kg for pelletization. Interestingly, the farmers were however noted to have a lower valuation for the certification attribute and would need a compensation of 0.77 INR/kg for certification.

Nutrient content and quality which have direct positive effects on farm yields and profits are preferred attributes. It is important to note that the noted premiums are slightly lower when socio-economic variables are factored into the choice set. Given these marginal estimates, the full analysis shows the estimated WTP for fortified and certified Fortifer to be 67.06 INR/kg, which is significantly higher than the current market of competitive products.

Table 64: Marginal WTP estimates for Fortifer

Compost types	Compost	
Model	Model 1	Model 2
Willingness to pay for fortification	16.41	10.36
willingness to pay for pelletization	31.57	14.97
Willingness to pay certification	- 4.56	- 0.77

Table 65: Marginal WTP estimates for compost and estimated total price of Fortifer

					Estimates from conditional logit model(INR/kg) - Model 1			
	Current market prices(INR/kg)				**Attributes**			
Soil input	Min	Max	Mean	Std.dev	Marginal WTP for fortification (INR/kg)	Marginal WTP for pelletization (INR/kg)	Marginal WTP for certification (INR/kg)	Total price of Fortifer (INR/kg)
Compost	20	65	42.5	19.36	10.36	14.97	-0.77	67.06

- **Estimated market demand for Fortifer**

The potential market for Fortifer is noted to be substantial with the demand estimated at 54,249 tons/year, assuming an adoption of 40% and application rate of 0.59 tons/ha/year. The total cultivated area considered is 231,377 ha[33]. Chemical fertilizer application rates were used as a basis for the calculation of the application rates of Fortifer (IFPRI, 2012). The average chemical fertilizer applications were estimated at 117 kg/ha (DOA, 2014) and Fortifer at 5 times this estimate as Fortifer is considered a close competitive substitute product to chemical fertilizer.

3.5.3 Market Structure - Business Models 15, 16, 17 and 20

As the related products for the 3 business models under assessment do not as yet have an established market - informal (nascent sub-sector), they are all viewed from the fertilizer industry perspective. The respective market of key competitors, in this case, chemical fertilizer were considered for the market structure assessment.

3.5.3.1 Background and Justification

As noted in the WTP assessment, the increased need for organic fertilizer use is critical and beneficial on several levels: a) promotion of sustainable agriculture, b) recovery of waste management costs, and c)

[33]http://agcensus.dacnet.nic.in/districtT1table1.aspx

significant health and environmental benefits. Private sector participation in organic fertilizer production, however, greatly depends on the degree of freedom in the market structure (i.e. ease of entry and long-run sustainability). New RRR businesses can only be successful if their operations are fine-tuned to the existing market structure, which in turn influences their performance. Thus, new businesses require information on the characteristics of market structure to identify the existing opportunities to enter and further penetrate the market. Moreover, information on the existing level of competition in the market, characteristics of competitors and factors which drive the market's competitiveness or collusiveness are necessary for investment decisions. This also requires an evaluation of relevant actors' pricing and distribution strategies.

3.5.3.2 Research Methods and Data Collection

The structure-conduct-performance (SCP) approach was used for the analysis and details of the approach are outlined in the methodology section in chapter 2. The SCP approach typically measures how the market structure of industries vary, how different market structures influence the market conduct of firms and how their conduct influence their market performance. An overview of the organic fertilizer market in India, movement of organic agriculture and government policies for the fertilizer sector were evaluated. The SCP approach measures the structure of the market, the conduct and performance (profitability) of the relevant economic actors through the use of different indicators.

- **Structure:** The market structure of the fertilizer market is assessed based on the level of market concentration in the industry, for which data was extracted from already published findings due to data unavailability on market share of different actors. Additional market dimensions, such as product differentiation in the market and barriers to entry and exit were also evaluated.
- **Conduct:** The conduct of the players is studied by their price setting behaviour, factors or determinants of pricing of the fertilizer market, buying and selling practices and marketing and distribution strategies of actors.
- **Performance:** The performance along the supply chain was evaluated, via the assessment of cost incurred by key market players along the supply chain and actors' net margins.

Results of the SCP assessment was then used to draw inferences to better describe the structural feasibility of the RRR products. Data was obtained from existing secondary literature, organizational reports and websites on the fertilizer market sector. Information on prevailing pricing policies was sourced from the recent organizational reports on fertilizer market and relevant newsletters and ministerial websites. Additional information on the chemical fertilizer sector structure, organic agriculture sector and policy setting were also sourced from the above mentioned sources.

3.5.3.3 Results and Discussion

- **Overview of competitive products in the fertilizer market**
  - **Fertilizers**

Chemical fertilizers are regarded as key elements of modern technology and have had a significant role in agricultural productivity growth in India. Since the Green Revolution in the 1960s, the use and application of fertilizers has steadily increased and has more or less matured with moderate growth in their annual sales as noted from the secondary data. However, the demand-supply gap of fertilizers in India has increased in recent times, thereby leading to increased dependency on imports. Indian imports, which were about 2 million tons in early 2000s, increased to 10.2 million tons of fertilizers in 2008-09. India is the second largest consumer of fertilizers in the world after China, consuming about 26.5 million tons.

However, Sharma and Thaker (2011) note that the average intensity of fertilizer use in India remains much lower than most countries in the world but is highly skewed, with wide inter-regional, inter-state, and inter-district variations. Although during 1990s, total fertilizer consumption fluctuated between 12.15 and 16.8 million tons with the exception in 1999-00, when fertilizer consumption was over 18 million tons, the total fertilizer consumption reached a record level of 26.5 million tons during 2009-10.

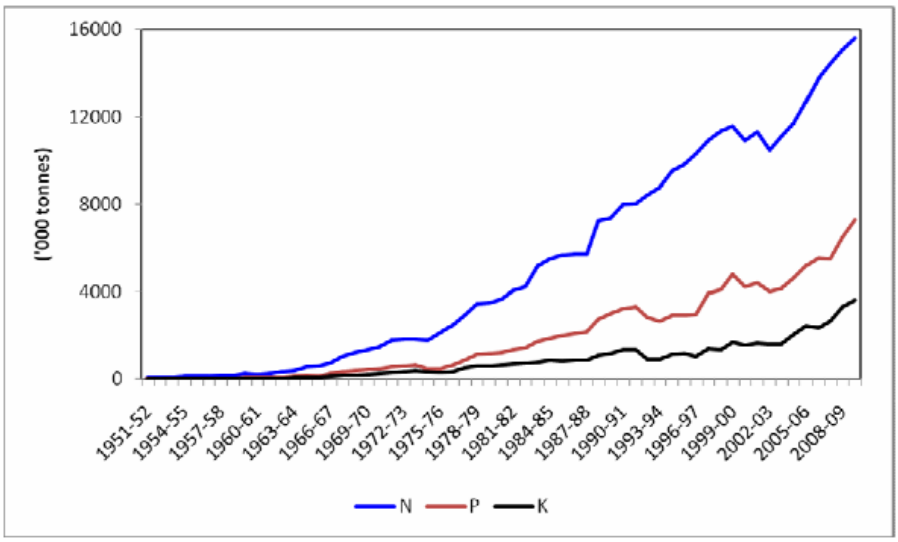

Figure 14: Trends in fertilizer consumption in India (from 1950-51 to 2009-10)

Source: Fertilizer Association of India (2010, In: Sharma and Thaker, 2011).

Irrigation being an important determinant of fertilizer demand and consumption, with continued emphasis of state governments on the development of irrigation for agriculture development, the demand for fertilizers in Indian economy is likely to grow further. However, India being a net importer of fertilizers, which is sold to farmers at subsidized prices by the government, promotion of any local substitute for fertilizers would prove beneficial to the country as a whole, and if such a substitute can contribute to the promotion of organic farming, it will be an additional advantage for sustainable development. If farmers can be educated on the virtues of such a substitute, its market penetration can be facilitated to that extent.

- **Organic compost**

The use of organic fertilizers from compost and dung has been very well established in rural India for decades. But this is done mostly informally by rural peasants, without the involvement of market exchange. However, in recent decades, they have received significant market acceptance and have been introduced with branding and certification, in some cases. They currently operate in a niche market with a close to premium pricing. Yadav (2013) notes the trends in organic management across the country. It is revealed that with only 42,000 ha under certified organic farming during 2003-04, organic agriculture has grown almost 29 fold during the last 5 years. By March 2010, India has about 4.48 million ha area under organic certification process (Yadav, 2013). It is reported that there were about 597,873 small and marginal farmers. Of the total organic producers in the world, approximately 50% of them are from India. With organic farming gaining acceptance and popularity globally, the market prospect for organic fertilizers is expected to grow/increase exponentially. Organic fertilizer products are thus considered to

be in the growth stage. This represents opportunities for new MSW-based compost and Fortifer businesses to capture a share of the fertilizer market.

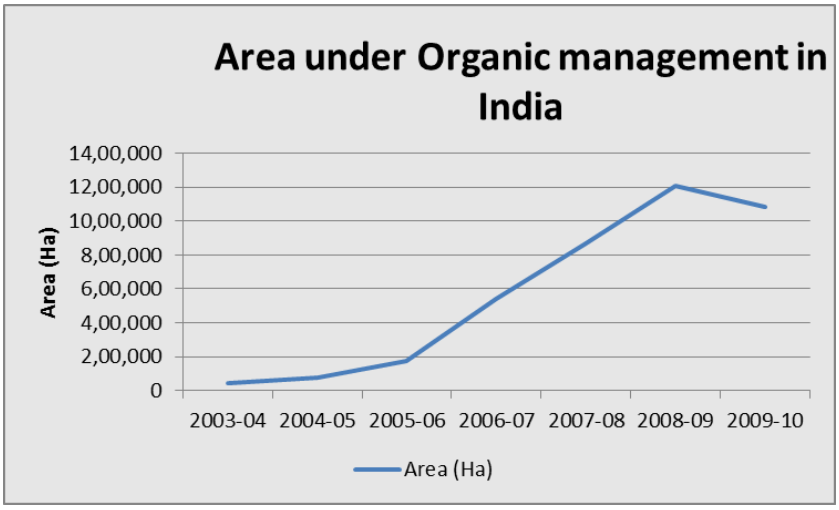

Figure 15: Area under organic management in India

Source: (Yadav, 2013)[34]

[34]Yadav, A. K., (2013). Organic Agriculture. *Director, National Centre of Organic Farming, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt of India, CGO-II, Kamla Nehru Nagar Ghaziabad*, *201*(001).http://ncof.dacnet.nic.in/Training_manuals/Training_manuals_in_English/Organic_Agriculture_in_India.pdflast accessed 9th July 2014

Table 66: Bio-fertilizer Production in India during 2008/09-2011/12

Sl. No.	State	Actual production of biofertilizers in MT during years			
		2008-09	2009-10	2010-11	2011-12
1	Andhra Pradesh	168.136	1345.28	999.60	1126.35
2	Arunachal Pradesh	-	-	-	-
3	Assam	129.3552	121.04	130.00	68.33
4	Bihar	-	-	136.26	75.00
5	Chhatishgarh	-	-	-	276.34
6	Delhi	1165.1	1021.85	1205.00	1617.00
7	Gujarat	1149.695	1309.19	6318.00	2037.35
8	Goa	-	0	443.40	0
9	Haryana	14.25	6.195	6.53	914.41
10	Himachal Pradesh	-	8.5	9.00	1.29
11	Jharkhand	15.0	15.0	0.00	8.38
12	Karnataka	11921.057	3695.5	6930.00	5760.32
13	Kerala	1187.001	1936.451	3257.00	904.17
14	Madhya Pradesh	848.448	1587.6775	2455.57	2309.06
15	Maharashtra	1249.87	1861.33	2924.00	8743.69
16	Manipur	-	-	-	-
17	Mizoram	1.996	2.5	2.00	-
18	Meghalaya	-	-	0.00	-
19	Nagaland	16.0092	18.25	21.50	13.00
20	Orissa	405.03	289.867	357.66	590.12
21	Punjab	1.14	301.232	2.50	692.22
22	Pondicherry	561.7924	452.79	783.00	509.45
23	Rajasthan	353.67	805.571	819.75	199.78
24	Sikkim	-	-	-	-
25	Tamil Nadu	4687.818	3732.5862	8691.00	3373.81
26	Tripura	14.68	278.402	850.00	1542.85
27	Uttar Pradesh	885.5174	962.6417	1217.45	8695.08
28	Uttarakhand	48.23	32.00	45.00	263.01
29	West Bengal	241.24	256.5	393.39	603.20
	Total	**25065.0352**	**20040.3534**	**37997.61**	**40324.21**

Source: Compiled by NCOF (Data as provided by Production Units / State Governments)

- **Product differentiation in the fertilizer and implications for RRR businesses**

The implications of the above analysis for MSW-based compost and Fortifer are briefly presented in Table 67 from the perspective of product differentiation. Fertilizer is a moderately differentiated product and therefore can be treated as a moderate substitute Fortifer. Chemical fertilizers are fairly well-accepted and their use is steadily growing in Indian agriculture. Although its increased consumption will have a heavy cost for the national exchequer (in view of provision of subsidy), the convenience in its use and the fairly reliable supply chain infrastructure setup by the fertilizer companies will only ensure its greater penetration particularly in rural India. Therefore, its competition is likely to grow in the future. Organic fertilizers on the other hand, are largely manufactured at the farm/household level. Whilst an increased scale of production may pose some competition to the chemical fertilizer producers, initial investments in R&D and innovative marketing strategies will be essential to penetrate the market.

Table 67: Implications of RRR Product: Compost, Fortier, Raw Sludge.

Competing Products	Level of Differentiation	Implications of Differentiation	Implications of the Stages of PLC of Competing Products
1. Fertilizers	Medium (moderate substitute)	It will offer high resistance in both rural and urban areas.	Competition is likely to continue in the future.
2. Organic Compost	Low (close substitute)	It will offer higher resistance only in rural areas in view of its availability.	Competition is likely to be tough in the future.

- **Supply chain analysis**

  - **Chemical fertilizer**

The Indian economy has a major agriculture component in terms of the number of people employed (17% of BETs and employs about 60% of the population) and the quantum of agricultural output produced. Wide spread use of chemical fertilizer plays a significant part in this industry. It has been estimated that India is the third largest producer and consumer of chemical fertilizer in the world. The Indian agricultural sector consumed a total of 27.7 million tons of NPK[35] per annum (2011-12) amounting to about 144 kg per hectare. The government of India introduced the Nutrient Based Subsidy (NBS) policy in 2010 under which a fixed rate of subsidy is provided for NPK. In India, urea prices are administratively set, and the NPK prices are market determined although the farmers are provided with subsidies. Since it is a very capital and energy intensive industry, it has evolved into a captive market with few large players like Southern Petrochemical Industries Corp. Ltd. (net revenue INR270 billion), Indian Farmers Fertilizer Cooperative Limited (net revenue INR212 billion), Rashtriya Chemicals & Fertilizers Ltd. (net revenue INR64 billion), and Mangalore Chemicals & Fertilizers Ltd. (net revenue INR33 billion). Although there are large and medium manufacturers there is very low level of product differentiation. The raw material for manufacturing NPK fertilizers and energy requirements is typically seen to be the weak link with heavy dependence on import of raw materials and intermediaries. Additionally, there is a gap in the installed capacity with significant import (about 25% of the total requirement). Whilst the fertilizer industry is highly concentrated, market distortions related to product differentiation, distribution inefficiencies in the supply chain, information flow, foreign exchange rate fluctuations, amongst others, represents opportunities for new organic fertilizer businesses.

  - **Compost from Organic waste**

The key players involved in the manufacturing and distribution of compost are manufacturers, distributors, and retailers. There is both an organized and unorganized sector in the manufacturing of compost. The large and concentrated generators of organic waste such as the big apartment complexes sometimes have an onsite composting facility, and the so produced compost is used onsite. The more

[35]NPK - Nitrogen (N), Phosphate (P), Potash (K)

centralized compost manufacturer such as the Karnataka Compost Development Corporation (KCDC) sources the required organic waste directly from BBMP. The manufactured compost is then sold to the consumers (Farmers /and the locals) or (Distributors – wholesalers- Retailers). The supply chain of the compost market is shown in Figure 16.

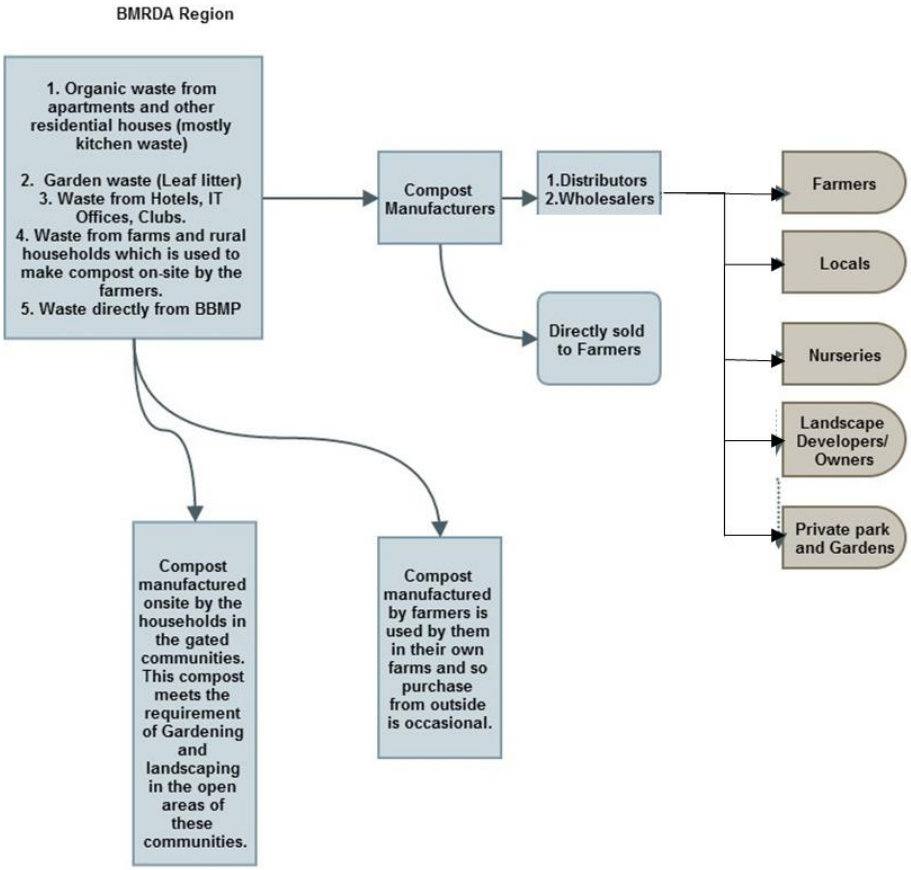

Figure 16: Supply chain in compost industry

The results suggest that rural farmers are a good customer segment at this point of time for compost since urban households and nurseries form a very small segment in comparison with rural farmers. In the case of urban households, most of them outsource the task of maintenance of gardens and there is little demand throughout the year. Moreover almost all the gated communities in Bangalore are successfully making their surroundings zero-waste zones by converting their waste into useful manure. The entire waste generated (wet and dry) is segregated at the source (being strictly followed) and the organic waste is converted into useful compost by the use of OWC (Organic waste converters) installed inside the communities itself. This compost meets the requirement of gardening and landscaping in the open areas of these communities. Households have started to follow this trend August 2012, when the Karnataka High Court ordered Bangalore's municipal corporation, the BBMP, to make segregation of waste at source mandatory, and to decentralize the management of waste through greater citizen participation. This is indicative of low household expenditure on compost. In regards to nurseries, they produce compost in-house with very little scope for purchasing them externally. It is only a small segment of offices and landscaping purchase compost. Although rural households prefer to add other supplements to enhance productivity and yield, they are willing to pay a lower price compost. Additionally, the farmers are already

significantly using compost that are mostly produced in-house (within their respective farms). The results also indicate that manufacturers play a key role in production and also importantly distribution and that indicates that the role of wholesalers, distributors and retailers is negligible at this point of time. There are not more than 40-50 compost manufacturers in Bangalore at present and these are small scale industries except for Karnataka compost development corporation (KCDC) which is a state enterprise.

- **Fertilizer industry structure, conduct and performance**

A) Market Structure

- **Market Concentration:** The *Herfindahl index* computed from the sampled compost manufacturers is 0.47. This indicates that the compost manufacturing industry is moderately dominated by a few select players. In fact among the sampled compost manufacturers there are two relatively large manufacturers (KCDC and Vennar fertilizers) and the others are small players. These players source their input organic waste either directly from BBMP or from large apartment complexes and office parks. The other players are neighbourhood manufacturers utilizing locally-generated waste. The large manufacturers have been in business for a long time (around 40 years for KCDC and 10 years for Vennar fertilizers). In contrast the small neighbourhood manufacturers are relatively new.
- **Product differentiation:** The compost manufactured is differentiated and sold to consumers under different labels by some manufacturers. The vermi-compost is one common special label used by the manufacturers. Other methods of differentiating the product include the raw materials used (leaf litter exclusively used) and composting time (24 hours composting time).
- **Market integration:** Four-wheeled motor vehicles are the most commonly used transporting means for both the raw materials and final product. However one of the smaller composting units has indicated the difficulty in hiring vehicles due to the nature of the load being transported. The rainy season often poses a special problem related to the transportation of the products. Telephone, e-mail, and in-person communications are used extensively for communicating with the suppliers and customers. Both self-financed operations and banks loans are common in the compost business. NETD terms are available from the material suppliers and the bulk final customers.
- **Drivers and barriers to entry:** The major barrier for entering this business is the huge capital investment required for infrastructure. The lack of stable markets have been cited as a major impediment. The lack of credit facilities is also seen as a major barrier also. Other limiting factors noted by the manufacturers include the lack of clarity on taxation issues, and complicated process of getting the required trade license.

B) Market Conduct

- **Pricing:** Market based pricing is typically used for the bulk undifferentiated product. However, the manufacturers are able to charge premium prices for specialized differentiated products such as vermi-compost. Although the tagged price is what is charged to most customers, the bulk purchasers and frequent customers have been able to get some discounts in the price. Some manufacturers also provide discounts to customers making bulk purchases.
- **Promotion and marketing:** Some of the manufacturers have special marketing budgets specifically for their specialized products. These promotion activities are typically self-financed to expand their market reach.

C) Market performance

- **Profitability, payback period and growth:** The verdict on the profitability of these business ventures is mixed. Although large manufacturers have been positive about their ventures, the smaller ones have greater difficulty in running their business. None of the sampled small manufacturers were noted to have been able to recover their initial investment even after being in operation for a number of years. The main challenge they face is the uncertainty in demand for organic manure and the growing competition.

- **Implications for new waste-based organic fertilizer businesses**

In summary, the market structure assessment suggests an oligopolistic fertilizer market, plagued by market distortions attributable to limited infrastructure (installed capacity); high energy requirements for production and a growing organic agricultural sector which has created an opportunity for business development in the organic fertilizer sub-sector. The chemical fertilizer sector is also a capital-intensive industry. Thus, limited access to financing at a large scale further exacerbates supply-related constraints (IFDC &CHEMONICS, 2007). There is however a large-scale government fertilizer program that provides subsidized fertilizer to farmers and a fairly active private fertilizer sector that supplies fertilizer at competitive prices; this represents a potential limitation for market entry of organic fertilizer businesses. It is important to note that there could be a potential revision to the current subsidy regime in the instance that the national budget deficit continues to grow. On the other hand, the growing organic foods market will increase the demand for organic fertilizers and the respective producers certainly have an opportunity to play a key role in filling this gap in the fertilizer market.

3.5.4 Market Outlook - Business Models 15, 16 and 17

3.5.4.1 Background and Justification

The market outlook assessment is particularly crucial for the nutrient business models as it has been noted that compost businesses typically in developing countries have short life cycles and often socially-driven more so than having a profit/business objective. The forecasting of MSW-based compost and Fortifer is a projection of demand levels in the future, based on current or past evolutions. The role of market or demand forecasting will aid business development management in planning into the future. Because investment toward an uncertain future is very difficult and risky, market forecasting will help alleviate the risk and obtain more accurate or reliable information. The most fundamental variable in determining an appropriate business strategy is the stage of the product life cycle as noted in the previous assessments. The product life-cycle management is the succession of strategies used by business management as a product goes through its life-cycle. The condition of the market, in which a product is sold changes over time and business strategies must be managed as it moves through its succession of stages. The goals of product life cycle management are to reduce time to market, improve product quality, reduce prototyping costs, identify potential sales opportunities and revenue contributions, and reduce environmental impacts at end-of-life. Thus, successful new organic fertilizer businesses will need to understand its customers, markets and competitors. Thus, the objective of this analysis is to forecast market growth behavior of MSW-based compost and Fortifer.

3.5.4.2 Research Methods and Data Collection

As with the other business models, the Bass model (1969) was used to assess the market outlook for MSW-based compost and Fortifer given data limitation. The model took into consideration the probability of purchase given that no previous purchases were made and the total number of potential buyers as parameters reflecting the rate of diffusion and the initial probability of first-time purchases (Proctor, 2000). A variant of the discrete time bass model function was applied. Satoh (2001) justified the adoption of the discrete time model when data used is discrete, as the Bass model is a continuous-time model. Satoh (2001) further noted that the discrete Bass model conserves the characteristics of the Bass model because the difference equation has an exact solution. Therefore, the discrete Bass model enables us to forecast the innovation diffusion of products and services without a continuous-time Bass model.

$$f(t) = \frac{\frac{(p+q)^2}{p} e^{-(p+q)t}}{\left(1 + \frac{q}{p} e^{-(p+q)t}\right)^2}$$

$$F(t) = \sum_{i=0}^{t} f(i)$$

$$A(t) = M\ F(t) \text{ and } a(t) = M\ f(t)$$

The optimal time to peak sales is given by:

$$\frac{\ln\left(\frac{q}{p}\right)}{p+q}$$

Other variables in the Bass Model which are calculated from M, p, q and t, are:

f(t): the portion of M that adopts at time t.
F(t): the portion of M that have adopted by time t,
a(t): adopters (or adoptions) at t and
A(t): cumulative adopters (or adoptions) at t.

The most critical determinants of the model are innovation and imitation coefficients p and q and the potential market size of the market for MSW-compost and Fortifer. In the absence of already available data on the p and q for these products, the study made use of an average estimation of those coefficients as per the findings of Sultan at al. (1990). Accordingly, the assumed estimate of p used was 0.03 and q, 0.38. Low diffusion rates (low switching behaviour) were assumed because although Bangalore farmers already use organic fertilizers quite extensively, their knowledge and use of human waste-based organic fertilizers is quite limited. Additionally, the total (p + q) is assumed to lie between 0.3 and 0.7. The potential market size for MSW-based compost and Fortifer are estimated at 578,400 tons/year and 54,249 tons/year, respectively, based on the WTP assessment.

3.5.4.3 Results and Discussion

A) Market outlook of products

- **MSW-based Compost**

The estimated market size for MSW compost and Fortifer is 578,400 tons/year and 54,249 tons/year, respectively. The value of p is assumed to be 0.03 and q as 0.38. The values of innovation and imitation are lesser than that of briquette because alternative products for compost are prevalent in the market. Additionally, the imitation or adoption of MSW compost or Fortifer would be a function of how every farming household would adopt the product. Figure 17 and Figure **18** show the behavior of new and cumulative product sales over the years for MSW compost. The results indicate that peak sales can be achieved between 6 - 7 years. A lower peak time, however, can be reached with strong business strategies including promotional and awareness programs for farmer communities and other potential industrial users. The estimated quantity of sales at the peak will be 63,870 tons. Given their current limited market size, the marketing for compost needs to be aggressively pursued so as to increase this and minimally cater to the existing size within the first six years. The strategies that may be recommended to promote early market penetration of MSW compost (so as to curtail the time needed to reach of its peak of market adoption) are:

1. To improve customer awareness (as part of Bharath Swachch Abhiyan)
2. To diffuse information about the environmental benefits that the adoption of RRR product would bring to the society.
3. Policy interventions in the form of cross-subsidization (imposing a fee for the collection of waste generated from households and enterprises can be partially transferred to the manufacturers of MSW compost and thereby enable them to subsidize their end-product.

MSW compost has a long market horizon with between 17-18 years for it to be comprehensively adopted by the current market size. This can be viewed as an opportunity and sound investments toward reaching out can certainly generate higher market demand eventually.

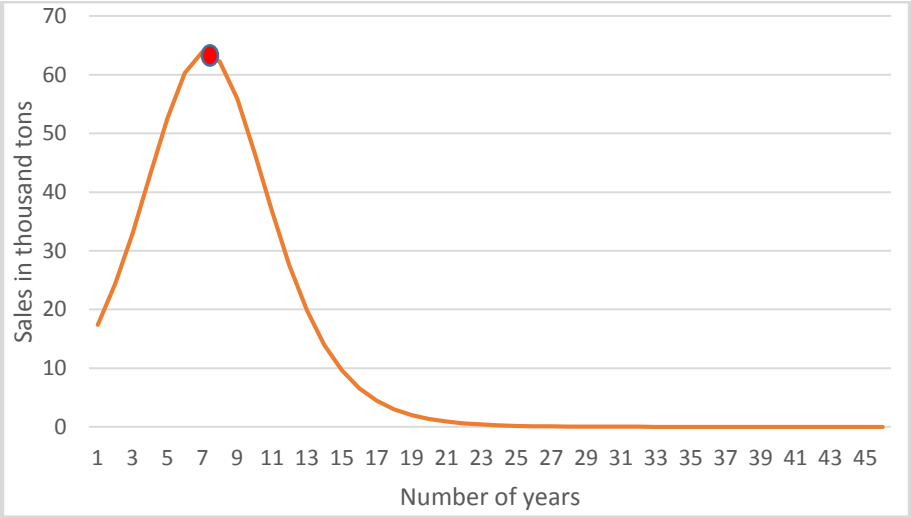

Figure 17: Probability of market adoptions for Compost

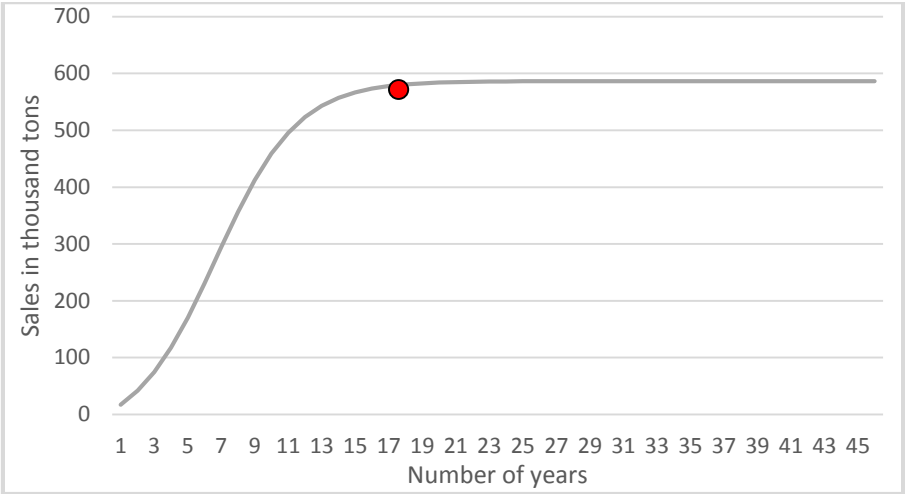

Figure 18: Cumulative adoptions of compost

- **Fortifer**

Error! Reference source not found. Figure 19 and Figure **20** show the behaviour of new and cumulative product sales over the years with 0.38 and 0.03 average coefficients of innovation and imitation. The results indicate that peak sales can be achieved between 6 -7 years. A lower peak time, however, can be reached with strong business strategies including promotional and awareness programs for farmer communities and other potential industrial users. The estimated quantity of sales at the peak will be 6,000 tons. Businesses can adjust their production capacity and other financial requirements to target a higher average peak volume at the average peak time. According to the figures of both scenarios, it will take approximately between 17 -18 years for new businesses to capture the total market size.

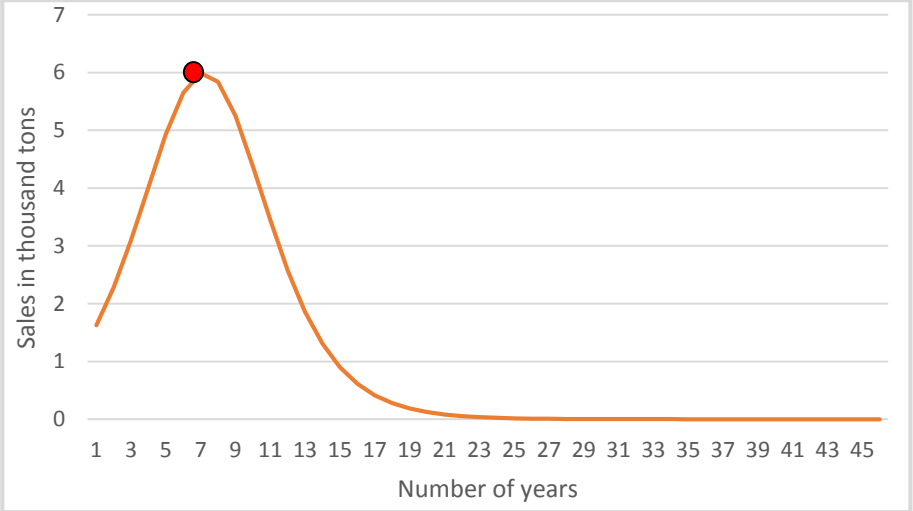

Figure 19: Volume of new sales over the years

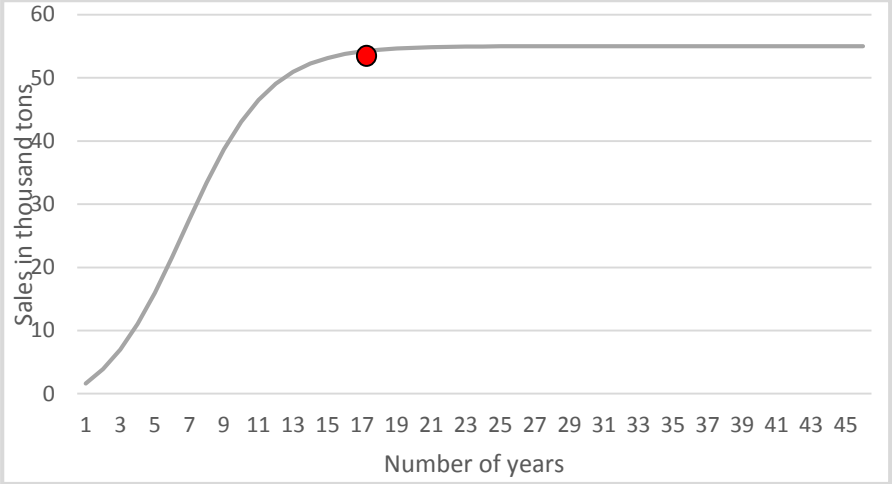

Figure 20: Cumulative sales over the years

3.5.5 Conclusions - Models 15, 16, and 17

The analysis shows that there is a significant demand for MSW compost and Fortifer. The potential market for MSW-compost is noted to be substantial with the demand estimated at 578,400 tons/year, with an adoption rate of 20% and application rate of 12.5 tons/ha/year. The total cultivated area is 231,377 ha[36]. The results indicate that farmers are willing to pay 1.458 INR/kg more to know the source of the waste input used to produce the compost; and an even higher premium of 5.359 INR/kg for pelletization and 14.397 INR/kg for certification. Nutrient content and quality which have direct positive effects on farm yields and profits are preferred attributes. Given these marginal estimates, the full analysis shows the estimated WTP for compost to be 61.214 INR/kg, which is significantly higher than the current market of competitive products. The results suggest that the demand for compost could increase if the abovementioned attributes are factored into the final product for the market. From a business perspective, it is pertinent to evaluate the costs of introducing any of these attributes as against the benefits, which are measured through the WTP estimates. In the instance where such product differentiation is not cost-effective, it is important to explore the opportunities that partnerships can offer and also those related to some form of government subsidization.

The potential market for Fortifer is noted to be substantial with the demand estimated at 54,249 tons/year, assuming an adoption of 40% and application rate of 0.59 tons/ha/year. The total cultivated area considered is 231,377 ha[37]. Chemical fertilizer application rates were used as a basis for the calculation of the application rates of Fortifer (IFPRI, 2012). The average chemical fertilizer applications were estimated at 117 kg/ha and Fortifer at 5 times this estimate as Fortifer is considered a close competitive substitute product. The results indicate that farmers are willing to pay 10.63 INR/kg more for fortification and an even higher premium of 14.97/kg for pelletization. Interestingly, the farmers were however noted to have a lower valuation for the certification attribute and would need a compensation of 0.77 INR/kg for certification. Nutrient content and quality which have direct positive effects on farm yields and profits are preferred attributes. It is important to note that the noted premiums are slightly lower when socio-economic variables are factored into the choice set. Given these marginal estimates,

[36]http://agcensus.dacnet.nic.in/districtT1table1.aspx
[37]http://agcensus.dacnet.nic.in/districtT1table1.aspx

the full analysis shows the estimated WTP for fortified and certified Fortifer to be 67.06 INR/kg, which is significantly higher than the current market of competitive products.

The market structure assessment suggests an oligopolistic fertilizer market, plagued by market distortions attributable to limited infrastructure (installed capacity); high energy requirements for production and a growing organic agricultural sector which has created an opportunity for business development in the organic fertilizer sub-sector. The chemical fertilizer sector is also a capital-intensive industry. Thus, limited access to financing at a large scale further exacerbates supply-related constraints (IFDC &CHEMONICS, 2007). There is however a large-scale government fertilizer program that provides subsidized fertilizer to farmers and a fairly active private fertilizer sector that supplies fertilizer at competitive prices; this represents a potential limitation for market entry of organic fertilizer businesses. It is important to note that there could be a potential revision to the current subsidy regime in the instance that the national budget deficit continues to grow. On the other hand, the growing organic foods market will increase the demand for organic fertilizers and the respective producers certainly have an opportunity to play a key role in filling this gap in the fertilizer market.

4. Summary and Conclusions

4.1 Summary and Key Implications of Findings

A key component of the feasibility studies is the market assessment of the RRR business models as functioning markets, an enabling institutional environment and positive economic and financial conditions are essential for sustainable business activity in any sector including the waste reuse sector. The set-up of any RRR business and the commercialization of a new product in a new market requires an accurate or close to accurate estimation of the relative market size for the new product. The successful development of any subsector market depends among other factors particularly on market demand. Specifically, the question of whether a demand actually exists and the price end-users are willing to pay for this new product needs to be explored. "Demand, even among those with limited resources, is not automatic." (Phillip et al., 2003; page 194). For this reason, the market assessment set out to evaluate the current and potential market for the recovered resource and the effect of different factors (e.g. Socio-cultural aspects and perceptions, price of substitute products, etc.) on market demand. Information on market segments, potential clients of the RRR product, their actual and potential number and resource absorption capacity and their willingness-to-pay (WTP) were assessed.

Additionally, the adoption of effective marketing and pricing strategies to ensure business sustainability require entrepreneurs to comprehensively understand the dynamics inherent in the relevant sub-sectors. This translates into the need for evaluating the structure (i.e. competition, differentiation of substitute products, barriers to market entry, among others) of the product market they operate in, i.e. how the behavior and performance of other businesses influence their decision making. Another important facet to the market assessment is demand forecasting – i.e. market outlook. Market forecasting is a crucial element for business owners in assessing future capacity requirements, evaluating their decisions in the implementation of new business strategies and pricing decisions. Businesses need to adopt different strategies ranging from establishing key partnerships and price markups to maintain a competitive advantage and ensure sustainability. An assessment of the above listed aspects provides entrepreneurs with a solid market information base crucial for business start-up and sustainability. In that regard, the specific objectives of the market assessment were:

1. To assess the market value of the RRR products under consideration –
    a. To assess consumers' willingness-to-pay (WTP) and differences in WTP estimates across different consumer segments and related factors influencing consumer demand;
    b. To estimate the potential market size for the RRR product;
2. To assess the extent and characteristics of the market structure;
3. To evaluate the market outlook of the RRR products and to what extent the RRR products would be viable over time in the market.

As noted earlier, a total of 12 RRR business models were selected for the feasibility studies in Bangalore. For the purposes of the market assessment, an end-use typology of the business models was employed as although the underlying concept of the business models were different, a number of the end-products were the same across different business models. Thus for some business models, the related customer segments and relevant actors along the value chain considered would be the same. In that regard, for the selected business models, the following 6 value-added products were considered: 1) briquettes, 2) electricity, 3) treated wastewater, 4) wastewater-fed fish, 5) MSW-based compost and 6) faecal sludge-based compost. Untreated wastewater is not considered a marketable commodity as it is considered to increase human health risk and environmental pollution and thus potential users' valuation was not assessed.

- ***Model 1: Dry fuel manufacturing: Agro-waste to briquette***

The results indicate that there is a fair market demand for agro-waste briquettes in Bangalore, although not substantial. Among the surveyed households (both urban and rural), none were currently noted to be using briquettes. Furthermore, the estimated supply of agro-waste for the generation of briquettes and the estimated demand for briquettes from the identified segments of the economy broadly reveal that there is no significant demand supply gap for briquettes, although the estimated demand exceeds estimated supply. This suggest that an appropriate planning and marketing strategy will be required for new briquette businesses to gain a share of the market. New briquette businesses also will need to accommodate customer expectations in terms of credit, delivery, and near nil expenditure for marketing by the current market players. Differential pricing can help in gaining market share, although its implementation needs to be studied in greater detail. Across all the studied markets product promotion and marketing is close to nil. New briquette businesses would need to invest in R&D in order to mitigate the effects of high social barriers and place them at a competitive disadvantage compared to their competitors.

There are also both policy induced factors and environmental factors that are representative of entry barriers for briquettes to penetrate the household sector. Government subsidies for existing competing products in the energy market (LPG and Kerosene) can potentially pose a challenge to new briquette businesses, and thus appropriate product positioning and customer targeting would be essential to overcome the challenges posed by the subsidy. Additionally, the extensive established network of LPG has improved the product's accessibility not only in urban areas but also in rural areas - thus representing a significant competitor for briquettes. In addition, urban low income households have the access to kerosene both through public distribution system and open markets; and in the rural areas, households have the luxury of collecting firewood free of cost.

- **Model 4: Onsite energy generation by sanitation service providers and Model 6: Power capture model - Livestock waste to energy**

The electricity market is heavily regulated and monopolized by state agencies. Private participation although present is very limited and permitted only for certain aspects of power generation. Pricing of electricity is negotiated between the private entrepreneurs and the respective electricity reforms commission. As private electricity suppliers do not supply directly supply to households but rather to the national grid, the only direct market/ consumer is with the latter. In that regard, a willingness-to-pay assessment was not conducted for business models 4 and 6. An assessment of the market structure and outlook is provided in detail in the 'Institutional analysis' report.

- **Model 8: Phyto-remediative wastewater treatment and fish production**

The results show that consumers derive a negative utility from wastewater-fed fish and wild fish. The primary survey shows that wastewater fish is presently not being consumed by the households. In absence of the revealed preference data an approximate price of wastewater fed fish with information about the source and certification is Rs. 173.6/Kg (which considers only the information price and certification price). The actual payment for wastewater-fed fish among the consumers was estimated to be Rs 63.97/Kg which lower than the current market price of non-certified fish with no source information. The results show that consumers are willing to pay Rs.37.25/kg to know the source of the fish (i.e. which medium the fish was reared in) and Rs. 136.36/kg for certification.

The market prospect for wastewater-fed fish has some promise but will face social barriers and consumer perceptions in the initial stages. Innovative marketing strategies including pricing and product promotion

strategies will be require to facilitate the entry of new businesses into the market. It is suggested that food products made from fish harvested in treated wastewater must be priced differentially lower than that of food products of freshwater fish, in order to capture a share of the market. An aggressive marketing strategy for the promotion of treated wastewater fish is also recommended. Overall, wastewater-fed fish has a good market outlook but will have to compete aggressively with their alternative products to sustain in the market eventually. Freshwater fish is a very a close substitute for fish from treated wastewater. Therefore, this product will offer a high degree of competition to the RRR product. With an ever-expanding cultivation of freshwater fish and with an ever increasing level of income and population, the demand for freshwater fish will grow steadily. However, if proper labelling is done by appropriate regulatory authorities to educate the prospective consumers that the consumption of fish reared from treated wastewater will not pose any health risks, and if it is sold at a competitive price, it will find its way into the market, though gradually and steadily.

- **Model 9: Cost recovery - Treated wastewater for irrigation, fertilizer and energy and Model 10: Informal to formal trajectory in wastewater irrigation**

The results from the WTP assessment show that the majority of farming households (93% of surveyed respondents) are willing to use and pay for treated wastewater for irrigation purposes, especially during the drier seasons (summer months). A lower percentage (63%) were however noted to be willing to pay for treated wastewater during the monsoon season. On average, 89% of these farmers were willing to pay for using treated wastewater for irrigation. The farmers were willing to pay Rs.482/- per 10000 litres (10 m^3) of treated/partially treated wastewater. The results also showed that the farmers placed a higher value on treated wastewater under a scenario of 'increased water scarcity' compared to any increment in cost of water supply. The bids offered by the farmers for an increase in cost of water at the initial levels (10% to 25%) are similar in terms of the average value (Rs.315.38). This increases marginally by Rs. 66 when an option of 100% cost increment is faced by the farmers. In comparison, the marginal change in the bid offered when scarcity of water increases from 25% to 50% is about Rs. 210 per 100m^3 which is 3 times the increase in the bid offered for cost changes. The results also showed that farmers with more farming experience were willing to pay a relatively higher fee than the other groups. It is however important to note that the standard deviation for these farmers was also higher in comparison to the groups. Additionally, farmers dependent on rainwater for irrigation were willing to pay a higher fee for wastewater for irrigation than farmers utilizing groundwater. This might be due to the fact that farmers practising rain-fed farming are willing to hedge the risk of vagaries of rainfall and hence have a higher willingness to pay. The farmers dependent on groundwater pay a relatively higher price for water compared to the other group of farmers and may not consider treated wastewater a substitute with the assured water supply they presently receive. Another reason for lower preference for payments is due to the fact that farmers who have already invested for groundwater are reluctant to phase it out completely since it entails a higher establishment cost.

In regards to the businesses, the results showed that on average of 84% of the surveyed enterprises were willing to pay for treated wastewater. The average WTP value was Rs.455/- per tanker of treated/partially treated wastewater. However, among the larger enterprise respondents, they were willing to pay on an average of Rs.1160/- per 8000 litre tanker. The results also indicated that the enterprises value treated wastewater relatively higher under the scenarios of 'increment in cost of water supply' than that of 'water. Under the water scarcity scenario, it was found that the payments offered by the enterprises were relatively lower. In fact even with a 10% scarcity of water, the enterprises were willing to pay about the same charges as when there was no water scarcity. Another important consideration is that while for the first 15% increase in scarcity of water the WTP for treated wastewater (a substitute) rises by Rs.50 (a rise of 10%) and for the next 75% increase in scarcity of water, the WTP rises by about Rs. 141 (about 28%).

Thus the changes in the WTP move in an opposite direction (as availability decreases, WTP rises) although not proportional to the change in the scarcity of water (which would become dearer which scarcity of water). This implies that the enterprises do consider wastewater as a substitute to water although not a perfect substitute. The enterprises included in the survey comprised of institutional houses (*Kalynmantapas*), hotels, car services, washer-man and industries (like brick manufactures, chemicals and garments). Except for the industries, it was found that other businesses incur water costs less than Rs.5000 and hence have lower payments for wastewater as can be seen from the above Table 41. Similarly, the consumption of these businesses are lower than that of the industries and hence have lower preference for WTP for treated wastewater. These smaller (and some medium) enterprises thus have a lower substitutability for treated wastewater rather than the larger industries and hence their demand curves are more inelastic to price changes of water.

It is clear that there is a fair demand for treated wastewater. In particular, the demand is higher among farmers but characterized by a WTP lower during the monsoon seasons that the summer season. Demand for treated wastewater among businesses was found to be specific to the enterprise type and use. Demand for water is expected to grow exponentially in the future particularly in the agricultural and industrial sectors. In terms of the structure of the water market, it is a well-regulated market and it is foreseen that the supply and distribution of wastewater and the related market structure will most likely follow a similar pattern.

- ***Model 15: Large-scale composting for revenue generation (MSW-based compost), Model* 16: Decentralized MSW composting *and Model 17: High value fertilizer production for profit (faecal sludge-based fertilizer)***

The analysis shows that there is a significant demand for MSW compost and Fortifer. The potential market for MSW-compost is noted to be substantial with the demand estimated at 578,400 tons/year, with an adoption rate of 20% and application rate of 12.5 tons/ha/year. The results indicate that farmers are willing to pay 1.458 INR/kg more to know the source of the waste input used to produce the compost; and an even higher premium of 5.359 INR/kg for pelletization and 14.397 INR/kg for certification. Nutrient content and quality which have direct positive effects on farm yields and profits are preferred attributes. Given these marginal estimates, the full analysis shows the estimated WTP for compost to be 61.214 INR/kg, which is significantly higher than the current market of competitive products. The results suggest that the demand for compost could increase if the abovementioned attributes are factored into the final product for the market. From a business perspective, it is pertinent to evaluate the costs of introducing any of these attributes as against the benefits, which are measured through the WTP estimates. In the instance where such product differentiation is not cost-effective, it is important to explore the opportunities that partnerships can offer and also those related to some form of government subsidization.

The potential market for Fortifer is noted to be substantial with the demand estimated at 54,249 tons/year, assuming an adoption of 40% and application rate of 0.59 tons/ha/year. The total cultivated area considered is 231,377 ha[38]. Chemical fertilizer application rates were used as a basis for the calculation of the application rates of Fortifer (IFPRI, 2012). The average chemical fertilizer applications were estimated at 117 kg/ha (DOA, 2014) and Fortifer at 5 times this estimate as Fortifer is considered a close competitive substitute product. The results indicate that farmers are willing to pay 10.63 INR/kg more for fortification and an even higher premium of 14.97/kg for pelletization. Interestingly, the farmers

[38]http://agcensus.dacnet.nic.in/districtT1table1.aspx

were however noted to have a lower valuation for the certification attribute and would need a compensation of 0.77 INR/kg for certification. Nutrient content and quality which have direct positive effects on farm yields and profits are preferred attributes. It is important to note that the noted premiums are slightly lower when socio-economic variables are factored into the choice set. Given these marginal estimates, the full analysis shows the estimated WTP for fortified and certified Fortifer to be 67.06 INR/kg, which is significantly higher than the current market of competitive products.

The market structure assessment suggests an oligopolistic fertilizer market, plagued by market distortions attributable to limited infrastructure (installed capacity); high energy requirements for production and a growing organic agricultural sector which has created an opportunity for business development in the organic fertilizer sub-sector. The chemical fertilizer sector is also a capital-intensive industry. Thus, limited access to financing at a large scale further exacerbates supply-related constraints (IFDC &CHEMONICS, 2007). There is however a large-scale government fertilizer program that provides subsidized fertilizer to farmers and a fairly active private fertilizer sector that supplies fertilizer at competitive prices; this represents a potential limitation for market entry of organic fertilizer businesses. It is important to note that there could be a potential revision to the current subsidy regime in the instance that the national budget deficit continues to grow. On the other hand, the growing organic foods market will increase the demand for organic fertilizers and the respective producers certainly have an opportunity to play a key role in filling this gap in the fertilizer market.

4.2 Ranking of the feasibility of the business models from a market perspective

The overall feasibility of the individual business models was evaluated based on the different aspects assessed (i.e. consumers' WTP and potential market size, market structure - level of market competition and ease of entry into industry, and market outlook). Specific indicators were used for each criterion. The indicators of the WTP and market size; and market structure were the overriding indicators in the evaluation of the overall feasibility assessment of the business models, as it is noted that limitations related to the product life cycle can be more easily mitigated, for example, with the implementation of key pricing and marketing strategies. For the WTP assessment evaluation, for a specific business model to be considered of a medium or high feasibility, the estimated consumers' WTP had to be equal to or higher that the current market price of the substitute product. The market structure evaluation considered several indicators: a) ease of market entry, b) level of market concentration, c) level of product differentiation; d) whether the main competitor is a price taker or price setter and where possible e) the level of potential net profit margins. Different constellations were used in deriving the feasibility ranking system for the business models. Table 68 below presents the methodology used to rank the business models.

The overall feasibility of the business models was then evaluated based on the different aspects (market demand, market structure and market outlook). It was noted that models 1a, 9, 15/16, 17, have a medium feasibility from a markets' perspective (Table 69). On the other hand, waste-to-energy models, in particular agro-waste and faecal sludge to electricity have a low feasibility potential as is the wastewater-fed fish business model from a market perspective.

Table 68: Methodology for ranking of business models

WTP and Market Demand	Market Structure	Market Outlook	Feasibility Ranking
WTP < Current market price of substitute product	1. Difficult market entry 2. High level of concentration (monopolistic/ oligopolistic market) 3. High level of product differentiation of competitive products 4. Price taker 5. Potential negative profit margins (without subsidies)	10 years and beyond to reach growth stage	No feasibility
WTP < Current market price of substitute product	1. Medium to difficult market entry 2. Medium to high level of concentration (monopolistic/ oligopolistic market) 3. Medium to high level of product differentiation of competitive products 4. Price taker 5. Potential negative profit margins (without subsidies)	10 years and beyond to reach growth stage	Low feasibility
WTP > Current market price of competitive/ substitute products	1. Medium level of ease for market entry 2. Low to medium levels of market concentration 3. Limited to no product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	5 - 9 years to reach growth stage in business life cycle	Medium feasibility
WTP > Current market price of competitive/ substitute products	1. Easy market entry 2. Limited level of market concentration 3. Limited to no product differentiation 4. Price setting market 5. Potential net profit margins –positive	5 - 9 years to reach growth stage in business life cycle	High feasibility

Table 69: Summary of the feasibility of the selected RRR business models from a market perspective

Business model	WTP and Market Demand	Market Structure	Market Outlook	Cumulative feasibility score	Value-added product/recovered resource
Model 1a – Dry fuel manufacturing: agro-waste to briquettes	WTP > Current market price of substitute product	1. Fairly easy market entry 2. Low-to-medium level of concentration 3. Limited to no product differentiation 4. Price setter 5. Potential net profit margins	4-5 years to reach growth stage in business life cycle	**Medium feasibility**	**Briquettes**
Model 4 – Onsite energy by sanitation service providers **Model 6 – Power capture model - Livestock waste to energy**	Consumers are price-takers. As electricity is subsidized - we assume that WTP = current market price	1. Medium to difficult market entry - regulated market 2. Medium to high level of concentration (oligopolistic market) 3. No product differentiation 4. Price taker 5. Potential negative profit margins (without subsidies)	Future demand scenario assessment indicates fair possibility for the government to fulfill supply gap	**Low feasibility**	**Electricity**
Model 8 – Beyond cost recovery: the aquaculture example	WTP < Current market price of substitute product	1. Medium level of ease for market entry 2. Low to medium levels of market concentration 3. Limited to no product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	10 -11 years to reach growth stage in business life cycle	**Low feasibility**	**Wastewater-fed fish**
Model 9, 11 & 12 – On cost savings and recovery (wastewater reuse)	WTP > Current market price (among farming households)	1. Medium level of ease for market entry 2. Low to medium levels of market concentration 3. Limited to no product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	Anticipated exponential growth in demand esp. in agricultural and industrial sectors	**Medium feasibility**	**Wastewater**
Model 10 – Informal to formal trajectory in wastewater irrigation	Not evaluated as policies, legislations and organizational structures are not supportive of this practice.			**No feasibility**	
Model 15 – Large-scale composting for revenue generation (MSW to compost) **Model 16– Subsidy-free community based composting (decentralized composting)**	WTP > Current market price of competitive/ substitute products	1. Medium level of difficulty for market entry 2. Fair level of concentration 3. Fair level of product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	6 -7 years to reach growth stage in business life cycle	**Medium feasibility**	**MSW-based Compost**
Model 17 – High value fertilizer production for profit	WTP > Current market price of competitive/ substitute products	1. Easy entry 2. Fair level of concentration 3. Fair level of product differentiation 4. Oligopolistic fertilizer market but potential price setter 5. Potential net profit margins –positive	6 -7 years to reach growth stage in business life cycle	**Medium feasibility**	**Faecal sludge-based organic fertilizer**
Model 20– Outsourcing faecal sludge treatment to the farm	Although practiced in the private sector, disposal of raw faecal sludge on farmland is illegal.			**Low feasibility**	

5. References

1. Adamowicz W. and J.R. Deshazo. 2006. Frontiers in stated Preferences Methods: An introduction. Environmental and Resource Economics.34(1): 1-6.
2. Agimass F. and A. Mekonnen. 2011. Low-income fisherman's willingness to pay for fisheries and watershed management: An application of choice experiment to Lake Tana, Ethiopia. Ecological Economics.71:162-170.
3. Agyekum E.O., Ohene-Yankyera K., Kerita B., Fialor S.C. and R. Abaidoo. 2014. Willingness to pay for feacal compost by farmers in southern Ghana. Journal of Economics and Sustainable Development. 5(2).
4. Anderson C.R. and C.P. Zeithaml. 1984. Stage of the product life cycle, business strategy, and business performance. Academy of Management Journal. 27: 5-14.
5. Arene C. J. and G. I. O. Mbata. 2008. Determinants of Profitability and Willingness to Pay for Metropolitan Waste-Use in Urban Agriculture of the Federal Capital Territory, Abuja, Nigeria. Journal of Tropical Agriculture, Food, Environment and Extension. 7(1): 41- 46.
6. Arnot C., Boxal P.C. and S.B. Cash. 2006. Do ethical consumers care about price? A revealed preference analysis of fair trade coffee purchases. Canadian journal of Agricultural Economics. 54:555-565.
7. Awunyo D.V., Ishak S., and G.S. Jasaw. 2013. Urban Households' Willingness to Pay for Improved Solid Waste Disposal Services in Kumasi Metropolis, Ghana. Urban Studies Research. 2013, Article ID 659425.
8. Bass F.M. 1969. A new product growth for model consumer durables. Management Science. 15(5):215-227.
9. BBMP.2013. Evaluation of Technology for processing existing waste at Seven Landfill sites of BBMP: Bangalore Technical committee Recommendations on EOI application.
10. Bennett J. and R. Blamey (Eds.). 2001. The Choice Modeling Approach to EnvironmentalValuation. New Horizons in Environmental Economics. Edward Elgar Publishing, Inc., Massachusetts, USA.
11. Birol E., Karousakis K., P. Koundouri. 2005. Using a choice experiment to estimate the non-use values of wetlands: the case of Cheimaditida wetland in Greece. Environmental Economy and Policy Research Discussion Paper Series Department of Land Economy, University of Cambridge.
12. Census of India. 2011. Rural-urban distribution in provisional population totals.Paper 2 (Vol. 1, India series 1: 1–19). Retrieved from http://www.censusindia.gov. in/2011-prov- results/paper2/data_files/india/paper2_1.pdf
13. Chamberlain G. 1980. Analysis of Covariance with Qualitative Data. Review of Economic Studies.47:225-238.
14. Danso G. and P. Drechsel. 2014. Nutrient recycling from organic wastes through viable business models in peri-urban areas in Sub-Saharan Africa. In: Maheshwari B., Purohit R., Malano H., Singh V.P. and P. Amerasinghe (Eds): Securing water, food, energy and the liveability of cities. pp. 311-323. Springer Dordrecht Heidelberg New York London.
15. Danso G., Drechsel P., Fialor S. and M. Giodano. 2006. Estimating the demand for municipal waste compost via farmers' willingness-to-pay in Ghana. Waste management.26:1400-1409.
16. Deaton A. and J. Muellbauer. 1980. Economics and Consumer Behavior.Cambridge University Press.

17. Dehadrai P.V.2003. Irrigation in India. In: PetrT. (ed.) Fisheries in irrigation systems of arid Asia. FAO Fisheries Technical Paper: No. 430. 59-70. Rome, FAO.
18. DOA. 2014. Soil Health Mission – Karnataka 2014-15. Department of Agriculture, Government of Karnataka
19. Edwards P. 1992. Reuse of human waste in aquaculture: a technical review. World Bank, Washington, DC, USA. Water and Sanitation Report 2.
20. Efron B., and R. J. Tibshirani.1993. An introduction to the bootstrap. New York, Chapman & Hall.
21. Freeman A.M. 2004.Economic valuation: What and why. In: A primer on nonmarket valuation. The Netherlands: Kluwer Academic Publishers.
22. Greene W.H. 2002. Econometric analysis. In: Maddala G.S. (Ed.). 1999. Limited dependent and qualitative variables in econometrics. Fifth Edition. Upper Saddle River, New Jersey:Prentice Hall. Cambridge: Cambridge University Press.
23. Hagos D., konnen A.M. and Z. Gebreegziabher. 2012. Environment for Development Discussion Paper Series: Households' Willingness to Pay for Improved Urban Waste Management in Mekelle City, Ethiopia.
24. Hanley N., Wright R.E. and B. Alvarez-Farizo. 2006. Estimating the economic value of improvements in rover ecology using choice experiments: An application to the water framework directive. Journal of environmental management.78:183-193.
25. Hensher D.A., Rose J.M. and W.H. Greene. 2005. Applied Choice Analysis – a primer.Cambridge, Cambridge University Press.
26. Hofer C. 1975. Toward a contingency theory of strategy. Academy of Management Journal. 784-810.
27. Holtzman S. 2002. Using Subsector Analysis to Assess the Impact of Policy Reform on Commodity Subsectors. Impact Assessment Report No. 27.
28. Hoyos, D. 2010. The State of the Art of Environmental Valuation with Discrete Choice Experiments. Ecological Economics. 69: 2372-2381.
29. ICLEI South Asia. 2007. Renewable Energy and Energy Efficiency Status in India. ICLEI-South Asia, Noida-201301, India.
30. IFDC & CHEMONICS. 2007. Fertilizer Supply and Costs in Africa.
31. Kakembo F. 2012. Innovative education and training for community-based water protection units. Water Practice & Technology. IWA Publishing.
32. Karousakis K. and E. Birol. 2006. Investigating Household Preferences for Kerbside Recycling Services in London: A Choice Experiment Approach. Environmental Economy and Policy Research working Paper Series. Department of Land Economy, University of Cambridge.
33. Kimenju S.C. and H.D. Groote. 2008. Consumer Willingness to Pay for Genetically Modified Food In Kenya. Agricultural Economics.38: 35-46.
34. Krinsky I. and A. L. Robb. 1986. On approximating the statistical properties of elasticities. The Review of Economics and Statistics.68(4): 715–719.
35. Krinsky I. and A.L. Robb.1990. On approximating the statistical properties of elasticities: a correction. Review of Economics and Statistics. 72(1):189–190.
36. Lancaster K.J. 1966. A New Approach to Consumer Theory. The Journal of Political Economy.74(2):132-157.The University of Chicago Press. http://www.jstor.org/stable/1828835.

37. Lim K.H., Hu W., Maynard L.J. and E. Goddard. 2013. U.S. consumers' preference and willingness to pay for country-of-origin labeled beef streak and food safety enhancements. Canadian Journal of Agricultural economics.62: 93-118.
38. Louviere J.J., Hensher D., Swait J. and W. Adamowicz. 2000. Stated choice method: Analysis and applications. Cambridge: Cambridge University Press.
39. Luce R. D. 1959. Individual Choice Behavior: A Theoretical Analysis. John Wiley & Sons, New York.
40. Lusk J.L. and D. Hudson. 2004. Willingness-to-Pay Estimates and Their Relevance to Agribusiness Decision Making. Review of Agricultural Economics. 26(2):152-169.
41. Lusk J.L., Traill W.B., House L.O., Valli C., Jaeger S.R., Moore M. and B. Morrow. 2006. Comparative advantage in demand: Experimental evidence of preferences for genetically modified food in the United States and European Union. Journal of Agricultural Economics.57:1–21.
42. Maddala G.S. 1999. Limited dependent and qualitative variables in econometrics. Cambridge: Cambridge University Press.
43. McFadden D. 1974. Conditional logit analysis of qualitative choice behaviour. In: Zarembka P. (Ed.). Frontiers of Econometrics. Academic Press, London, 105-142.
44. MNRE.2012. Annual Report 2011-12. Ministry of New and Renewable Energy, Government of India.
45. Nagendra H., Nagendran S., Paul S. and S. Pareeth (2012). Graying, greening and fragmentation in the rapidly expanding Indian city of Bangalore. Landscape and Urban Planning 105: 400-406.
46. Ndunda E. and E. Mungatana. 2013. Evaluating the welfare effects of improved wastewater treatment using a discrete choice experiment. Journal of environmental management.123:49-57.
47. NSSO. 2014. Household Consumption of Various Goods and Services in India 2011-12: 68th Round. National Sample Survey Office, Government of India.
48. Palatnik R., Ayalon O. and M. Shechter. 2005. Household Demand for Waste Recycling Services. Environmental Management. 35(2): 121-129.
49. Satoh D. 2001. A Discrete Bass Model and Its Parameter Estimation. Journal of the Operations Research Society of Japan. 44(1).The Operations Research Society of Japan.
50. Sharma V.P., H.W.P. Thaker.2011. Demand for Fertiliser in India: Determinants and Outlook for 2020. Indian Institute of Management Ahmedabad -380 015, India.
51. Shaw W.D., Nayga R.M. and A. Silva. 2006. Health Benefits and Uncertainty: An Experimental Analysis of the Effect of Risk Presentation on Auction Bids for a Healthful Product. Economics Bulletin.4:1-8.
52. Sudhira H.S., Ramachandra T.V. and M.H.B. Subramanya. 2007. City Profile: Bangalore. Cities. 24(5): 379-90.
53. Sultan F., Farley J.U. and D.R. Lehmann.1990. A meta-analysis of applications of diffusion models. Journal of Marketing Research. 27: 70-77.
54. Swaminathan L.P.S and S. Varadharaj. 2001.The status of firewood in India. In: K. Connor, Beardmore T., Tolentino E.L., W.M. Carandang (Eds) 2001. Proceedings of the IUFRO Joint Symposium on Tree Seed Technology, Physiology and Tropical Silviculture. 150-157. TREES, College of forestry and Natural Resources, University of the Philippines Los Banos, College, Laguna, Philippines.
55. The Hindu. 2011. Bangalore's sewage network faulty: CAG. The Hindu. 13 April 2011. Available athttp://www.thehindu.com/todays-paper/tp-national/article1692534.ece: Accessed 8 August 2012.
56. Train K.E. 2003. Discrete choice methods with simulations. Cambridge, Cambridge University Press.

57. Valerian J., Domonko E., Mwita S. and A. Shirima.2011. Assessment of the Willingness to Pay for Organic Products amongst Households in Morogoro Municipal, Sustainable Agriculture, Tanzania.
58. Wanzala M.M., Bumb B. and R. Groot. 2009. Fertilizer Markets in Africa: Challenges and Policy Responses. Prepared for presentation at the Conference towards Priority Actions for Market Development for African Farmers. Nairobi, Kenya.
59. Yadav A. K.2013. Organic Agriculture. Director, National Centre of Organic Farming, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt of India, CGO-II, Kamla Nehru Nagar Ghaziabad, 201(001).Retrieved from; http://ncof.dacnet.nic.in/Training_manuals/Training_manuals_in_English/Organic_Agriculture_in_India.pdfl ast accessed 9th July 2014