CHAPTER 6

SUSTAINABILITY OF MILK SUPPLY CHAIN AND
PERFORMANCE EVALUATION OF SELECTED
SAMPLE SOCIETIES

6.1 INTRODUCTION

In this chapter sustainability of milk supply chain and network of routes are reconstructed to transport maximum capacity with shortest distance than existing. Sustainability of milk supply chain analyzed based on the certain indicators and by using flow base algorithm with the basic logic of Transshipment Method five sample milk routes from hill terrain and milk routes from normal surface terrain were taken for constructing shortest routes with maximum capacity transportation. This chapter is divided into two sections. The first section discusses about the sustainability and the second section covers SWOT analysis used to study the factors affecting the milk transportation, vehicles used for transporting milk, factors affecting transportation of milk, number of milk routes, number of nodes and the maximum capacity transportation with shortest route through Network diagram along with distance covered in kilometers.

6.2 SUSTAINABILITY OF AAVIN MILK SUPPLY CHAIN

Individual consumers are demanding higher quality goods in greater variety, delivered with short lead times at a reasonable cost. These changes in customer characteristics, combined with the external challenges of
constrained energy and natural resources pose an emerging set of challenges to the modern supply chain.

6.2.1 Supply Chain Outputs

Some supply chain output traditionally classified as waste, will be newly-classified as residuals. Formally this type of process would tend to close the loop between supply chain output and inputs, ultimately moving from type 1 systems to type 2 and type 3 systems as shown in the figure.

1. Type 1: one-way system

   Inputs → Process → Outputs

   Figure 6.1 Type 1: one-way system

2. Type 2 (partly-closed) system

   Inputs → Process → Limited Wastes
   Residuals ← Limited Wastes

   Figure 6.2 Type 2 (partly-closed) system
3. **Type 3 (Closed system)**

![Diagram showing a closed system with inputs, process, and residuals](image)

**Figure 6.3 Type 3 (Closed system)**

**Type 1:**

Type 1 systems, raw materials and energy inputs enter the process, are used once and exit the system as products and waste outputs.

**Type 2:**

Type 2 systems, raw materials and energy inputs enter the process, but a fraction of the process outputs are re-used as inputs.

**Type 3:**

Systems are completely closed, as no waste is generated from the process.

The milk supply chain in discussion belongs to type 1 system since the milk residuals can’t be recycled, because the modern supply chain will need to consider the lifecycle of products beyond their traditional end-of-life and design products accordingly. Lifecycle product design facilitates the processes applied to a product after it reaches its traditional end-of-life.
6.2.2 Sustainable Supply Chain

In day to day life it’s often discussed about sustainability of communities, cities, and business and even of technology and that is termed as sustainable system. It’s possible to identify four types of sustainable systems.

Type 1:

Type 1 systems typify global concern (or) problems such as global warming, ozone depletion, genetically modified crops.

Type 2:

Type 2 systems are characterized by geographical boundaries.

Type 3:

Business, either localized (or) distributed, constitutes type 3 systems. Businesses strive to be sustainable by practicing cleaner technologies, recycling byproducts, eliminating waste products.

Type 4:

Type 4 systems are the smallest of the system and that can be called as “sustainable technologies”. Any particular technology that is designed to provide economic value through better supply chain would be an example of type 4 system.

For all practical purposes the sustainability of any chosen system for consideration can’t be guaranteed however, comparative assertion can be made about the state of the system to be more sustainable than another.
It’s been suggested that a hierarchical approach can be used for the metrics for design and analysis of type 3 and Type 4 system for making assertions about milk supply chain towards sustainability.

6.3 TYPES OF METRICS FOR SUSTAINABILITY

Two classes of metrics are in development to indicate the state and performance of a system. These metrics are more popularly known as indicators. Indicators are our link to the world. Indicators condense its enormous complexity to a manageable amount of meaningful information, to small subsets of observations informing our decisions and directing our actions. Indicators sets about a given system are determined by two distinct requirements (1) indicators have to provide vital information providing a picture about the current state and corresponding variability of the system; and(2) indicators have to provide sufficient information about the system’s contribution to the performance of the other system that depends on them. This is particularly obvious where humans try to manage systems for their own goals and interests. Here, Aavin need indicators not only to inform them of the state of the system, Aavin dairy is managing this, but also relevant indicators to successfully intervene and correct system behavior in accordance with given objectives, and to determine the relative success of this intervention.

Content indicators:

1. Those that indicate the state of a system are known as content indicators

Performance indicators:

2. Those that measure the behavior of system are known as performance indicator.
6.3.1 Content Indicators

The major reason for the search for indicators is the wish to receive timely warning of changes that are developing in the system to allow prompt control and counteraction, if that should be necessary. Aavin in itself implies continuing but unpredictable changes - sometimes slow, sometimes fast. The rate of change provides the most important information about changes in a system. At Aavin the structure is overwhelmingly determined by the internal structure and processes of the system and can be hardly influenced from the outside. The structure determines the pace of this slow and fast change within the system and it is directly related to system viability. The process of learning and adoption are slower than the pace of environmental changes then its adaptability is inadequate for ensuring long term viability, i.e., sustainability.

The fact that system states can only change gradually that means in real systems the response to even a strong interaction will always be delayed. For Aavin sustainability, reactive control may come too late; proactive control is often needed. It may not be enough to wait until a crucial variable actually changes (feedback control), but it may be necessary to anticipate that change before it happens (feed forward control). Aavin requires a dynamic model that can reliably predict what is going to happen next. In the view of the dynamics of the real systems, it is essential to focus on indicators that provide early warning of impending threats, leaving enough time for adequate response. For assessing sustainable development, Aavin need to be concerned with the viability of the different essential systems and their contribution to the viability of the system.

In particular, Aavin has to determine whether the viability of the different systems is improving or deteriorating. To stay viable and sustainable, there must be enough time (respite time) for an effective
response. The time Aavin takes to get an effective response underway (also
called walk-away time) must be less than the respite time. Coping
successfully with these possibilities, calls for early and accurate signals i.e.,
proper indicators of the rate of threats especially, when Aavin hike the prices
of milk, consumers are not left with sufficient time to decide on their loyalty
towards Aavin.

6.3.2 Performance Indicator

Performance indicator is all about measuring the behavior of the
system. To assess the viability of a system requires that an essential minimum
satisfaction of each of the factors associated with the content indicator must
be assured. The reason behind this is, the system produce their own intrinsic
dynamics with characteristic time scale. Aavin systems are complex, adaptive,
and self-organizing, changing their structure and behavior in the course of
time. In the beginning of the chapter it’s discussed that Aavin has a one-way
system under supply chain outputs and it belongs to type 3 and Type 4 of
sustainable systems which is capable of creating the business in a self-
organized manner. At Aavin, the processes of self-organization that
continuously changes the complex systems in the real world, often exhibit
their own cyclical dynamics. These development cycles have some relevance
for the selection of indicators, since the focus of attention will necessarily
shift during the cycle.

Four distinct stages of the development cycle can be identified

1. Renewal and growth
2. Conservation
3. Deterioration and creative destruction
4. Innovation and reorganization.
The cycle then repeats. This sequence can be observed in Aavin which is expected to play a role in the sustainable development of the organization and the stakeholders who are associated with Aavin. The penetration of new technologies, the renewal of infrastructure and production capital, changes in work and employment, changes in the age composition with their implications for infrastructure and social and cultural changes all drive this cycle. When the management of Aavin fails to see these changes in the light of the external conditions, the sustainability of Aavin remains a big question mark.

6.4 VEHICLES USED FOR TRANSPORTING MILKS

All the unions are not using same kind of vehicle for collecting milk. Based on the routes and primary society’s milk capacity vehicles are assigned. Vehicles are hired using tender method, generally the tender call are given in the leading magazines and while giving tender all the information are given related to milk routes viz distance, number of milk collection centre, capacity of the vehicle need etc. After receiving sealed tender from transport companies, tenders are opened in the presence of higher officials of the union. The tender that quotes the least cost for per kilometer will be given the opportunity to collect milk from the societies. Usually vehicles are classified based on the size such as small, medium and heavy vehicles. The classifications of vehicles are shown in the following Table 6.1.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Classification</th>
<th>Capacity in tons</th>
<th>Cost per km</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Small</td>
<td>3-5</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>Medium</td>
<td>5-8</td>
<td>11</td>
</tr>
<tr>
<td>3</td>
<td>Heavy</td>
<td>Above 8 tones</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 6.1 Classification of Vehicles
Table 6.1 shows the cost for hiring the vehicles based on its loading capacity. Since milk is of perishable nature, vehicles are chosen, depending on the distance. For transporting milk to metro cities air-conditioned vehicles are used to supply on fresh condition. From the study it is found that the maximum capacity of carrying milk is above eight tons with rupees fifteen per kilometer.

6.5 FACTORS AFFECTING MILK TRANSPORTATION

The main factors affecting transportation of milk are natural calamities viz, hot climate, heavy rain and sometimes the routes also may be one of the major affecting factors. Since milk is perishable nature that has to be protected till reaches the processing and chilling center.

6.5.1 SWOT Analysis

In this section an attempt has been made to study the performance of logistic departments of the union. For this SWOT analysis technique was employed for a systematic analysis and better results.

Table 6.2 Milk Transportation and Related Factors (SWOT)

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicles of all Capacities are available as per the requirement of union in round clock.</td>
<td>Poor contact with transport department</td>
<td>More number of Transport companies with variable price per kilometer</td>
<td>Maintenance of the vehicle</td>
</tr>
<tr>
<td>Experienced truck drivers</td>
<td>Poor rapport with milk producers.</td>
<td>Generally milk producers are dependent of vehicle</td>
<td>Climatic conditions</td>
</tr>
<tr>
<td>Ability to give continue work for trucks round the year</td>
<td>Timings between one-milk collection centers to other milk collection center.</td>
<td>Availability of more number of vehicles in the district even elsewhere</td>
<td>Poor route network between one milk collection center to other milk collection center</td>
</tr>
</tbody>
</table>
Table 6.2 reveals that the main weakness and threat of the transporting milk from milk producers’ societies to processing centre are poor knowledge about transport, poor rapport with milk producers and timings between the milk collection centres. The threats are the maintenance of vehicles by the transport companies, seasonality of milk production and poor route network between the primary milk collection centres. Though many strengths and opportunities like availability of all sort of vehicles, experienced truck drivers, availability of milk production round the year, different price level for hiring vehicles and availability of more number of vehicles strengthen the union into right direction to achieve the goals, since transportation acts as a hindrance to the development of the organization it has to be concentrated more on the weak and threatening areas.

6.6. CONSTRUCTION OF SHORTEST ROUTE

For constructing the shortest routes flow based algorithm and basic logic of transshipment methods are used. Because of maximum capacity with shortest route construction it is not require covering the entire milk collection center. Milk can be collected using separate low capacity vehicles from the nodes that are left without collecting milk and transported to the nearest neighboring node in the main stream. By doing this, it is possible to minimize the transportation cost- instead of giving higher rent to heavy vehicles, it is optimal to choose small vehicle with lower cost. In the following section, all the information related to milk transportation namely existing route map, name of the route, distance between each node and directions are shown for all thirty sample routes.
6.6.1 Hill Terrain Sample Routes network Model

The following network models were constructed for transporting maximum capacity with shortest distance using flow based algorithm, network logic, and transshipment ideas.

ANCHETTI ROUTE

Step 1

There is no alternate route; therefore the following sequence can be retained.

1 → 2 → 3 → 4 → 5 → 6 = 39 km is an optimal route.

Step 2

There are two alternate routes

6 → 7 → 8 = 8 km and 6 → 8 = 5 km

Here 6 → 8 = 5 km is an optimal route.
Step 3

There are two alternate routes

$8 \rightarrow 9 \rightarrow 10 = 10 \text{ km}$ and $8 \rightarrow 10 = 6 \text{ km}$

Here $8 \rightarrow 10 = 6 \text{ km}$ is an optimal route.

Step 4

There is no alternate route and therefore the following sequence can be retained $10 \rightarrow 11 \rightarrow 12 \rightarrow 13 \rightarrow 14 = 12 \text{ km}$ is an optimal sequence of route.

Step 5

The ultimate route from the starting node is following

$1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 6 \rightarrow 8 \rightarrow 10 \rightarrow 11 \rightarrow 12 \rightarrow 13 \rightarrow 14 = 68 \text{ km}$

Step 6

The following Table 6.3 represents the uncovered milk collection centres, capacity of milk and to which node milk from a particular society has to be transferred. Based on the production capacity of that society, small vehicles can be arranged to transport milk from that primary society.

**Table 6.3 Uncovered Nodes, Capacity of Milk and Alternative Arrangements**

<table>
<thead>
<tr>
<th>From the node</th>
<th>To the node</th>
<th>Distance in km</th>
<th>Weight in litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>8</td>
<td>2</td>
<td>452</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>2</td>
<td>110</td>
</tr>
</tbody>
</table>
From the above Table 6.3, of Anchetti route, it can be understood that a distance of 49 km is reduced when utilizing the alternative arrangements to transport milk from the uncovered nodes. The calculations are given below in detail:

**For one trip**

- Actual distance = 121 km
- Total distance as per network flow = 68 km
- As per above arrangements = 4 km with 562 litres

Total distance = 72 km

Distance saved through this model = 49 Km

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**KOTAIYUR ROUTE**

**Distance in Kilo Meter**

**Weight in litre**

![Kottaiyur Route Diagram]

*Figure 6.5 Kottaiyur Route*
2) KOTTAIYUR ROUTE

Step 1

There is no alternate route and therefore the following sequence can be retained $1 \rightarrow 2 = 2$ km is an optimal route.

Step 2

There are two alternate routes

$2 \rightarrow 3 \rightarrow 4 = 6$ km and $2 \rightarrow 4 = 4$ km

Here $2 \rightarrow 4 = 4$ km is an optimal route.

Step 3

There is no alternate route; therefore the following sequence can be retained $4 \rightarrow 5 \rightarrow 6 \rightarrow 7 = 24$ km is an optimal sequence of route.

Step 4

The ultimate route from the starting node is following

$1 \rightarrow 2 \rightarrow 4 \rightarrow 5 \rightarrow 6 \rightarrow 7 = 30$ km

Step 5

The following Table 6.4 represents the uncovered milk collection centres and to which node milk from a particular society has to be transferred. Based on the production capacity of the society, vehicles can be arranged to transport milk.
Table 6.4 Uncovered Nodes and Alternative Arrangements for kotaiyur route

<table>
<thead>
<tr>
<th>From the node</th>
<th>To the node</th>
<th>Distance in km</th>
<th>Weight in litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2</td>
<td>1</td>
<td>825</td>
</tr>
</tbody>
</table>

The above Table 6.4 shows that a distance of 33.5 km from the regular total traveling distance is reduced for a single trip. The calculations are given below in detail:

**For one trip**

Actual distance = 64.5 km

Total distance as per network flow = 30 km

As per above arrangements = 1 km with 825 litres

Total = 31 km

Distance saved through this model = 33.5 Km

Figure 6.6 Mudhuganapalli Route
3) **MUTHUGANA PALLI ROUTE**

**Step 1**

There is no alternate route and therefore the following sequence can be retained: 1→2→3→4→5→6→7 = 22 km is an optimal sequence of route.

**Step 2**

There are three alternate routes: 7→8→9→10 = 22 km, 7→9→10 = 9 km and 7→8→10 = 10 km.

7→9→10=9km is an optimal sequence of route.

**Step 3**

There are two alternate routes:

10→11→12→13→14 = 13 km and 10→14 = 7 km.

There 10→14 = 7 km is an optimal route.

**Step 4**

There are three alternate routes:

14→15→16→17 = 16 km, 14→16→17=10 km and 14→15→17=13 km.

14→16→17=10km is an optimal sequence of the route.

**Step 5**

There is no alternate route; therefore the following sequence can be retained: 17→18→19=8km is an optimal sequence of the route.

**Step 6**

There are two alternate routes:

19→21 = 9 km, and 19→20→21 = 17 km and

19→21 = 9 km is an optimal route.
Step 7
There is no alternate route; therefore the following sequence can be retained $21 \rightarrow 22 = 6$ km is an optimal sequence of the route

Step 8
The ultimate route from the starting node is following

$1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 6 \rightarrow 7 \rightarrow 9 \rightarrow 10 \rightarrow 14 \rightarrow 16 \rightarrow 17 \rightarrow 18 \rightarrow 19 \rightarrow 21 \rightarrow 22 = 71$ km

Step 9
The following Table 6.5 represents the uncovered milk collection centres and to which node milk from a particular society has to be transferred. Based on the production capacity of the society, vehicles can be arranged to transport milk.

**Table 6.5 Uncovered Nodes and Alternative Arrangements for muthuganapalli route**

<table>
<thead>
<tr>
<th>From the node</th>
<th>To the node</th>
<th>Distance in km</th>
<th>Weight in litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>7</td>
<td>8</td>
<td>110</td>
</tr>
<tr>
<td>11 and 12</td>
<td>10</td>
<td>5</td>
<td>470</td>
</tr>
<tr>
<td>13</td>
<td>14</td>
<td>3</td>
<td>290</td>
</tr>
<tr>
<td>15</td>
<td>16</td>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td>20</td>
<td>21</td>
<td>5</td>
<td>100</td>
</tr>
</tbody>
</table>

From the above Table 6.5, it can be inferred that the alternative arrangements for transporting milk from the uncovered nodes 8, 11 and 12, 13, 15 and 20 to the nodes 7, 10, 14, 16 and 21, respectively, reduce a distance of 16 km from the regular total traveling distance for a single trip.
For one trip

Actual distance = 111 km

Total distance as per network flow = 71 km

As per above arrangements = 24 km with 1020 litres

Total = 95 km

Distance saved through this model = 16 km

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**JAVALAGIRI ROUTE**

*Distance in Kilo Meter*

*Weight in litre*

![Route Diagram](image)

**Figure 6.7 Javalagiri Route**

4) **JAVALAGIRI ROUTE**

**Step 1**

There are two alternate routes

1→2→3→4 = 16 km and 1→4 = 10 km

1→4 = 10km is an optimal sequence of route

**Step 2**

There is no alternate route; therefore the following sequence can be retained 4→5→6→7 = 11 km is an optimal sequence of the route
Step 3
There are two alternate routes
$7\rightarrow8\rightarrow9\rightarrow10 = 14$ km, and $7\rightarrow10 = 9$ km
Here $7\rightarrow10 = 9$ km is an optimal route

Step 4
There is no alternate route; therefore the following sequence can be retained $10\rightarrow11\rightarrow12\rightarrow13 = 24$ km is an optimal sequence of the route.

Step 5
The ultimate route from the starting node is following
$1\rightarrow4\rightarrow5\rightarrow6\rightarrow7\rightarrow10\rightarrow11\rightarrow12\rightarrow13 = 54$ km

Step 6
The following Table 6.6 represents the uncovered milk collection centres and to which node milk from a particular society has to be transferred. Based on the production capacity of the society, vehicles can be arranged to transport milk.

Table 6.6 Uncovered Nodes and Alternative Arrangements for Javalagiri route

<table>
<thead>
<tr>
<th>From the node</th>
<th>To the node</th>
<th>Distance in km</th>
<th>Weight in litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
<td>5</td>
<td>314</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>3</td>
<td>216</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
<td>5</td>
<td>169</td>
</tr>
<tr>
<td>9</td>
<td>10</td>
<td>2</td>
<td>369</td>
</tr>
</tbody>
</table>
From the above Table 6.6, In Javalagiri route, milk can be transported from the uncovered nodes 2, 3 and both the node 8 and 9 to the nodes 1, 4, and 10 respectively. And doing this can save a distance of 2 km. The calculations are given below in detail:

For one trip

Actual distance = 71 km
Total distance as per network flow = 54 km
As per above arrangements = 15 km with 899

Total = 69 km

Distance saved through this model = 2 Km

PANCHAPALLI ROUTE

Distance in Kilo Meter
Weight in litre

Figure 6.8 Panjapalli Route

5) PANCHAPALLI ROUTE

Step 1

There is no alternate route; therefore the following sequence can be retained 1→2→3→4→5 = 34 km is an optimal route.
Step 2

There are two alternate routes

\[5 \rightarrow 6 \rightarrow 7 = 22 \text{ km} \text{ and } 5 \rightarrow 7 = 10 \text{ km}\]

Here \(5 \rightarrow 7 = 10 \text{ km}\) is an optimal route

Step 3

There is no alternate route and therefore the following sequence can be retained \(7 \rightarrow 8 \rightarrow 9 \rightarrow 10 = 39 \text{ km}\) is an optimal route

Step 4

The ultimate route from the starting node is following

\[1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 7 \rightarrow 8 \rightarrow 9 \rightarrow 10 = 83 \text{ km}\]

Step 5

The following Table 6.7 represents the uncovered milk collection centre and to which node milk has to be transferred by arranging small vehicles, based on the production capacity of that society.

**Table 6.7  Uncovered Nodes and Alternative Arrangements for Panchapalli route**

<table>
<thead>
<tr>
<th>From the node</th>
<th>To the node</th>
<th>Distance in km</th>
<th>Weight in litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>5</td>
<td>6</td>
<td>326</td>
</tr>
</tbody>
</table>

As per the above Table 6.7, when transporting milk using the alternative arrangements, 34 km is saved for a single trip. The calculations are given below in detail:
For one trip

Actual distance = 123 km
Total distance as per network flow = 83 km
As per above arrangements = 6km with 326 litres

Distance saved through this model = 34 Km

6.6.2 Normal Surface Terrain Sample Routes Network Model

The following network models were constructed based on the operation research techniques and survey conducted to construct shortest route with maximum capacity in order to avoid delay in transportation

Figure 6.9 Echampatti Route
6) **EACHAMPATTI ROUTE**

**Step 1**

There is no alternate route therefore the following sequence can be retained $1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 5 = 13 \text{ km}$ is an optimal route.

**Step 2**

There are three alternate $5 \rightarrow 6 \rightarrow 8 = 3 \text{ km}$, $5 \rightarrow 6 \rightarrow 7 \rightarrow 8 = 8 \text{ km}$ and $5 \rightarrow 7 \rightarrow 8 = 5 \text{ km}$

$5 \rightarrow 6 \rightarrow 8 = 3 \text{ km}$ is an optimal route.

**Step 3**

There is no alternate route therefore the following sequence can be retained $8 \rightarrow 9 \rightarrow 10 \rightarrow 11 \rightarrow 12 = 11 \text{ km}$ is an optimal route.

**Step 4**

There are two alternate routes $12 \rightarrow 19 = 17 \text{ km}$ and $12 \rightarrow 13 \rightarrow 14 \rightarrow 15 \rightarrow 16 \rightarrow 17 \rightarrow 18 \rightarrow 19 = 28 \text{ km}$

$12 \rightarrow 19 = 17 \text{ km}$ is an optimal route.

**Step 5**

There is no alternate route therefore the following sequence can be retained $19 \rightarrow 20 \rightarrow 21 = 7 \text{ km}$ is an optimal route.

**Step 6**

The ultimate route from the starting node is following

$1 \rightarrow 2 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 7 \rightarrow 8 \rightarrow 9 \rightarrow 10 \rightarrow 11 \rightarrow 12 \rightarrow 19 \rightarrow 20 \rightarrow 21 = 51 \text{ km}$
Step 7

The following Table 6.8 represents the uncovered milk collection centres and to which node milk from a particular society has to be transferred. Based on the production capacity of the society, vehicles can be arranged to transport milk.

Table 6.8  Uncovered Nodes and Alternative Arrangements for Eachampatti route

<table>
<thead>
<tr>
<th>From the node</th>
<th>To the node</th>
<th>Distance in km</th>
<th>Weight in litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>5</td>
<td>1</td>
<td>220</td>
</tr>
<tr>
<td>13 and 14</td>
<td>12</td>
<td>9</td>
<td>760</td>
</tr>
<tr>
<td>15,16,17 and 18</td>
<td>19</td>
<td>9</td>
<td>570</td>
</tr>
</tbody>
</table>

The above Table 6.8 shows that when transporting milk from the uncovered nodes 6 to node 5, 13 and 14 to the node 12 and finally the nodes 15, 16, 17 and 18 to the nodes 19 respectively, maximum of 23 km from the regular total traveling distance is reduced for a single trip. The calculations are given below in detail:

For one trip

Actual distance = 93 km
Total distance as per network flow = 51 km
As per above arrangements = 19 km with 1550 litres

Total = 70 km

Distance saved through this model = 23 Km
7) **SOMANAHALLI ROUTE**

**Step 1**

There is no alternate route. Therefore the following sequence can be retained $1 \rightarrow 2 = 1$ km is an optimal route.

**Step 2**

There are two alternate

$2 \rightarrow 3 \rightarrow 4 = 2$ km and $2 \rightarrow 4 = 1$ km

$2 \rightarrow 4 = 1$ km is an optimal route.

**Step 3**

There are two alternate

$4 \rightarrow 5 \rightarrow 6 = 10$ km and $4 \rightarrow 6 = 6$ km

$4 \rightarrow 6 = 6$ km is an optimal route.
Step 4

There is no alternate route. Therefore the following sequence can be retained $6\rightarrow 7\rightarrow 8\rightarrow 9\rightarrow 10\rightarrow 11\rightarrow 12\rightarrow 13\rightarrow 14 = 42$ km is an optimal route.

Step 5

There are three alternate routes

$14\rightarrow 16\rightarrow 17 = 8$ km, $14\rightarrow 15\rightarrow 16\rightarrow 17 = 12$ km

and $14\rightarrow 15\rightarrow 17 = 7$ km

Here $14\rightarrow 15\rightarrow 17 = 7$ km is an optimal route

Step 6

There is no alternate route. Therefore the following sequence can be retained $17\rightarrow 18\rightarrow 19 = 3$ km is an optimal route.

Step 7

There are three alternate routes

$19\rightarrow 20\rightarrow 21\rightarrow 22\rightarrow 23\rightarrow 24 = 13$ km and $19\rightarrow 24 = 5$ km

Here $19\rightarrow 24 = 5$ km is an optimal route

Step 8

There is no alternate route. Therefore the following sequence can be retained $24\rightarrow 25\rightarrow 26\rightarrow 27 = 12$ km is an optimal route.

Step 9

The ultimate route from the starting node is following

$1\rightarrow 2\rightarrow 4\rightarrow 6\rightarrow 7\rightarrow 8\rightarrow 9\rightarrow 10\rightarrow 11\rightarrow 12\rightarrow 13\rightarrow 14\rightarrow 15\rightarrow 17\rightarrow 18\rightarrow 19\rightarrow 24\rightarrow 25\rightarrow 26\rightarrow 27 = 77$ km
Step 10

The following Table 6.9 represents the uncovered milk collection centres and to which node milk from a particular society has to be transferred. Based on the production capacity of the society, vehicles can be arranged to transport milk.

Table 6.9  Uncovered Nodes and Alternative Arrangements for somanahalli route

<table>
<thead>
<tr>
<th>From the node</th>
<th>To the node</th>
<th>Distance in km</th>
<th>Weight in litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>2</td>
<td>110</td>
</tr>
<tr>
<td>16</td>
<td>17</td>
<td>1</td>
<td>295</td>
</tr>
<tr>
<td>20 and 21</td>
<td>19</td>
<td>4</td>
<td>300</td>
</tr>
<tr>
<td>22 and 23</td>
<td>24</td>
<td>7</td>
<td>148</td>
</tr>
</tbody>
</table>

From the above Table 6.9, it can be inferred that nearly 23 km from the regular total traveling distance is reduced for a single trip, when transporting milk from the uncovered nodes 3 to 4, 5 to 6, 16 to 17, the nodes 20 and 21 to 19 and finally 22 and 23 to the node 24 respectively. The calculations are given below in detail:

For one trip

Actual distance = 115 km
Total distance as per network flow = 77 km
As per above arrangements = 15 km with 903 litres

Total

Distance saved through this model = 23 Km
8) JAGADEVI ROUTE

Step 1

There is no alternate route. Therefore the following sequence can be retained $1\to 2\to 3\to 4\to 5\to 6 = 57$ km is an optimal route

Step 2

There are two alternate routes
$6\to 7\to 8 = 23$ km and $6\to 8 = 16$ km
Here $6\to 8 = 16$ km is an optimal route

Step 3

There is no alternate route therefore the following sequence can be retained $8\to 9\to 10\to 11 = 42$ km is an optimal route

Step 4

The ultimate route from the starting node is following
$1\to 2\to 3\to 4\to 5\to 6\to 8\to 9\to 10\to 11 = 105$ km
Step 5

The following Table 6.10 gives information about the uncovered milk collection centre and to which node milk from the particular society has to be transferred. Small vehicles can be arranged, based on the production capacity of that society, to transport milk from that primary society.

**Table 6.10 Uncovered Nodes and Alternative Arrangements for Jagadevi route**

<table>
<thead>
<tr>
<th>From the node</th>
<th>To the node</th>
<th>Distance in km</th>
<th>Weight in litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>8</td>
<td>10</td>
<td>550</td>
</tr>
</tbody>
</table>

From the above Table 6.10, it is observed that a distance of 12 km from the regular total traveling distance is reduced for a single trip, when having alternative vehicles to transport milk to the nodes in the main stream. The calculations are given below in detail:

**For one trip**

Actual distance = 127 km

Total distance as per network flow = 105 km

As per above arrangements = 10km with 550 litres

Total

Distance saved through this model = 12 Km
9) UTTHANGARAI ROUTE

Step 1

There is no alternate route. Therefore the following sequence can be retained $1 \rightarrow 2 = 5 \text{ km}$ is an optimal route

Step 2

There are two alternate routes

$2 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 6 = 23 \text{ km}$ and $2 \rightarrow 6 = 11 \text{ km}$

Here $2 \rightarrow 6 = 11 \text{ km}$ is an optimal route

Step 3

There is no alternate route therefore the following sequence can be retained

$6 \rightarrow 7 \rightarrow 8 \rightarrow 9 \rightarrow 10 \rightarrow 11 \rightarrow 12 \rightarrow 13 \rightarrow 14 \rightarrow 15 \rightarrow 16 = 93 \text{ km}$ is an optimal route

Step 4

The ultimate route from the starting node is following

$1 \rightarrow 2 \rightarrow 6 \rightarrow 7 \rightarrow 8 \rightarrow 9 \rightarrow 10 \rightarrow 11 \rightarrow 12 \rightarrow 13 \rightarrow 14 \rightarrow 15 \rightarrow 16 = 109 \text{ km}$
Step 5

The following Table 6.11 represents the uncovered milk collection centres and to which node milk from a particular society has to be transferred. Based on the production capacity of the society, vehicles can be arranged to transport milk.

Table 6.11 Uncovered Nodes and Alternative Arrangements for utthangarai route

<table>
<thead>
<tr>
<th>From the node</th>
<th>To the node</th>
<th>Distance in km</th>
<th>Weight in litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,4</td>
<td>2</td>
<td>5</td>
<td>1080</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>8</td>
<td>240</td>
</tr>
</tbody>
</table>

From the above Table No.6.11 shows that in Uttangarai route, a distance of 32 km from the regular total traveling distance is reduced for a single trip when transporting milk from the uncovered nodes to the nearest nodes in the main stream. The calculations are given below in detail:

For one trip

Actual distance = 150 km

Total distance as per network flow = 105 km

As per above arrangements = 13 km with 1320 litres

Total = 118 km

Distance saved through this model = 32 Km
KANDI KUPPAM ROUTE

Step 1

Starting node is 1. There are two alternate routes

1→3 = 4 km and 1→2→3 = 9

1→3 = 4 is an optimal route

Step 2

There are two alternate routes

3→4→5 = 26 km and 3→5 = 9 km

Step 3

There are two alternate routes

5→6→7 = 25 km and 5→7 = 17 km

Here 5→7 = 17 km is an optimal route

Step 4

There is no alternate route and therefore the following sequence can be retained 7→8 = 16 km is an optimal route
Step 5

The ultimate route from the starting node is following
1 → 3 → 5 → 7 → 8 = 46 km

Step 6

The following Table 6.12 represents the uncovered milk collection centres and to which node milk has to be transferred. Small vehicles can be arranged, based on the production capacity of that society, to transport milk from that primary society.

Table 6.12 Uncovered Nodes and Alternative Arrangements for kanndikuppam route

<table>
<thead>
<tr>
<th>From the node</th>
<th>To the node</th>
<th>Distance in km</th>
<th>Weight in litres</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 and 4</td>
<td>3</td>
<td>14</td>
<td>1034</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>8</td>
<td>550</td>
</tr>
</tbody>
</table>

From the above Table 6.12, it can be concluded that transporting milk from the uncovered nodes 2 and 4 to 3 in the same way node 6 to node 7, reduces a traveling distance of 28 km for a single trip. The calculations are given below in detail:

For one trip

Actual distance = 96 km
Total distance as per network flow = 46 km
As per above arrangements = 22 km with 1584 litres

Total = 68 km
Distance saved through this model = 28 Km
6.7 CONCLUSION

This chapter covers the sustainability of milk supply chain and construction of the shortest route for milk collection.

1. Content indicator shows Aavin structure and process of the system can be hardly influence from the outside, learning and adoption is very slow than the environmental changes.

2. Performance indicators shows the penetration of new technology, renewal of infrastructure, changes in work and employment in all these areas the management of Aavin fails to see changes in the light of the external conditions, the sustainability of Aavin not up to the mark.

3. Here, flow based algorithm and Transshipment logic were employed and it is found that the traveling distance has been notably reduced with a minimum of 2 Km to maximum of 86 Km for one trip and with an average of 30.15 Km. Milk collection from the nodes that are left unconnected through the shortest route were 129 km with 9539 Litres, this has to be done using alternative small/medium vehicles to the nearest possible node in the main stream. This enhances the reduction of cost (vehicle rent) and time (transportation). Among all these factors, the ‘Empty’ trips are totally wiped away and this saves lot of money and time.