**Title: Construction of efficient Wireless Sensor Networks for Energy Minimization using a modified ACO Algorithm.**

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**Graphical Abstract**

Step 1: A Deployment Strategy has been chosen from different deployment strategies. (Random, Spiral, S-shaped)

Step 2: Indexing of each and every node of Wireless Sensor Network (WSN) has been done.

Step 3: Area wise clustering has been implemented for target Wireless Sensor Network.

Step 4: Cluster head for each and every cluster of the Wireless Sensor Network has been selected.

Step 5: Modified Ant Colony Optimization has been applied to get the optimized energy consumption.

Step 6: Energy minimization and number of days (saved) has been calculated for the whole WSN.

**Abstract:** In this paper, we have proposed different deployment strategies and have applied area-wise clustering along with modified Ant Colony Optimization to minimize energy consumption.

* **Background**: Previously some deployment strategies were used to enhance the lifetime of WSN. In our research, we have applied some novel deployment strategies like random, spiral, and S-pattern along with a novel area-wise clustering process to get better results than the existing literature as shown in Table 4.
* **Objective:** The main objective of the research article is to enhance the lifetime of Wireless Sensor Networkwith the help of different deployment strategies like random, spiral, and S-pattern). A novel clustering process (i.e., area-wise clustering), and a Meta-heuristic algorithm (modified ACO) are applied.
* **Method:** We have applied different methods for deployment strategies (random, spiral, and S-pattern). A novel clustering process (i.e., area-wise clustering), and a Meta-heuristic algorithm (modified ACO) are applied to get the desired results.
* **Results:** Random Deployment: 11.15 days to 15.09 days.

Spiral Deployment: 11.25 days to 15.23 days.

S-Pattern Deployment: 11.33 days to 15.33 days.

* **Conclusion:** In this paper, efficient Wireless Sensor Networks have been configured considering energy minimization as the prime concern. To minimize the energy consumption a modified ACO algorithm has been proposed. In our work, the minimization of energy consumption leads to an increment of the lifetime of WSN to a significant margin theoretically. The obtained result has been compared with the existing literature and it has been found that the proposed algorithm produced a better result than the existing literature.

**Keywords**: Wireless Sensor Network (WSN), Deployment Strategy; Clustering Process; Ant Colony Optimization (ACO); Meta-heuristic Methods; Cluster Head (CH).

**1. INTRODUCTION**

A wireless sensor network is employed in various fields like medicine, agriculture, meteorology, etc. WSN eases many tasks in real life especially in the area of surveillance. It can be a solution to some inspiring problems like “War Field Monitoring”, “Temperature Sensing”, “Pressure Sensing”, etc. Apart from sensing the major job of WSN is to transmit and receive data in the network. Wireless Sensor Network has a good range of applications in modern technology. WSN is a tiny device having sensing, communicative, processing, and storage units with power back-up usually by a non-rechargeable battery*.* The WSN nodes are deployed within the target area to collect various sorts of important information and transfer that information to the sink node*.* Nowadays this sort of network is getting used to facilitate the modern army for “environmental monitoring” [1], “Battlefield Monitoring” [2], “Body Area Network” (BAN), “Intelligent Household”, “Smart Home System” etc*.* The Sink node [3] is the controller communicative node acting as an administrator node in the WSN.

Depending upon the nature of WSN, it is classified into two types and those are static WSN [4] and dynamic WSN [5]. In the case of static WSN, the whole unit is mounted and fixed to a certain fixed point (the co-ordinate system is maintained referencing “sink node” as origin). In the case of dynamic WSN, the node is dynamic, though the sink node is generally mounted to a fixed coordinate (generally considered as origin). Now depending upon the need and purpose the node is selected to develop the communication network. In our experiment, static nodes were used where the coordinate of the sink node [6] as well as typical nodes are fixed and permanent (considered as origin).

In the case of a typical WSN design, the sensor nodes are deployed to cover the target area. [7]. The sensor nodes are deployed to sense the required data like weather information or enemy related information in case of the battlefield of modern war system and transfer it to the sink node may be directly or via another sensor node. Now in the case of our research, the target area has been clustered. A cell structure is defined as the arrangement of cells in a particular network. The cell structure may be triangular or square in structure but not circular. A circular cell structure leaves out a lot of areas. Out of the remaining square was chosen as the triangular structure cannot cover more area as compared to the square cell structure. In this paper, our objective is to minimize the energy consumption of a WSN. The traversal path is being minimized to cover every cell of the particular path as well as the traversal path between the sink node and cells. The movement of the ants motivated us in using a modified Ant Colony Optimization technique though which provides us with the shortest path.

Figure **1**: Clusterization of the whole area using a circular cluster cell structure.

Figure **2**: Clusterization of the whole area using a square cluster cell structure.

The shaded circle indicates the clusterization of the whole area using a circular cluster cell structure (Figure 1). We can see that there are gaps between the circular clusters [8] which lead to wastage of space. Due to this reason, circular clustering has not been adopted.

The whole area has been divided into multiple square structures (Figure 2). The dots in the figure denote the position of WSN nodes. The nodes have been arranged in such a manner that the maximum area is covered by each node while maintaining uniformity. This deployment will vary in the case of real-life WSN deployment.

Each cell consists of more than one sensor node (denoted as N). The sink node (denoted as SN) acts as a control point like the local server node [9]. The main aim of the network is to transfer information from one node of a particular cell to another node of an adjacent cell using minimum total power consumption. Each cell is considered as one cluster and each cluster having an active sensor node. The active node of each cluster is called Cluster-Head (CH) [10] The Cluster-Head is connected with another Cluster-Head of a different cell or cluster and thus a network is established. The established network will persist until all Cluster-Head becomes fully exhausted due to a shortage of power backup and after that, the exhausted Cluster-Head will be replaced by another Cluster-Head and so on until all cluster heads of the cluster become exhausted. Here two types of communication will take place i.e., inter-cluster communication (CH-CH communication) [3] or Sink-Cluster communication (SN-CH communication).

The WSN lifetime is dependent on the battery life of the WSN. The lifetime of WSN depends upon so many design factors like the “Deployment Strategy” of WSN nodes and the “Clustering Process”. The deployment strategy has a great effect on the power consumption and network coverage of sensor networks. In the clustering process, the area is divided into many clusters for creating congestion-free transmission. After clustering, some specific nodes are selected to design the network and some of them are designated as “Cluster Head” or “Leader node” for those clusters. After that, a modified version of the ACO algorithm has been implemented for getting the shortest path to design an effective and succinct network for the minimization of energy consumption. The obtained result by applying different deployment strategies has been compared with an identical network of various works of literature. A significant amount of energy saving has been observed and recorded for the proposed algorithm. The obtained result has been compared with some existing literature and it claimed better results than other implemented results of existing literature.

In section 2 we have done the “Literature Survey” which indicates the related work about WSN by different researchers. After that, the “Solution Methodology” is described in section 3 where we have discussed how a modified ACO helps to find the shortest path. Then after sections 5 and 6, we have introduced “Numerical Data Analysis” and Data Representation” where we displayed the data in terms of tables and pictures. In section 6 we have explained the “Result Analysis” which has been represented in terms of the “number of days” the network can sustain. At last, we have completed a “Conclusion” in section 7 which discussed the scope for future work.

**2. LITERATURE SURVEY**

Kurt et al. [11] have suggested a new power optimization technique to increase network lifetime. Pughat et al. [12] have proposed the technique of DPM (Dynamic Power Management) which helps to control the duty cycle efficiently which helps in minimize power consumption. Yildiz et al. [13] explained how minimized handshaking helps in reducing the optimized power level which in turn increases the lifetime of the WSN. Akbas et al. [14] discussed how to maintain a balance between data packet size and transmission energy. Small data packet size increases the transmission energy while large data packet size will be difficult to transmit hence can result in loss of data. Hua et al. [15] suggested the concept of a UAV (unmanned aerial vehicle) that helps in establishing a flexible movement path that helps in reliable communication. Lei et al. [16] Expressed the concept of IWSMACO which is a modified version of ACO (Ant colony optimization) based on the information weight factor. Paniri et al. [17] Suggested MLACO (method based on ant colony optimization) which uses supervised and unsupervised learning algorithms. Arjunan et al. [18] Introduce a hybrid algorithm based on fuzzy logic unequal clustering and ACO. Here fuzzy logic is used to select cluster heads. Khediri et al. [19] Explained how the LEACH cluster algorithm can be used to select cluster heads which reduces the consumption of energy. Boubrima et al. [20] suggested that deployment is an important concept of WSN. Aznoli et al. [21] Proposed deployment can be classified as deterministic and non-deterministic. Tsai et al. [22] Introduced a new meta-heuristic algorithm called SE (Search Economics) to solve the deployment problem of WSN. Benatia et al. [23] Proposed MODS (Multi-Objective deployment strategy) for solving the placement problem to optimize it. Arya et al. [24] Suggested optimizing the physical distance and signal strength between two nodes. Mohajerani et al. [25] Advise us to use a routing algorithm that uses special parameters to reduce energy consumption by each node. Gajjar et al. [26] explained using a combination of ACO-based MAC and unequal clustering cross-layer protocol for cluster head selection. Nayyar et al. [27] suggested using swarm intelligence-based computational techniques to improve the overall WSN. Wang et al. [28] suggested that information could be exploited fully and used in the later optimization process; the quality of the succeeding solutions would be improved significantly. Guo et al. [29] said his paper introduces the chaos theory into the KH optimization process intending to accelerate its global convergence speed. Gao D et al. [30] explained the advantage of the DE algorithm is that it uses a special evolutionary strategy of difference vector sets to carry out mutation operation. Wang GG et al. [31] suggested that by simplifying and idealizing the migration of monarch butterflies, a new kind of nature-inspired met heuristic algorithm, called monarch butterfly optimization (MBO) can be constructed. Gu et al. [32] mentioned the problem of NSGA-III. Yi JH et al. [33] discussed the drawbacks of MOEAs. Zhang Y et al. [34] introduced the information feedback models to improve the ability of NSGA-III to solve large-scale optimization problems. Zhang Q et al. [35] proposed the standard MOEA/D algorithm, the update process of individuals is a forward search process without using the information of previous individuals.

**3. SOLUTION METHODOLOGY**

In our paper, a modified version of the ACO algorithm is implemented for the minimization of consumed energy in WSN. This technique has acquired attention due to its precision towards the optimal results. In Ant Colony Optimization, several artificial ants build solutions are considered towards the optimization problem. These exchange data about the quality of these results via a communication media, “pheromone trail, which is reminiscent of the one adopted by real ants” [36].

The original ACO algorithm acknowledged as the Ant System was presented in [36]. A brief discussion on ACO is followed next.

In this algorithm, we have used the ants as the solution variance which solves the optimization problem by applying the state transition rule. The solution can be enhanced by “the Local Search Algorithm”. Then the ant adapts “...the amount of pheromone on the visited edges by applying a local pheromone updating rule” [36]. Once all ants have finished their operations, “the amount of pheromone is modified by applying a global updating rule” [36]. ACO activity may be realized with the following two equations Equation 1 and Equation 2.

(1)

The local pheromone updating rule is shown in Equation 2.

(2)

**Contribution:** Modification in ACO algorithm: At first the ANT solution is updated using the local update rule. Then the updated ANT solution is modified using the global update rule and ultimately the ANT solution is compared with a previous feasible solution and has taken the following strategies:

1. If both (before modification by global update rule and after modification by global update rule) solution is feasible then choose the ANT solution for which the nearest value of global optimum is achieved.
2. If anyone's solution is in-feasible then discard it and obtain the feasible ANT solution.
3. If both (before modification by global update rule and after modification by global update rule) solution is in-feasible then discard the ANT solution and find the next ANT solution.
4. In this paper, a modified meta-heuristic algorithm is used (i.e., modified ACO algorithm) that has been used, for selecting the cluster head of the efficient WSN to get the efficient network route.
5. In the modified ACO there are 2 types of updates (i.e. global update as well as a local update) the global update guarantees to obtain the nearest value to the global optimum.in other cases, the local update rule guarantees local optimum to the nearest value in our modified ACO algorithm we have used at first the local update rule and then the global update rule. If the solution is found in the local optimum then the solution will be selected and if the solution is found in global optimum the global optimum selected. In this strategy, we can do the local search as well as global search therefore there is every chance to miss out on any feasible solution from the solution space. In the case of DE-QPSO, there is some chance to miss out on the local or global solution because de is generally used for global searching, and PSO is used for local searching. In our proposed modified ACO as we are searching the local solution (using local update rule) firstly and then the global solution, therefore, there is very less chance to miss out on any solution. Therefore, we can tell our proposed algorithm as a local search among global search, which is the specialty of our proposed modified algorithm.

**Pseudo-code for modified ACO**

**Step 1:** Initialize the parameters of the ACO algorithm, including the number of ants to be deployed, the maximum number of iterations, the tune-able parameters, and the initial level of pheromone.

**Step 2**: Randomly select a node within any cluster and select the other node from another cluster until all the clusters are covered and follow the ACO rule (ACO update rule).

**Step 3**: If all paths have been traversed by each ant, then continue; otherwise go to step 2.

**Step 4:** Evaluate the path using the update rule to achieve accuracy depending upon verification.

**Step 5:** After evaporation of the pheromone, find the ant with the best path. Only permit those ants to deposit pheromone on its traversed paths. If the maximum number of iteration max has not been reached go back to step 2; otherwise, go to the next step.

**Step 6:** Search for the globally best path which produces the highest accuracy among all local best solutions.

**Step 7**: End

In this paper, the entire process of network formation has been done through the following steps:

**3.1.    Indexing for Sensor Nodes**: The sensor nodes to be deployed must be indexed virtually to denote or keep track of each sensor node before and after the deployment. This indexing process will also help to construct the network. The indexing has been proposed with the help of row and column number of the cell (as depicted in figure 2.). It also helps us to know the row and column number of the matrix of the target area. The indexing is a sequential number.

Initialize all the initial parameters as mentioned in Step 1.

For each ant initialize a specific path and traverse it.

Evaluate all the paths and then select the best path (depending upon update rule).

Condition met as mentioned in step 3?

Generate new ants

Return the best path

NO

Update pheromone by the update rule

YES

Figure **3**: Flowchart of the modified ACO algorithm

Step 1: A Deployment Strategy has been chosen from different deployment strategies. (Random, Spiral, S-shaped)

Step 2: Indexing of every node of Wireless Sensor Network (WSN) has been done.

Step 3: Area wise clustering has been implemented for the target Wireless Sensor Network.

Step 4: Cluster head for every cluster of the Wireless Sensor Network has been selected.

Step 5: Modified Ant Colony Optimization has been applied to get the optimized energy consumption.

Step 5A: Initialize the parameters of the ACO algorithm, including the number of ants to be deployed, the maximum number of iterations, the tune-able parameters, and the initial level of pheromone.

Step 5B: Randomly select a node within any cluster and select the other node from another cluster until all the clusters are covered and follow the ACO rule (ACO update rule).

Step 5C: If all paths have been traversed by each ant, then continue; otherwise go to step 2.

Step 5D: Evaluate the path using the update rule to achieve accuracy depending upon verification.

Step 5E: After evaporation of the pheromone, find the ant with the best path. Only permit those ants to deposit pheromone on its traversed paths. If the maximum number of iteration max has not reached go back to step 2; otherwise, go to the next step.

Step 5F: Search for the globally best path which produces the highest accuracy among all local best solutions.

Step 5G: End of modified ACO.

Step 6: Energy minimization and the number of days (saved) has been calculated for the whole WSN.

Step 7: End of the proposed algorithm.

Figure **4**: The Overall Proposed Algorithm

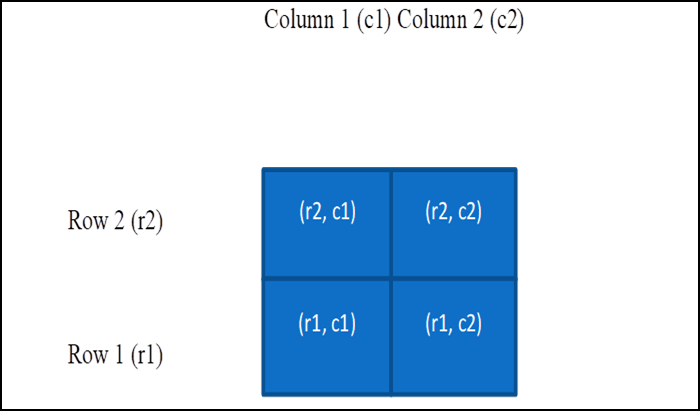
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Figure **5**: Structure of cluster cell and their representation

***3.1.1. Indexing before Deployment***: This is the indexing that is given to the sensor node before deployment. It will help us to keep track of the total number of sensor nodes to be deployed and to maintain the sequence of sensor nodes. (Figures 7, 8, 9, 11, 12, 13, 15, 16, 17).

***3.1.2. Indexing after Deployment*:**This type of indexing much more important because this indexing is assigned to the sensor nodes after deployment. By this indexing, the sensor node will be denoted until the sensor node becomes fully exhausted. (Figures 10, 14, 18)

**3.2. Clustering:**Here clustering meansdividing the target area into some uniform or equal-size sectors. The aim is to construct an efficient network. The structure of cluster cells has been chosen as a square. It can be proved [37] that using square cluster-cell the target area can be covered properly. Here the term “efficient network” refers to the efficient and uniform coverage of the target area with no communication gap between the neighboring clusters. The importance of the clustering process to minimize energy is to segregate the target area into uniform sectors which will help to construct an efficient network as well as to cover the target area uniformly.

**3.3 Different strategies for the deployment of WSN nodes:**

The importance of deployment strategies to minimize the energy of WSN is to predict the position of nodes in the WSN especially in the case of S-pattern deployment as well as spiral deployment. In the case of random deployment, it is not so easy to predict the position of WSN nodes but this deployment is a realistic deployment strategy that is very practical in a real-life situation, therefore, this strategy has been considered in our work.

***3.3.1.******Random deployment of sensor nodes***: Here we consider the deployment to be done from a certain distance. In the case of random deployment, it is very difficult to predict the position of sensor nodes. A fixed number of nodes are deployed for a fixed amount of time. For example, suppose we have to deploy x amount of sensor nodes in y

amount of time. Therefore, we don’t have any fixed strategy to cover the target area.

***3.3.2.******S pattern deployment***: In this type of deployment deployment-strategy follow the S-pattern deployment of sensor nodes. The deployment time is considered a fixed period. The time interval between two deployments is assumed

as fixed time and the path is followed as a fixed path.

Here the starting time and ending time of deployment are fixed and the deployment is done in between this period (see figures no. 6 to 8).

***3.3.3.******Spiral deployment***: In this type of deployment we follow the Spiral-pattern at the time of deployment of sensor nodes, other criteria are the same as previous deployment.

**3.4**. **Selection of a sensor node as cluster head**: The selection process has been done with the help of a meta-heuristic algorithm i.e., ACO algorithm. The selection of a sensor node as a cluster head (CH) is an important job towards the development of an efficient network configuration because with the help of the cluster head only the internal network is formed.

Here in this paper, the selection of the cluster head has been done by calculating the uniform distance between different nodes in a cluster maintaining the following conditions:

a) One cluster head has been selected from each cluster and the process has been done with the help of a meta-heuristic algorithm i.e., modified ACO algorithm.

b) After the full exhaustion of energy of one cluster head, another sensor node is considered as an active cluster head and the previous cluster head becomes inactive.

c) The intermediate network will sustain for some time and when the cluster head of any cluster cell will be exhausted it will form another network thus it will give stability to the whole network to perform for a longer period and ultimately when all the sensor-nodes of a particular cluster will be exhausted the whole network will go down.

**3.5.** **WSN network configuration through modified ACO algorithm:**

In the ACO Algorithm, we choose the minimized path for transmitting and receiving information among the nodes.

The linear problem as described below:

The energy consumption during successful data transmission between cluster head (CH) to cluster head (CH) and cluster head (CH) to sink node (SN) has been calculated and minimized using the below-maintained equations:

The energy consumption during successful data transmission between cluster head (CH) to cluster head (CH) and cluster head (CH) to sink node (SN) has been calculated and minimized using the below-maintained equations [39]:

(3)

Subject to,

ddo, for free-space propagation model and d > do for two- ray ground propagation model.

Where do is the threshold transmission distance.

Here R is the size of the data packet to be communicated.

Where,

(4)

(5)

(6)

(7)

(8)

(9)

(10)

(11)

(12)

= energy required for the transmitting data packets between two adjacent cluster head for the amplifier to maintain an acceptable signal-to-noise ratio to transfer data messages reliably.

= energy required for the transmitting data packets between sink node and cluster head for the amplifier to maintain an acceptable signal-to-noise ratio to transfer data messages reliably.

=Electronic energy degenerated during the transmission between two adjacent cluster heads.

=Electronic energy degenerated during the transmission between the sink node and adjacent cluster head.

Etransmission = amount of energy used by each node at the time of transmitting data packets.

Ereceiving = energy used for receiving data packets.

Measurement of distance between two cluster heads is done using the following formula

dxy

Ets= Amount of energy consumption by a single node for free-space propagation

Where (x1, y1) and (x2, y2) are coordinates of reference nodes and dxy is the distance measured between two adjacent cluster heads and the notation dxy and d are the same.

Now in terms of minimizing the total energy transmission and using the proposed ACO algorithm, the optimized path has been established as shown in Figure 6. The data used in Table 1. After getting an efficient path through the meta-heuristic algorithm i.e., ACO total energy saved was determined in hours. In this paper, the tolerance percentage has been fixed to ±15% which is the most acceptable tolerance in the case of Wireless Sensor Network. The designed network is an efficient network concerning the minimization of energy consumption.

In this section, the energy minimization problem was solved using ACO. The proposed method was tested using the data of Table 1 using the ACO algorithm and obtained the optimized path for the network for minimizing energy consumption.

The following parameter values are used in the experiment for simulating the system. [40].

**4. NUMERICAL DATA ANALYSIS**

Table **1**: Parameters for simulation.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | Values | Parameters | Values |
| Deployment Area | 980 x 980 m2 | Data packet size (R) | 4096 bits |
| Total number of Clusters | 49 | Max no. of nodes (in the network) | 490 |
| The initial energy of each node | 1J |  | 50nJ/bit |
|  | 10pJ • bit−1 •m−2 | Maximum Number of Rounds | 6000 |

In Table 1, different units (Joule, Nano Joule, and Pico-Joule) were used Therefore to maintain uniformity, all calculations have been done in Pico-Joule in Table 2, Table 3, and Table 4.In this paper the best path is plotted for shortest distances (see Figures 10**,** 14**,** 18) obtained from the ACO algorithm for different deployments by solving the equations 1 to 10 based on the data supplied in Table 1. As the energy consumption is directly proportional to the distance between nodes that’s why we have calculated the maximum coverage area. Table 1 shows the communication between the sink node and the cluster head, whereas Table 2, 3, and 4 show the communication between adjustment cluster heads. In the below diagram we are going to show the 4 phases of forming a network and finding the shortest path. The first process is the deployment where three strategies namely random, spiral, and s-pattern have been used (see Figures 7**,** 11, and 15 respectively). The next step is the division of the nodes into clusters or clustering (See Figures 8**,** 12**,** 16). The third process consists of electing the Cluster Heads. (See Figures 9,13**,** 17) and the fourth process includes connecting all the cluster heads among themselves using the ACO algorithm (See Figures 9**,** 13**,** 17).

**5. NUMERICAL DATA REPRESENTATION**

Now the numerical data is being represented with the help of the tabular format depicted below. With the help of table 2, Energy Saving (Es) calculations applying random deployment and area-wise clustering processes have been done. With the help of table 3, Energy Saving (Es) calculations have been done applying spiral deployment and area-wise Clustering Process. With the help of table 4, Energy Saving (Es) calculations applying s-pattern deployment and area-wise Clustering Process have been done.

We have used certain notations to calculate the energies. A brief description of them is given below. (This notation can be found in Tables 2,3 and 4)

1. E\_tx0: This indicates the actual energy required to transform the data packets from one node to another (equation 5 and 6)
2. E\_tx(min): This is E\_tx0 but after applying minimum possible tolerance.
3. E\_tx(max): This is also E\_tx0 but after applying maximum possible tolerance.
4. total0: This the total energy required during the whole communication (transmitting and receiving) among the nodes.
5. totalxy(min): This is the total energy required but after applying minimum possible tolerance.
6. totalxy(max): This is the total energy

required but after applying maximum possible tolerance.

1. maxEng: This is the difference between totalxy(max) and totalxy(min).
2. minEng: This is the difference between total0 and totalxy(min).
3. avgEng: This is the difference between totalxy(max) and total0.

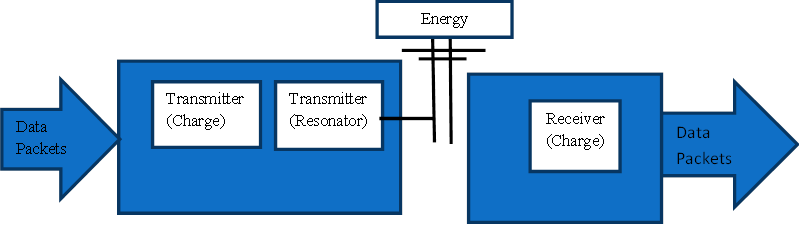


Figure **6**: Block Diagram of WSN nodes with transmitter and receiver

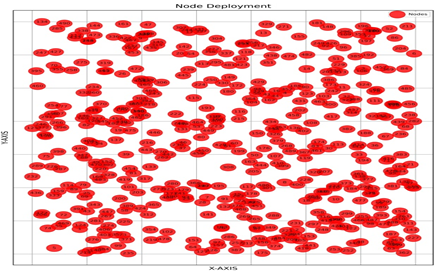


Figure **7**: Random deployment: The above figure shows the random deployment of the nodes in the area.

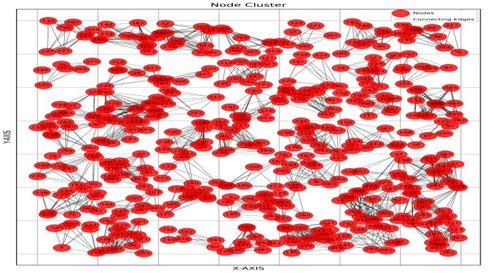


Figure **8**: Random clustering-This figure shows how the nodes are grouped into clusters.

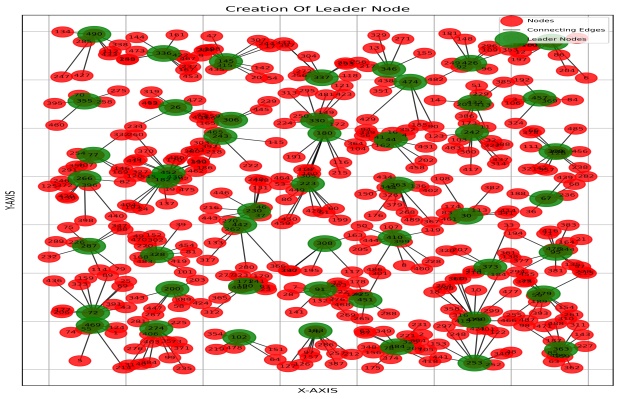
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Figure **9**: Leader Nodes of the clusters-The above figure shows the leader nodes of their respective clusters denoted by the green colour.

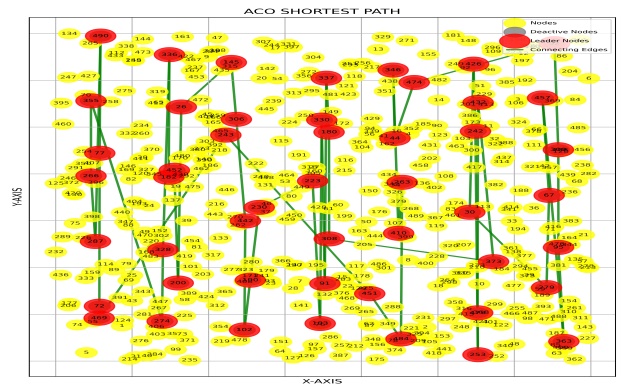
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Figure **10**: Shortest path after applying ACO Algorithm denoted by green lines.

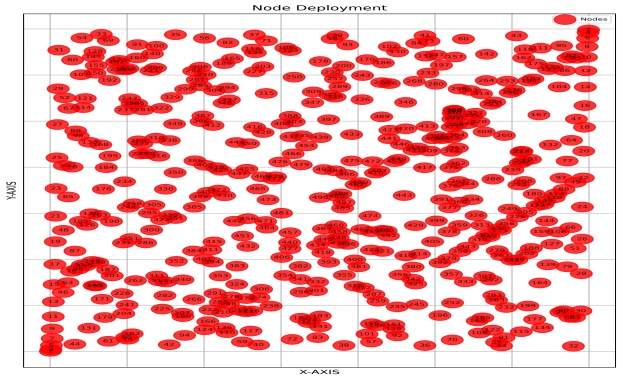
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Figure **11**: Spiral deployment-The above figure shows the deployment of nodes spirally starting from the upper left side and ending at the centre.

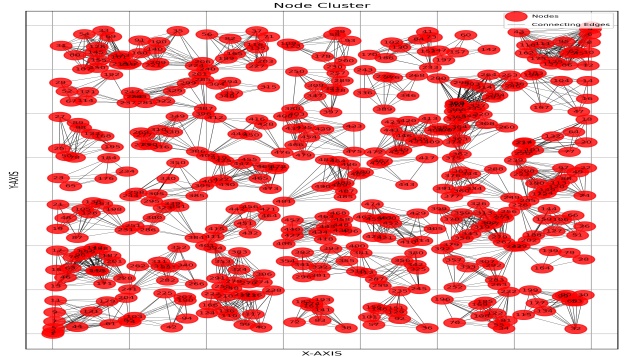
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Figure **12**: Spiral Clustering-This figure shows the clusters formed within the nodes and is connected through black lines.

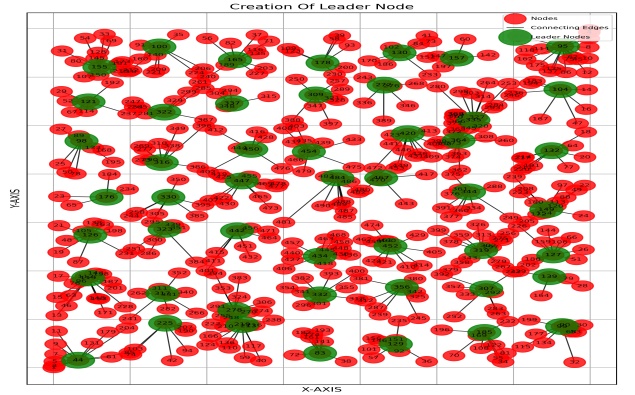
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Figure **13**: Leader nodes or head nodes of the clusters. The green nodes indicate the leader nodes of the respective clusters.

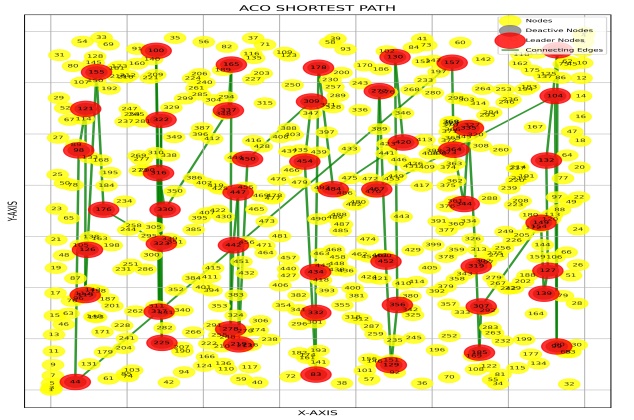
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Figure **14**: Shortest path obtained after applying ACO denoted by green lines.

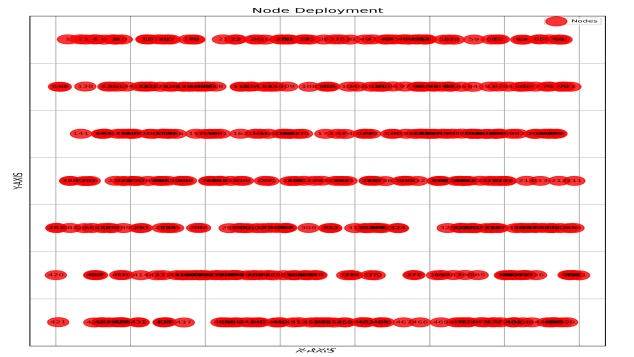
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Figure **15**: S-pattern Deployment-This above figure shows the deployment of the nodes in an s-pattern fashion.

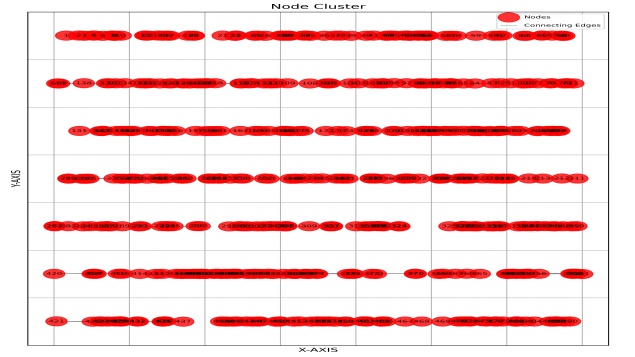


Figure **16**: S-pattern Clustering-This figure shows the clustering of the nodes in an s-pattern manner.

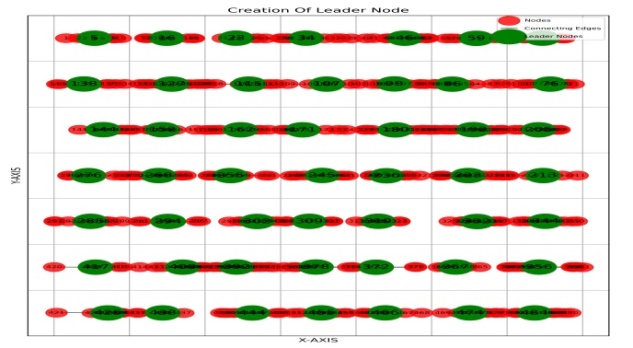


Figure **17**: Leader nodes or head nodes of the clusters- The green nodes indicate the leader nodes of the respective cluster

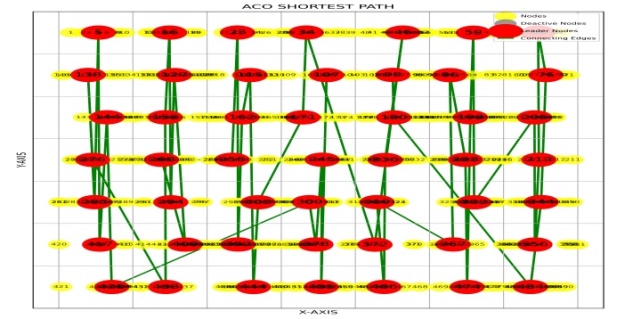


Figure **18**: Shortest path after applying the ACO algorithm denoted by the green line.

Table **2**: Energy saving (ES) calculations applying S-pattern Deployment Strategy and Area Wise Clustering Process

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **dmin(d=42mm or 4.2cm)** | | | | **dmax(d=42mm or 4.2cm)** | | | |  |  |  |  |  |  |  |  |  |  |  |  |
| INO-CL NO. | (x1-d/2) | (y1-d/2) | (x2-d/2) | (y2-d/2) | (x1+d/2) | (y1+d/2) | (x2+d/2) | (y2+d/2) | dis(zero) | dxy(min) | dxy(max) | E\_tx0 | E\_tx(min) | E\_tx(max) | max Eng | min Eng | AvgEng | total0 | totalxy(min) | totalxy(max) |
| 1-1 | -2.1 | -2.1 | 65.28 | 68.03 | 2.1 | 2.1 | 69.48 | 72.23 | 97.2537 | 91.31526 | 103.1923 | 50418.28 | 49298.48 | 51608.65 | 2310.168 | 1119.804 | 1190.364 | 50418.28 | 49298.48 | 51608.65 |
| 1-2 | 65.28 | 68.03 | 68.28 | 208.3 | 69.48 | 72.23 | 72.48 | 212.5 | 140.3021 | 136.0753 | 144.6493 | 60644.67 | 59476.48 | 61883.42 | 2406.936 | 1168.188 | 1238.748 | 60644.67 | 59476.48 | 61883.42 |
| 1-3 | 68.28 | 208.3 | 73.42 | 348.04 | 72.48 | 212.5 | 77.62 | 352.24 | 139.8345 | 135.5433 | 144.2427 | 60513.69 | 59331.98 | 61765.96 | 2433.984 | 1181.712 | 1252.272 | 60513.69 | 59331.98 | 61765.96 |
| 1-4 | 73.42 | 348.04 | 96.92 | 488.73 | 77.62 | 352.24 | 101.12 | 492.93 | 142.6391 | 137.8478 | 147.5141 | 61305.93 | 59962.01 | 62720.4 | 2758.392 | 1343.916 | 1414.476 | 61305.93 | 59962.01 | 62720.4 |
| 1-5 | 96.92 | 488.73 | 89.81 | 628.26 | 101.12 | 492.93 | 94.01 | 632.46 | 139.711 | 135.8018 | 143.7595 | 60479.17 | 59402.13 | 61626.78 | 2224.656 | 1077.048 | 1147.608 | 60479.17 | 59402.13 | 61626.78 |
| 1-6 | 89.81 | 628.26 | 83.93 | 768.45 | 94.01 | 632.46 | 88.13 | 772.65 | 140.3133 | 136.3631 | 144.3998 | 60647.81 | 59554.89 | 61811.29 | 2256.408 | 1092.924 | 1163.484 | 60647.81 | 59554.89 | 61811.29 |
| 1-7 | 83.93 | 768.45 | 34.85 | 908.48 | 88.13 | 772.65 | 39.05 | 912.68 | 148.3821 | 145.906 | 151.0513 | 62977.25 | 62248.55 | 63776.51 | 1527.96 | 728.7 | 799.26 | 62977.25 | 62248.55 | 63776.51 |
| 1-8 | 34.85 | 908.48 | 215.44 | 68.65 | 39.05 | 912.68 | 219.64 | 72.85 | 859.0269 | 862.2645 | 855.8182 | 778887.2 | 784460.1 | 773384.8 | 11075.23 | 5572.896 | 5502.336 | 778887.2 | 784460.1 | 773384.8 |
| 1-9 | 215.44 | 68.65 | 188.95 | 208.48 | 219.64 | 72.85 | 193.15 | 212.68 | 142.3171 | 139.0589 | 145.7446 | 61214.15 | 60297.37 | 62201.49 | 1904.112 | 916.776 | 987.336 | 61214.15 | 60297.37 | 62201.49 |
| 1-10 | 188.95 | 208.48 | 190.93 | 348.65 | 193.15 | 212.68 | 195.13 | 352.85 | 140.184 | 135.9881 | 144.5022 | 60611.55 | 59452.77 | 61840.89 | 2388.12 | 1158.78 | 1229.34 | 60611.55 | 59452.77 | 61840.89 |
| 1-11 | 190.93 | 348.65 | 210.24 | 487.91 | 195.13 | 352.85 | 214.44 | 492.11 | 140.5924 | 135.9026 | 145.3736 | 60726.22 | 59429.52 | 62093.49 | 2663.976 | 1296.708 | 1367.268 | 60726.22 | 59429.52 | 62093.49 |
| 1-12 | 210.24 | 487.91 | 212.45 | 628.13 | 214.44 | 492.11 | 216.65 | 632.33 | 140.2374 | 136.0346 | 144.5622 | 60626.53 | 59465.4 | 61858.22 | 2392.824 | 1161.132 | 1231.692 | 60626.53 | 59465.4 | 61858.22 |
| 1-13 | 212.45 | 628.13 | 189.03 | 768.52 | 216.65 | 632.33 | 193.23 | 772.72 | 142.3301 | 138.9625 | 145.8618 | 61217.85 | 60270.58 | 62235.68 | 1965.096 | 947.268 | 1017.828 | 61217.85 | 60270.58 | 62235.68 |
| 1-14 | 189.03 | 768.52 | 175.03 | 908.36 | 193.23 | 772.72 | 179.23 | 912.56 | 140.5391 | 136.8556 | 144.373 | 60711.23 | 59689.45 | 61803.56 | 2114.112 | 1021.776 | 1092.336 | 60711.23 | 59689.45 | 61803.56 |
| 1-15 | 175.03 | 908.36 | 342.97 | 68.55 | 179.23 | 912.56 | 347.17 | 72.75 | 856.4372 | 859.7463 | 853.1566 | 774444.7 | 780123.7 | 768836.3 | 11287.42 | 5678.988 | 5608.428 | 774444.7 | 780123.7 | 768836.3 |
| 1-16 | 342.97 | 68.55 | 322.61 | 208.3 | 347.17 | 72.75 | 326.81 | 212.5 | 141.2253 | 137.757 | 144.8542 | 60904.59 | 59937 | 61942.75 | 2005.752 | 967.596 | 1038.156 | 60904.59 | 59937 | 61942.75 |
| 1-17 | 322.61 | 208.3 | 366.29 | 348.78 | 326.81 | 212.5 | 370.49 | 352.98 | 147.1141 | 141.8834 | 152.3968 | 62602.57 | 61090.91 | 64184.8 | 3093.888 | 1511.664 | 1582.224 | 62602.57 | 61090.91 | 64184.8 |
| 1-18 | 366.29 | 348.78 | 350.87 | 488.58 | 370.49 | 352.98 | 355.07 | 492.78 | 140.6478 | 137.0121 | 144.4365 | 60741.82 | 59732.3 | 61821.89 | 2089.584 | 1009.512 | 1080.072 | 60741.82 | 59732.3 | 61821.89 |
| 1-19 | 350.87 | 488.58 | 326.85 | 628.51 | 355.07 | 492.78 | 331.05 | 632.71 | 141.9766 | 138.6326 | 145.4864 | 61117.37 | 60179 | 62126.29 | 1947.288 | 938.364 | 1008.924 | 61117.37 | 60179 | 62126.29 |
| 1-20 | 326.85 | 628.51 | 324.74 | 768.58 | 331.05 | 632.71 | 328.94 | 772.78 | 140.0859 | 136.0164 | 144.2851 | 60584.06 | 59460.47 | 61778.2 | 2317.728 | 1123.584 | 1194.144 | 60584.06 | 59460.47 | 61778.2 |
| 1-21 | 324.74 | 768.58 | 297.27 | 907.99 | 328.94 | 772.78 | 301.47 | 912.19 | 142.0906 | 138.8695 | 145.4831 | 61149.75 | 60244.73 | 62125.33 | 1880.592 | 905.016 | 975.576 | 61149.75 | 60244.73 | 62125.33 |
| 1-22 | 297.27 | 907.99 | 499.05 | 68.71 | 301.47 | 912.19 | 503.25 | 72.91 | 863.1953 | 866.3119 | 860.1083 | 786066.1 | 791456.4 | 780746.4 | 10710 | 5390.28 | 5319.72 | 786066.1 | 791456.4 | 780746.4 |
| 1-23 | 499.05 | 68.71 | 486.83 | 208.24 | 503.25 | 72.91 | 491.03 | 212.44 | 140.0641 | 136.3225 | 143.9536 | 60577.95 | 59543.83 | 61682.63 | 2138.808 | 1034.124 | 1104.684 | 60577.95 | 59543.83 | 61682.63 |
| 1-24 | 486.83 | 208.24 | 483.81 | 348.56 | 491.03 | 212.44 | 488.01 | 352.76 | 140.3525 | 136.3113 | 144.5248 | 60658.82 | 59540.78 | 61847.42 | 2306.64 | 1118.04 | 1188.6 | 60658.82 | 59540.78 | 61847.42 |
| 1-25 | 483.81 | 348.56 | 511.25 | 488.31 | 488.01 | 352.76 | 515.45 | 492.51 | 142.4185 | 137.5278 | 147.3862 | 61243.02 | 59873.9 | 62682.69 | 2808.792 | 1369.116 | 1439.676 | 61243.02 | 59873.9 | 62682.69 |
| 1-26 | 511.25 | 488.31 | 460.9 | 628.36 | 515.45 | 492.51 | 465.1 | 632.56 | 148.8258 | 146.393 | 151.4526 | 63109.13 | 62390.93 | 63897.89 | 1506.96 | 718.2 | 788.76 | 63109.13 | 62390.93 | 63897.89 |
| 1-27 | 460.9 | 628.36 | 490.01 | 768.47 | 465.1 | 632.56 | 494.21 | 772.67 | 143.1021 | 138.1739 | 148.1045 | 61438.2 | 60052.04 | 62894.93 | 2842.896 | 1386.168 | 1456.728 | 61438.2 | 60052.04 | 62894.93 |
| 1-28 | 490.01 | 768.47 | 483.42 | 908.79 | 494.21 | 772.67 | 487.62 | 912.99 | 140.4747 | 136.547 | 144.5398 | 60693.13 | 59605.08 | 61851.74 | 2246.664 | 1088.052 | 1158.612 | 60693.13 | 59605.08 | 61851.74 |
| 1-29 | 483.42 | 908.79 | 636.31 | 67.96 | 487.62 | 912.99 | 640.51 | 72.16 | 854.6171 | 858.0119 | 851.2503 | 771330.4 | 777144.4 | 765587 | 11557.39 | 5813.976 | 5743.416 | 771330.4 | 777144.4 | 765587 |
| 1-30 | 636.31 | 67.96 | 648.55 | 208.78 | 640.51 | 72.16 | 652.75 | 212.98 | 141.3509 | 136.8564 | 145.9489 | 60940.09 | 59689.67 | 62261.07 | 2571.408 | 1250.424 | 1320.984 | 60940.09 | 59689.67 | 62261.07 |
| 1-31 | 648.55 | 208.78 | 639.6 | 348.39 | 652.75 | 212.98 | 643.8 | 352.59 | 139.8966 | 136.047 | 143.8884 | 60531.05 | 59468.79 | 61663.88 | 2195.088 | 1062.264 | 1132.824 | 60531.05 | 59468.79 | 61663.88 |
| 1-32 | 639.6 | 348.39 | 622.27 | 488.64 | 643.8 | 352.59 | 626.47 | 492.84 | 141.3166 | 137.743 | 145.0455 | 60930.39 | 59933.14 | 61998.2 | 2065.056 | 997.248 | 1067.808 | 60930.39 | 59933.14 | 61998.2 |
| 1-33 | 622.27 | 488.64 | 643.26 | 627.95 | 626.47 | 492.84 | 647.46 | 632.15 | 140.8824 | 136.1492 | 145.704 | 60807.86 | 59496.62 | 62189.66 | 2693.04 | 1311.24 | 1381.8 | 60807.86 | 59496.62 | 62189.66 |
| 1-34 | 643.26 | 627.95 | 668.26 | 768.21 | 647.46 | 632.15 | 672.46 | 772.41 | 142.4706 | 137.6407 | 147.3816 | 61257.87 | 59904.96 | 62681.33 | 2776.368 | 1352.904 | 1423.464 | 61257.87 | 59904.96 | 62681.33 |
| 1-35 | 668.26 | 768.21 | 627.62 | 907.92 | 672.46 | 772.41 | 631.82 | 912.12 | 145.5008 | 142.7361 | 148.4519 | 62130.49 | 61333.59 | 62997.96 | 1664.376 | 796.908 | 867.468 | 62130.49 | 61333.59 | 62997.96 |
| 1-36 | 627.62 | 907.92 | 786.64 | 68.37 | 631.82 | 912.12 | 790.84 | 72.57 | 854.4774 | 857.8364 | 851.1465 | 771091.6 | 776843.3 | 765410.4 | 11432.9 | 5751.732 | 5681.172 | 771091.6 | 776843.3 | 765410.4 |
| 1-37 | 786.64 | 68.37 | 754.28 | 208.44 | 790.84 | 72.57 | 758.48 | 212.64 | 143.7594 | 140.7028 | 146.9926 | 61626.77 | 60757.29 | 62566.82 | 1809.528 | 869.484 | 940.044 | 61626.77 | 60757.29 | 62566.82 |
| 1-38 | 754.28 | 208.44 | 762.36 | 348.65 | 758.48 | 212.64 | 766.56 | 352.85 | 140.4426 | 136.0653 | 144.9312 | 60684.13 | 59473.77 | 61965.05 | 2491.272 | 1210.356 | 1280.916 | 60684.13 | 59473.77 | 61965.05 |
| 1-39 | 762.36 | 348.65 | 744.58 | 488.02 | 766.56 | 352.85 | 748.78 | 492.22 | 140.4996 | 136.9454 | 144.2108 | 60700.13 | 59714.05 | 61756.76 | 2042.712 | 986.076 | 1056.636 | 60700.13 | 59714.05 | 61756.76 |
| 1-40 | 744.58 | 488.02 | 787.09 | 628.69 | 748.78 | 492.22 | 791.29 | 632.89 | 146.9529 | 141.7453 | 152.2141 | 62555.15 | 61051.72 | 64129.14 | 3077.424 | 1503.432 | 1573.992 | 62555.15 | 61051.72 | 64129.14 |
| 1-41 | 787.09 | 628.69 | 751.75 | 768.68 | 791.29 | 632.89 | 755.95 | 772.88 | 144.3818 | 141.4296 | 147.5143 | 61806.12 | 60962.34 | 62720.46 | 1758.12 | 843.78 | 914.34 | 61806.12 | 60962.34 | 62720.46 |
| 1-42 | 751.75 | 768.68 | 767.48 | 908.68 | 755.95 | 772.88 | 771.68 | 912.88 | 140.8809 | 136.2886 | 145.5708 | 60807.43 | 59534.58 | 62150.84 | 2616.264 | 1272.852 | 1343.412 | 60807.43 | 59534.58 | 62150.84 |
| 1-43 | 767.48 | 908.68 | 882.95 | 68.65 | 771.68 | 912.88 | 887.15 | 72.85 | 847.9291 | 851.5312 | 844.3534 | 759943.7 | 766065.3 | 753892.7 | 12172.61 | 6121.584 | 6051.024 | 759943.7 | 766065.3 | 753892.7 |
| 1-44 | 882.95 | 68.65 | 901.02 | 208.78 | 887.15 | 72.85 | 905.22 | 212.98 | 141.2903 | 136.6358 | 146.038 | 60922.94 | 59629.34 | 62287.1 | 2657.76 | 1293.6 | 1364.16 | 60922.94 | 59629.34 | 62287.1 |
| 1-45 | 901.02 | 208.78 | 886.16 | 348.71 | 905.22 | 212.98 | 890.36 | 352.91 | 140.7168 | 137.0617 | 144.5237 | 60761.22 | 59745.92 | 61847.09 | 2101.176 | 1015.308 | 1085.868 | 60761.22 | 59745.92 | 61847.09 |
| 1-46 | 886.16 | 348.71 | 899.04 | 488.08 | 890.36 | 352.91 | 903.24 | 492.28 | 139.9639 | 135.4484 | 144.5824 | 60549.89 | 59306.27 | 61864.07 | 2557.8 | 1243.62 | 1314.18 | 60549.89 | 59306.27 | 61864.07 |
| 1-47 | 899.04 | 488.08 | 897.17 | 628.34 | 903.24 | 492.28 | 901.37 | 632.54 | 140.2725 | 136.1953 | 144.4788 | 60636.36 | 59509.17 | 61834.12 | 2324.952 | 1127.196 | 1197.756 | 60636.36 | 59509.17 | 61834.12 |
| 1-48 | 897.17 | 628.34 | 895.15 | 768.77 | 901.37 | 632.54 | 899.35 | 772.97 | 140.4445 | 136.3719 | 144.6464 | 60684.67 | 59557.3 | 61882.59 | 2325.288 | 1127.364 | 1197.924 | 60684.67 | 59557.3 | 61882.59 |
| 1-49 | 895.15 | 768.77 | 900.24 | 908.06 | 899.35 | 772.97 | 904.44 | 912.26 | 139.383 | 135.0929 | 143.7904 | 60387.61 | 59210.1 | 61635.68 | 2425.584 | 1177.512 | 1248.072 | 60387.61 | 59210.1 | 61635.68 |
| 2-1 | -2.1 | -2.1 | 69.34 | 68.02 | 2.1 | 2.1 | 73.54 | 72.22 | 100.1024 | 94.16297 | 106.0418 | 50980.49 | 49826.66 | 52204.87 | 2378.208 | 1153.824 | 1224.384 | 50980.49 | 49826.66 | 52204.87 |
| 2-2 | 69.34 | 68.02 | 55.94 | 208.11 | 73.54 | 72.22 | 60.14 | 212.31 | 140.7294 | 137.025 | 144.583 | 60764.77 | 59735.85 | 61864.24 | 2128.392 | 1028.916 | 1099.476 | 60764.77 | 59735.85 | 61864.24 |
| 2-3 | 55.94 | 208.11 | 98.38 | 348.42 | 60.14 | 212.31 | 102.58 | 352.62 | 146.588 | 141.3797 | 151.85 | 62448.05 | 60948.23 | 64018.43 | 3070.2 | 1499.82 | 1570.38 | 62448.05 | 60948.23 | 64018.43 |
| 2-4 | 98.38 | 348.42 | 51.46 | 487.97 | 102.58 | 352.62 | 55.66 | 492.17 | 147.2267 | 144.682 | 149.9635 | 62635.69 | 61892.88 | 63449.06 | 1556.184 | 742.812 | 813.372 | 62635.69 | 61892.88 | 63449.06 |
| 2-5 | 51.46 | 487.97 | 86.01 | 628.02 | 55.66 | 492.17 | 90.21 | 632.22 | 144.2488 | 139.1989 | 149.3641 | 61767.71 | 60336.35 | 63269.63 | 2933.28 | 1431.36 | 1501.92 | 61767.71 | 60336.35 | 63269.63 |
| 2-6 | 86.01 | 628.02 | 84.71 | 768.89 | 90.21 | 632.22 | 88.91 | 773.09 | 140.876 | 136.7806 | 145.099 | 60806.05 | 59668.94 | 62013.71 | 2344.776 | 1137.108 | 1207.668 | 60806.05 | 59668.94 | 62013.71 |
| 2-7 | 84.71 | 768.89 | 31.14 | 908.27 | 88.91 | 773.09 | 35.34 | 912.47 | 149.3202 | 147.0068 | 151.8309 | 63256.53 | 62571.01 | 64012.61 | 1441.608 | 685.524 | 756.084 | 63256.53 | 62571.01 | 64012.61 |
| 2-8 | 31.14 | 908.27 | 213.69 | 68.5 | 35.34 | 912.47 | 217.89 | 72.7 | 859.3824 | 862.6089 | 856.185 | 779498.2 | 785054.1 | 774012.8 | 11041.3 | 5555.928 | 5485.368 | 779498.2 | 785054.1 | 774012.8 |
| 2-9 | 213.69 | 68.5 | 174.01 | 208.74 | 217.89 | 72.7 | 178.21 | 212.94 | 145.7455 | 142.9417 | 148.7338 | 62201.76 | 61392.34 | 63081.74 | 1689.408 | 809.424 | 879.984 | 62201.76 | 61392.34 | 63081.74 |
| 2-10 | 174.01 | 208.74 | 198.99 | 348.18 | 178.21 | 212.94 | 203.19 | 352.38 | 141.6599 | 136.8271 | 146.5739 | 61027.51 | 59681.67 | 62443.92 | 2762.256 | 1345.848 | 1416.408 | 61027.51 | 59681.67 | 62443.92 |
| 2-11 | 198.99 | 348.18 | 243.29 | 488.66 | 203.19 | 352.38 | 247.49 | 492.86 | 147.2994 | 142.0572 | 152.5928 | 62657.12 | 61140.25 | 64244.55 | 3104.304 | 1516.872 | 1587.432 | 62657.12 | 61140.25 | 64244.55 |
| 2-12 | 243.29 | 488.66 | 182.53 | 628.67 | 247.49 | 492.86 | 186.73 | 632.87 | 152.6256 | 150.5462 | 154.905 | 64254.58 | 63624.16 | 64955.56 | 1331.4 | 630.42 | 700.98 | 64254.58 | 63624.16 | 64955.56 |
| 2-13 | 182.53 | 628.67 | 171.48 | 768.12 | 186.73 | 632.87 | 175.68 | 772.32 | 139.8871 | 136.107 | 143.8132 | 60528.41 | 59485.13 | 61642.25 | 2157.12 | 1043.28 | 1113.84 | 60528.41 | 59485.13 | 61642.25 |
| 2-14 | 171.48 | 768.12 | 174.42 | 908.54 | 175.68 | 772.32 | 178.62 | 912.74 | 140.4508 | 136.2258 | 144.7961 | 60686.42 | 59517.48 | 61925.92 | 2408.448 | 1168.944 | 1239.504 | 60686.42 | 59517.48 | 61925.92 |
| 2-15 | 174.42 | 908.54 | 317.74 | 68.09 | 178.62 | 912.74 | 321.94 | 72.29 | 852.5824 | 856.0304 | 849.1621 | 767856.8 | 773748 | 762036.2 | 11711.78 | 5891.172 | 5820.612 | 767856.8 | 773748 | 762036.2 |
| 2-16 | 317.74 | 68.09 | 319.57 | 208.02 | 321.94 | 72.29 | 323.77 | 212.22 | 139.942 | 135.7507 | 144.2561 | 60543.75 | 59388.25 | 61769.82 | 2381.568 | 1155.504 | 1226.064 | 60543.75 | 59388.25 | 61769.82 |
| 2-17 | 319.57 | 208.02 | 371.63 | 348 | 323.77 | 212.22 | 375.83 | 352.2 | 149.3474 | 143.968 | 154.7678 | 63264.64 | 61686.79 | 64913.06 | 3226.272 | 1577.856 | 1648.416 | 63264.64 | 61686.79 | 64913.06 |
| 2-18 | 371.63 | 348 | 347.91 | 488.66 | 375.83 | 352.2 | 352.11 | 492.86 | 142.646 | 139.287 | 146.1693 | 61307.87 | 60360.86 | 62325.45 | 1964.592 | 947.016 | 1017.576 | 61307.87 | 60360.86 | 62325.45 |
| 2-19 | 347.91 | 488.66 | 353.28 | 628.47 | 352.11 | 492.86 | 357.48 | 632.67 | 139.9131 | 135.615 | 144.3276 | 60535.67 | 59351.44 | 61790.47 | 2439.024 | 1184.232 | 1254.792 | 60535.67 | 59351.44 | 61790.47 |
| 2-20 | 353.28 | 628.47 | 324.68 | 768.55 | 357.48 | 632.67 | 328.88 | 772.75 | 142.9698 | 139.7827 | 146.3287 | 61400.37 | 60499.21 | 62372.08 | 1872.864 | 901.152 | 971.712 | 61400.37 | 60499.21 | 62372.08 |
| 2-21 | 324.68 | 768.55 | 292.36 | 908.62 | 328.88 | 772.75 | 296.56 | 912.82 | 143.7504 | 140.6925 | 146.9849 | 61624.19 | 60754.37 | 62564.57 | 1810.2 | 869.82 | 940.38 | 61624.19 | 60754.37 | 62564.57 |
| 2-22 | 292.36 | 908.62 | 505.33 | 68.41 | 296.56 | 912.82 | 509.53 | 72.61 | 866.7809 | 869.8351 | 863.7566 | 792269.1 | 797573.2 | 787035.5 | 10537.63 | 5304.096 | 5233.536 | 792269.1 | 797573.2 | 787035.5 |
| 2-23 | 505.33 | 68.41 | 496.47 | 208.2 | 509.53 | 72.61 | 500.67 | 212.4 | 140.0705 | 136.2175 | 144.0654 | 60579.74 | 59515.21 | 61714.84 | 2199.624 | 1064.532 | 1135.092 | 60579.74 | 59515.21 | 61714.84 |
| 2-24 | 496.47 | 208.2 | 494.96 | 348.56 | 500.67 | 212.4 | 499.16 | 352.76 | 140.3681 | 136.2797 | 144.585 | 60663.21 | 59532.15 | 61864.83 | 2332.68 | 1131.06 | 1201.62 | 60663.21 | 59532.15 | 61864.83 |
| 2-25 | 494.96 | 348.56 | 477.66 | 488.56 | 499.16 | 352.76 | 481.86 | 492.76 | 141.0648 | 137.4914 | 144.7938 | 60859.29 | 59863.89 | 61925.25 | 2061.36 | 995.4 | 1065.96 | 60859.29 | 59863.89 | 61925.25 |
| 2-26 | 477.66 | 488.56 | 498.41 | 628.86 | 481.86 | 492.76 | 502.61 | 633.06 | 141.8261 | 137.1026 | 146.6382 | 61074.65 | 59757.11 | 62462.75 | 2705.64 | 1317.54 | 1388.1 | 61074.65 | 59757.11 | 62462.75 |
| 2-27 | 498.41 | 628.86 | 477.24 | 768.04 | 502.61 | 633.06 | 481.44 | 772.24 | 140.7808 | 137.3435 | 144.3808 | 60779.24 | 59823.24 | 61805.81 | 1982.568 | 956.004 | 1026.564 | 60779.24 | 59823.24 | 61805.81 |
| 2-28 | 477.24 | 768.04 | 496.46 | 908.08 | 481.44 | 772.24 | 500.66 | 912.28 | 141.3528 | 136.6679 | 146.129 | 60940.61 | 59638.11 | 62313.67 | 2675.568 | 1302.504 | 1373.064 | 60940.61 | 59638.11 | 62313.67 |
| 2-29 | 496.46 | 908.08 | 647.58 | 68.89 | 500.66 | 912.28 | 651.78 | 73.09 | 852.6882 | 856.0912 | 849.313 | 768037.1 | 773852.2 | 762292.6 | 11559.58 | 5815.068 | 5744.508 | 768037.1 | 773852.2 | 762292.6 |
| 2-30 | 647.58 | 68.89 | 677.69 | 208.46 | 651.78 | 73.09 | 681.89 | 212.66 | 142.7809 | 137.8273 | 147.8073 | 61346.4 | 59956.37 | 62806.99 | 2850.624 | 1390.032 | 1460.592 | 61346.4 | 59956.37 | 62806.99 |
| 2-31 | 677.69 | 208.46 | 644.94 | 348.17 | 681.89 | 212.66 | 649.14 | 352.37 | 143.4972 | 140.4573 | 146.7147 | 61551.45 | 60688.26 | 62485.19 | 1796.928 | 863.184 | 933.744 | 61551.45 | 60688.26 | 62485.19 |
| 2-32 | 644.94 | 348.17 | 646.18 | 488.81 | 649.14 | 352.37 | 650.38 | 493.01 | 140.6455 | 136.4721 | 144.9421 | 60741.15 | 59584.64 | 61968.22 | 2383.584 | 1156.512 | 1227.072 | 60741.15 | 59584.64 | 61968.22 |
| 2-33 | 646.18 | 488.81 | 685.68 | 628.77 | 650.38 | 493.01 | 689.88 | 632.97 | 145.4271 | 140.2743 | 150.638 | 62109.05 | 60636.87 | 63651.8 | 3014.928 | 1472.184 | 1542.744 | 62109.05 | 60636.87 | 63651.8 |
| 2-34 | 685.68 | 628.77 | 673.84 | 768.22 | 689.88 | 632.97 | 678.04 | 772.42 | 139.9517 | 136.1978 | 143.853 | 60546.49 | 59509.84 | 61653.69 | 2143.848 | 1036.644 | 1107.204 | 60546.49 | 59509.84 | 61653.69 |
| 2-35 | 673.84 | 768.22 | 628.52 | 908.01 | 678.04 | 772.42 | 632.72 | 912.21 | 146.9529 | 144.3498 | 149.7464 | 62555.15 | 61796.88 | 63383.97 | 1587.096 | 758.268 | 828.828 | 62555.15 | 61796.88 | 63383.97 |
| 2-36 | 628.52 | 908.01 | 790.49 | 68.78 | 632.72 | 912.21 | 794.69 | 72.98 | 854.7171 | 858.0592 | 851.4033 | 771501.3 | 777225.5 | 765847.6 | 11377.97 | 5724.264 | 5653.704 | 771501.3 | 777225.5 | 765847.6 |
| 2-37 | 790.49 | 68.78 | 782.43 | 208.61 | 794.69 | 72.98 | 786.63 | 212.81 | 140.0621 | 136.183 | 144.0817 | 60577.39 | 59505.8 | 61719.54 | 2213.736 | 1071.588 | 1142.148 | 60577.39 | 59505.8 | 61719.54 |
| 2-38 | 782.43 | 208.61 | 744.1 | 348.8 | 786.63 | 212.81 | 748.3 | 353 | 145.3356 | 142.4854 | 148.3689 | 62082.43 | 61262.08 | 62973.33 | 1711.248 | 820.344 | 890.904 | 62082.43 | 61262.08 | 62973.33 |
| 2-39 | 744.1 | 348.8 | 804.78 | 488.12 | 748.3 | 353 | 808.98 | 492.32 | 151.9609 | 146.4493 | 157.5037 | 64052.12 | 62407.4 | 65767.4 | 3360 | 1644.72 | 1715.28 | 64052.12 | 62407.4 | 65767.4 |
| 2-40 | 804.78 | 488.12 | 780.18 | 628.22 | 808.98 | 492.32 | 784.38 | 632.42 | 142.2433 | 138.9181 | 145.7349 | 61193.17 | 60258.25 | 62198.65 | 1940.4 | 934.92 | 1005.48 | 61193.17 | 60258.25 | 62198.65 |
| 2-41 | 780.18 | 628.22 | 751.2 | 768.67 | 784.38 | 632.42 | 755.4 | 772.87 | 143.4087 | 140.2319 | 146.7572 | 61526.04 | 60624.97 | 62497.67 | 1872.696 | 901.068 | 971.628 | 61526.04 | 60624.97 | 62497.67 |
| 2-42 | 751.2 | 768.67 | 799.8 | 908.09 | 755.4 | 772.87 | 804 | 912.29 | 147.6479 | 142.3229 | 153.0181 | 62759.9 | 61215.81 | 64374.54 | 3158.736 | 1544.088 | 1614.648 | 62759.9 | 61215.81 | 64374.54 |
| 2-43 | 799.8 | 908.09 | 881.7 | 68.39 | 804 | 912.29 | 885.9 | 72.59 | 843.6846 | 847.4695 | 839.9247 | 752763.7 | 759164.5 | 746433.5 | 12731.04 | 6400.8 | 6330.24 | 752763.7 | 759164.5 | 746433.5 |
| 2-44 | 881.7 | 68.39 | 908.58 | 208.45 | 885.9 | 72.59 | 912.78 | 212.65 | 142.6161 | 137.7401 | 147.57 | 61299.34 | 59932.32 | 62736.91 | 2804.592 | 1367.016 | 1437.576 | 61299.34 | 59932.32 | 62736.91 |
| 2-45 | 908.58 | 208.45 | 938.78 | 348.35 | 912.78 | 212.65 | 942.98 | 352.55 | 143.1225 | 138.1683 | 148.1491 | 61444.05 | 60050.49 | 62908.17 | 2857.68 | 1393.56 | 1464.12 | 61444.05 | 60050.49 | 62908.17 |
| 2-46 | 938.78 | 348.35 | 891.03 | 488.12 | 942.98 | 352.55 | 895.23 | 492.32 | 147.7014 | 145.1827 | 150.4126 | 62775.72 | 62038.03 | 63583.96 | 1545.936 | 737.688 | 808.248 | 62775.72 | 62038.03 | 63583.96 |
| 2-47 | 891.03 | 488.12 | 894.28 | 628.51 | 895.23 | 492.32 | 898.48 | 632.71 | 140.4276 | 136.1933 | 144.7818 | 60679.91 | 59508.62 | 61921.77 | 2413.152 | 1171.296 | 1241.856 | 60679.91 | 59508.62 | 61921.77 |
| 2-48 | 894.28 | 628.51 | 892.76 | 767.92 | 898.48 | 632.71 | 896.96 | 772.12 | 139.4183 | 135.3309 | 143.635 | 60397.46 | 59274.46 | 61591.01 | 2316.552 | 1122.996 | 1193.556 | 60397.46 | 59274.46 | 61591.01 |
| 2-49 | 892.76 | 767.92 | 909.63 | 908.12 | 896.96 | 772.12 | 913.83 | 912.32 | 141.2113 | 136.5889 | 145.9291 | 60900.64 | 59616.53 | 62255.3 | 2638.776 | 1284.108 | 1354.668 | 60900.64 | 59616.53 | 62255.3 |
| 3-1 | -2.1 | -2.1 | 73.84 | 68.23 | 2.1 | 2.1 | 78.04 | 72.43 | 103.5046 | 97.56949 | 109.4401 | 51673.19 | 50479.8 | 52937.14 | 2457.336 | 1193.388 | 1263.948 | 51673.19 | 50479.8 | 52937.14 |
| 3-2 | 73.84 | 68.23 | 54.66 | 208.35 | 78.04 | 72.43 | 58.86 | 212.55 | 141.4266 | 137.9162 | 145.0954 | 60961.49 | 59980.87 | 62012.66 | 2031.792 | 980.616 | 1051.176 | 60961.49 | 59980.87 | 62012.66 |
| 3-3 | 54.66 | 208.35 | 102.51 | 348.87 | 58.86 | 212.55 | 106.71 | 353.07 | 148.4436 | 143.1379 | 153.7956 | 62995.49 | 61448.46 | 64613.08 | 3164.616 | 1547.028 | 1617.588 | 62995.49 | 61448.46 | 64613.08 |
| 3-4 | 102.51 | 348.87 | 50.45 | 488.05 | 106.71 | 353.07 | 54.65 | 492.25 | 148.5978 | 146.2354 | 151.1569 | 63041.32 | 62344.79 | 63808.4 | 1463.616 | 696.528 | 767.088 | 63041.32 | 62344.79 | 63808.4 |
| 3-5 | 50.45 | 488.05 | 105.56 | 628.72 | 54.65 | 492.25 | 109.76 | 632.92 | 151.08 | 145.6568 | 156.5407 | 63785.16 | 62175.89 | 65464.99 | 3289.104 | 1609.272 | 1679.832 | 63785.16 | 62175.89 | 65464.99 |
| 3-6 | 105.56 | 628.72 | 93.09 | 768.08 | 109.76 | 632.92 | 97.29 | 772.28 | 139.9168 | 136.1841 | 143.798 | 60536.71 | 59506.11 | 61637.87 | 2131.752 | 1030.596 | 1101.156 | 60536.71 | 59506.11 | 61637.87 |
| 3-7 | 93.09 | 768.08 | 30.07 | 908.38 | 97.29 | 772.28 | 34.27 | 912.58 | 153.8038 | 151.7951 | 156.013 | 64615.61 | 64001.74 | 65300.04 | 1298.304 | 613.872 | 684.432 | 64615.61 | 64001.74 | 65300.04 |
| 3-8 | 30.07 | 908.38 | 242.13 | 68.18 | 34.27 | 912.58 | 246.33 | 72.38 | 866.548 | 869.6075 | 863.5186 | 791865.5 | 797177.1 | 786624.4 | 10552.75 | 5311.656 | 5241.096 | 791865.5 | 797177.1 | 786624.4 |
| 3-9 | 242.13 | 68.18 | 196.58 | 208.78 | 246.33 | 72.38 | 200.78 | 212.98 | 147.7943 | 145.1896 | 150.5884 | 62803.16 | 62040.02 | 63636.86 | 1596.84 | 763.14 | 833.7 | 62803.16 | 62040.02 | 63636.86 |
| 3-10 | 196.58 | 208.78 | 202.9 | 348.73 | 200.78 | 212.98 | 207.1 | 352.93 | 140.0926 | 135.7666 | 144.5334 | 60585.94 | 59392.56 | 61849.89 | 2457.336 | 1193.388 | 1263.948 | 60585.94 | 59392.56 | 61849.89 |
| 3-11 | 202.9 | 348.73 | 246.56 | 488.18 | 207.1 | 352.93 | 250.76 | 492.38 | 146.1249 | 140.8888 | 151.413 | 62312.5 | 60809.65 | 63885.9 | 3076.248 | 1502.844 | 1573.404 | 62312.5 | 60809.65 | 63885.9 |
| 3-12 | 246.56 | 488.18 | 247.76 | 628.07 | 250.76 | 492.38 | 251.96 | 632.27 | 139.8951 | 135.7232 | 144.1912 | 60530.65 | 59380.78 | 61751.09 | 2370.312 | 1149.876 | 1220.436 | 60530.65 | 59380.78 | 61751.09 |
| 3-13 | 247.76 | 628.07 | 200.58 | 768.43 | 251.96 | 632.27 | 204.78 | 772.63 | 148.0773 | 145.5316 | 150.814 | 62886.88 | 62139.45 | 63704.87 | 1565.424 | 747.432 | 817.992 | 62886.88 | 62139.45 | 63704.87 |
| 3-14 | 200.58 | 768.43 | 173.32 | 908.74 | 204.78 | 772.63 | 177.52 | 912.94 | 142.9336 | 139.6985 | 146.3383 | 61390 | 60475.66 | 62374.9 | 1899.24 | 914.34 | 984.9 | 61390 | 60475.66 | 62374.9 |
| 3-15 | 173.32 | 908.74 | 383.45 | 68.04 | 177.52 | 912.94 | 387.65 | 72.24 | 866.5628 | 869.6339 | 863.5216 | 791891.1 | 797223.2 | 786629.6 | 10593.58 | 5332.068 | 5261.508 | 791891.1 | 797223.2 | 786629.6 |
| 3-16 | 383.45 | 68.04 | 307.45 | 207.93 | 387.65 | 72.24 | 311.65 | 212.13 | 159.2018 | 157.6192 | 160.9881 | 66305.21 | 65803.82 | 66877.17 | 1073.352 | 501.396 | 571.956 | 66305.21 | 65803.82 | 66877.17 |
| 3-17 | 307.45 | 207.93 | 342.51 | 348.57 | 311.65 | 212.13 | 346.71 | 352.77 | 144.9442 | 139.8864 | 150.0666 | 61968.81 | 60528.21 | 63479.97 | 2951.76 | 1440.6 | 1511.16 | 61968.81 | 60528.21 | 63479.97 |
| 3-18 | 342.51 | 348.57 | 357.25 | 488.11 | 346.71 | 352.77 | 361.45 | 492.31 | 140.3164 | 135.7498 | 144.9825 | 60648.68 | 59388.01 | 61979.91 | 2591.904 | 1260.672 | 1331.232 | 60648.68 | 59388.01 | 61979.91 |
| 3-19 | 357.25 | 488.11 | 325.23 | 627.94 | 361.45 | 492.31 | 329.43 | 632.14 | 143.4493 | 140.383 | 146.6922 | 61537.71 | 60667.39 | 62478.59 | 1811.208 | 870.324 | 940.884 | 61537.71 | 60667.39 | 62478.59 |
| 3-20 | 325.23 | 627.94 | 320.72 | 768.72 | 329.43 | 632.14 | 324.92 | 772.92 | 140.8522 | 136.8574 | 144.9803 | 60799.35 | 59689.96 | 61979.3 | 2289.336 | 1109.388 | 1179.948 | 60799.35 | 59689.96 | 61979.3 |
| 3-21 | 320.72 | 768.72 | 323.34 | 908.79 | 324.92 | 772.92 | 327.54 | 912.99 | 140.0945 | 135.8792 | 144.4311 | 60586.47 | 59423.15 | 61820.35 | 2397.192 | 1163.316 | 1233.876 | 60586.47 | 59423.15 | 61820.35 |
| 3-22 | 323.34 | 908.79 | 487.01 | 68.39 | 327.54 | 912.99 | 491.21 | 72.59 | 856.1892 | 859.523 | 852.8838 | 774020 | 779739.8 | 768370.8 | 11369.06 | 5719.812 | 5649.252 | 774020 | 779739.8 | 768370.8 |
| 3-23 | 487.01 | 68.39 | 472.57 | 208.41 | 491.21 | 72.59 | 476.77 | 212.61 | 140.7626 | 137.0931 | 144.5831 | 60774.11 | 59754.52 | 61864.27 | 2109.744 | 1019.592 | 1090.152 | 60774.11 | 59754.52 | 61864.27 |
| 3-24 | 472.57 | 208.41 | 519.71 | 348.62 | 476.77 | 212.61 | 523.91 | 352.82 | 147.9224 | 142.6274 | 153.2646 | 62841.02 | 61302.56 | 64450.04 | 3147.48 | 1538.46 | 1609.02 | 62841.02 | 61302.56 | 64450.04 |
| 3-25 | 519.71 | 348.62 | 516.49 | 488.29 | 523.91 | 352.82 | 520.69 | 492.49 | 139.7071 | 135.6731 | 143.8733 | 60478.08 | 59367.18 | 61659.54 | 2292.36 | 1110.9 | 1181.46 | 60478.08 | 59367.18 | 61659.54 |
| 3-26 | 516.49 | 488.29 | 433.55 | 628.74 | 520.69 | 492.49 | 437.75 | 632.94 | 163.1111 | 161.7326 | 164.6925 | 67565.25 | 67117.44 | 68083.61 | 966.168 | 447.804 | 518.364 | 67565.25 | 67117.44 | 68083.61 |
| 3-27 | 433.55 | 628.74 | 473.75 | 768.29 | 437.75 | 632.94 | 477.95 | 772.49 | 145.2248 | 140.0558 | 150.4507 | 62050.24 | 60575.62 | 63595.42 | 3019.8 | 1474.62 | 1545.18 | 62050.24 | 60575.62 | 63595.42 |
| 3-28 | 473.75 | 768.29 | 497.77 | 908.84 | 477.95 | 772.49 | 501.97 | 913.04 | 142.5877 | 137.783 | 147.4752 | 61291.26 | 59944.15 | 62708.93 | 2764.776 | 1347.108 | 1417.668 | 61291.26 | 59944.15 | 62708.93 |
| 3-29 | 497.77 | 908.84 | 653.74 | 68.72 | 501.97 | 913.04 | 657.94 | 72.92 | 854.4754 | 857.8522 | 851.1267 | 771088.3 | 776870.4 | 765376.7 | 11493.72 | 5782.14 | 5711.58 | 771088.3 | 776870.4 | 765376.7 |
| 3-30 | 653.74 | 68.72 | 608.33 | 208.42 | 657.94 | 72.92 | 612.53 | 212.62 | 146.8951 | 144.2962 | 149.6846 | 62538.16 | 61781.4 | 63365.47 | 1584.072 | 756.756 | 827.316 | 62538.16 | 61781.4 | 63365.47 |
| 3-31 | 608.33 | 208.42 | 646.94 | 348.34 | 612.53 | 212.62 | 651.14 | 352.54 | 145.1494 | 140.0142 | 150.3438 | 62028.34 | 60563.97 | 63563.27 | 2999.304 | 1464.372 | 1534.932 | 62028.34 | 60563.97 | 63563.27 |
| 3-32 | 646.94 | 348.34 | 648.62 | 488.04 | 651.14 | 352.54 | 652.82 | 492.24 | 139.7101 | 135.5234 | 144.0201 | 60478.91 | 59326.6 | 61701.78 | 2375.184 | 1152.312 | 1222.872 | 60478.91 | 59326.6 | 61701.78 |
| 3-33 | 648.62 | 488.04 | 634.36 | 628.02 | 652.82 | 492.24 | 638.56 | 632.22 | 140.7045 | 137.0291 | 144.5305 | 60757.75 | 59736.98 | 61849.08 | 2112.096 | 1020.768 | 1091.328 | 60757.75 | 59736.98 | 61849.08 |
| 3-34 | 634.36 | 628.02 | 683.18 | 767.95 | 638.56 | 632.22 | 687.38 | 772.15 | 148.2019 | 142.8761 | 153.5727 | 62923.8 | 61373.58 | 64544.58 | 3171 | 1550.22 | 1620.78 | 62923.8 | 61373.58 | 64544.58 |
| 3-35 | 683.18 | 767.95 | 629.93 | 908.42 | 687.38 | 772.15 | 634.13 | 912.62 | 150.2244 | 147.8851 | 152.759 | 63527.38 | 62830.02 | 64295.31 | 1465.296 | 697.368 | 767.928 | 63527.38 | 62830.02 | 64295.31 |
| 3-36 | 629.93 | 908.42 | 773.18 | 68.79 | 634.13 | 912.62 | 777.38 | 72.99 | 851.7623 | 855.2099 | 848.3424 | 766459.1 | 772344 | 760644.8 | 11699.18 | 5884.872 | 5814.312 | 766459.1 | 772344 | 760644.8 |
| 3-37 | 773.18 | 68.79 | 738.23 | 208.12 | 777.38 | 72.99 | 742.43 | 212.32 | 143.6466 | 140.687 | 146.787 | 61594.35 | 60752.84 | 62506.42 | 1753.584 | 841.512 | 912.072 | 61594.35 | 60752.84 | 62506.42 |
| 3-38 | 738.23 | 208.12 | 727.71 | 348.52 | 742.43 | 212.32 | 731.91 | 352.72 | 140.7936 | 136.9931 | 144.738 | 60782.83 | 59727.12 | 61909.1 | 2181.984 | 1055.712 | 1126.272 | 60782.83 | 59727.12 | 61909.1 |
| 3-39 | 727.71 | 348.52 | 739.83 | 488.03 | 731.91 | 352.72 | 744.03 | 492.23 | 140.0355 | 135.5416 | 144.6337 | 60569.93 | 59331.52 | 61878.91 | 2547.384 | 1238.412 | 1308.972 | 60569.93 | 59331.52 | 61878.91 |
| 3-40 | 739.83 | 488.03 | 801.77 | 628.65 | 744.03 | 492.23 | 805.97 | 632.85 | 153.6572 | 148.1362 | 159.2085 | 64570.55 | 62904.32 | 66307.33 | 3403.008 | 1666.224 | 1736.784 | 64570.55 | 62904.32 | 66307.33 |
| 3-41 | 801.77 | 628.65 | 743.48 | 768.17 | 805.97 | 632.85 | 747.68 | 772.37 | 151.207 | 149.052 | 153.5616 | 63823.55 | 63176.5 | 64541.17 | 1364.664 | 647.052 | 717.612 | 63823.55 | 63176.5 | 64541.17 |
| 3-42 | 743.48 | 768.17 | 752.08 | 908.86 | 747.68 | 772.37 | 756.28 | 913.06 | 140.9526 | 136.5609 | 145.4543 | 60827.64 | 59608.88 | 62116.95 | 2508.072 | 1218.756 | 1289.316 | 60827.64 | 59608.88 | 62116.95 |
| 3-43 | 752.08 | 908.86 | 864.04 | 68.63 | 756.28 | 913.06 | 868.24 | 72.83 | 847.6565 | 851.278 | 844.0612 | 759481.5 | 765634.2 | 753399.3 | 12234.94 | 6152.748 | 6082.188 | 759481.5 | 765634.2 | 753399.3 |
| 3-44 | 864.04 | 68.63 | 896.96 | 208.44 | 868.24 | 72.83 | 901.16 | 212.64 | 143.6334 | 138.6179 | 148.7171 | 61590.56 | 60174.91 | 63076.77 | 2901.864 | 1415.652 | 1486.212 | 61590.56 | 60174.91 | 63076.77 |
| 3-45 | 896.96 | 208.44 | 950.79 | 348.81 | 901.16 | 212.64 | 954.99 | 353.01 | 150.3376 | 144.9324 | 155.7818 | 63561.41 | 61965.41 | 65227.97 | 3262.56 | 1596 | 1666.56 | 63561.41 | 61965.41 | 65227.97 |
| 3-46 | 950.79 | 348.81 | 916.88 | 488.21 | 954.99 | 353.01 | 921.08 | 492.41 | 143.4651 | 140.4685 | 146.6412 | 61542.25 | 60691.41 | 62463.64 | 1772.232 | 850.836 | 921.396 | 61542.25 | 60691.41 | 62463.64 |
| 3-47 | 916.88 | 488.21 | 892.85 | 628.44 | 921.08 | 492.41 | 897.05 | 632.64 | 142.274 | 138.9284 | 145.785 | 61201.89 | 60261.09 | 62213.25 | 1952.16 | 940.8 | 1011.36 | 61201.89 | 60261.09 | 62213.25 |
| 3-48 | 892.85 | 628.44 | 901.89 | 768.68 | 897.05 | 632.64 | 906.09 | 772.88 | 140.5311 | 136.1261 | 145.0455 | 60708.98 | 59490.31 | 61998.21 | 2507.904 | 1218.672 | 1289.232 | 60708.98 | 59490.31 | 61998.21 |
| 3-49 | 901.89 | 768.68 | 917.32 | 907.97 | 906.09 | 772.88 | 921.52 | 912.17 | 140.142 | 135.556 | 144.8265 | 60599.79 | 59335.42 | 61934.72 | 2599.296 | 1264.368 | 1334.928 | 60599.79 | 59335.42 | 61934.72 |
| 4-1 | -2.1 | -2.1 | 95.37 | 68.02 | 2.1 | 2.1 | 99.57 | 72.22 | 120.0717 | 114.2136 | 125.9375 | 55377.22 | 54004.74 | 56820.25 | 2815.512 | 1372.476 | 1443.036 | 55377.22 | 54004.74 | 56820.25 |
| 4-2 | 95.37 | 68.02 | 84.3 | 208.18 | 99.57 | 72.22 | 88.5 | 212.38 | 140.5965 | 136.8148 | 144.5234 | 60727.37 | 59678.29 | 61847.01 | 2168.712 | 1049.076 | 1119.636 | 60727.37 | 59678.29 | 61847.01 |
| 4-3 | 84.3 | 208.18 | 63.99 | 348.69 | 88.5 | 212.38 | 68.19 | 352.89 | 141.9703 | 138.4961 | 145.604 | 61115.56 | 60141.16 | 62160.52 | 2019.36 | 974.4 | 1044.96 | 61115.56 | 60141.16 | 62160.52 |
| 4-4 | 63.99 | 348.69 | 101.22 | 488.57 | 68.19 | 352.89 | 105.42 | 492.77 | 144.7497 | 139.6426 | 149.9183 | 61912.49 | 60460.04 | 63435.49 | 2975.448 | 1452.444 | 1523.004 | 61912.49 | 60460.04 | 63435.49 |
| 4-5 | 101.22 | 488.57 | 110.64 | 628.59 | 105.42 | 492.77 | 114.84 | 632.79 | 140.3365 | 135.9203 | 144.8617 | 60654.34 | 59434.32 | 61944.91 | 2510.592 | 1220.016 | 1290.576 | 60654.34 | 59434.32 | 61944.91 |
| 4-6 | 110.64 | 628.59 | 63.11 | 768.25 | 114.84 | 632.79 | 67.31 | 772.45 | 147.5263 | 145.0014 | 150.2438 | 62724.02 | 61985.4 | 63533.19 | 1547.784 | 738.612 | 809.172 | 62724.02 | 61985.4 | 63533.19 |
| 4-7 | 63.11 | 768.25 | 66.85 | 908.2 | 67.31 | 772.45 | 71.05 | 912.4 | 140 | 135.7508 | 144.3685 | 60559.99 | 59388.27 | 61802.27 | 2413.992 | 1171.716 | 1242.276 | 60559.99 | 59388.27 | 61802.27 |
| 4-8 | 66.85 | 908.2 | 194.35 | 68.04 | 71.05 | 912.4 | 198.55 | 72.24 | 849.7794 | 853.3151 | 846.2706 | 763085.1 | 769106.7 | 757134 | 11972.69 | 6021.624 | 5951.064 | 763085.1 | 769106.7 | 757134 |
| 4-9 | 194.35 | 68.04 | 203.29 | 208.21 | 198.55 | 72.24 | 207.49 | 212.41 | 140.4548 | 136.0526 | 144.9667 | 60687.55 | 59470.31 | 61975.36 | 2505.048 | 1217.244 | 1287.804 | 60687.55 | 59470.31 | 61975.36 |
| 4-10 | 203.29 | 208.21 | 165.27 | 348.31 | 207.49 | 212.41 | 169.47 | 352.51 | 145.1672 | 142.3072 | 148.2103 | 62033.53 | 61211.34 | 62926.28 | 1714.944 | 822.192 | 892.752 | 62033.53 | 61211.34 | 62926.28 |
| 4-11 | 165.27 | 348.31 | 177.93 | 488.81 | 169.47 | 352.51 | 182.13 | 493.01 | 141.0692 | 136.5623 | 145.6789 | 60860.53 | 59609.26 | 62182.35 | 2573.088 | 1251.264 | 1321.824 | 60860.53 | 59609.26 | 62182.35 |
| 4-12 | 177.93 | 488.81 | 168.91 | 628.48 | 182.13 | 493.01 | 173.11 | 632.68 | 139.961 | 136.1135 | 143.9507 | 60549.07 | 59486.89 | 61681.81 | 2194.92 | 1062.18 | 1132.74 | 60549.07 | 59486.89 | 61681.81 |
| 4-13 | 168.91 | 628.48 | 163.09 | 767.98 | 173.11 | 632.68 | 167.29 | 772.18 | 139.6214 | 135.6705 | 143.7091 | 60454.12 | 59366.49 | 61612.31 | 2245.824 | 1087.632 | 1158.192 | 60454.12 | 59366.49 | 61612.31 |
| 4-14 | 163.09 | 767.98 | 164 | 908.62 | 167.29 | 772.18 | 168.2 | 912.82 | 140.6429 | 136.4797 | 144.9301 | 60740.44 | 59586.7 | 61964.74 | 2378.04 | 1153.74 | 1224.3 | 60740.44 | 59586.7 | 61964.74 |
| 4-15 | 164 | 908.62 | 315.59 | 68 | 168.2 | 912.82 | 319.79 | 72.2 | 854.1789 | 857.5807 | 850.8049 | 770581.5 | 776404.6 | 764828.9 | 11575.7 | 5823.132 | 5752.572 | 770581.5 | 776404.6 | 764828.9 |
| 4-16 | 315.59 | 68 | 368.45 | 208.32 | 319.79 | 72.2 | 372.65 | 212.52 | 149.9463 | 144.556 | 155.3766 | 63443.88 | 61856.45 | 65101.87 | 3245.424 | 1587.432 | 1657.992 | 63443.88 | 61856.45 | 65101.87 |
| 4-17 | 368.45 | 208.32 | 373.25 | 348.53 | 372.65 | 212.52 | 377.45 | 352.73 | 140.2921 | 136.0113 | 144.6902 | 60641.88 | 59459.08 | 61895.25 | 2436.168 | 1182.804 | 1253.364 | 60641.88 | 59459.08 | 61895.25 |
| 4-18 | 373.25 | 348.53 | 359.79 | 488.47 | 377.45 | 352.73 | 363.99 | 492.67 | 140.5858 | 136.884 | 144.4371 | 60724.38 | 59697.22 | 61822.09 | 2124.864 | 1027.152 | 1097.712 | 60724.38 | 59697.22 | 61822.09 |
| 4-19 | 359.79 | 488.47 | 365.7 | 628.56 | 363.99 | 492.67 | 369.9 | 632.76 | 140.2146 | 135.9008 | 144.6438 | 60620.14 | 59429.02 | 61881.82 | 2452.8 | 1191.12 | 1261.68 | 60620.14 | 59429.02 | 61881.82 |
| 4-20 | 365.7 | 628.56 | 318.11 | 768.28 | 369.9 | 632.76 | 322.31 | 772.48 | 147.6025 | 145.0789 | 150.3185 | 62746.49 | 62007.87 | 63555.66 | 1547.784 | 738.612 | 809.172 | 62746.49 | 62007.87 | 63555.66 |
| 4-21 | 318.11 | 768.28 | 278.32 | 907.99 | 322.31 | 772.48 | 282.52 | 912.19 | 145.2657 | 142.4713 | 148.2455 | 62062.13 | 61258.08 | 62936.74 | 1678.656 | 804.048 | 874.608 | 62062.13 | 61258.08 | 62936.74 |
| 4-22 | 278.32 | 907.99 | 512.59 | 68.49 | 282.52 | 912.19 | 516.79 | 72.69 | 871.5748 | 874.5067 | 868.6737 | 800602.7 | 805721.9 | 795554 | 10167.86 | 5119.212 | 5048.652 | 800602.7 | 805721.9 | 795554 |
| 4-23 | 512.59 | 68.49 | 508.3 | 208.29 | 516.79 | 72.69 | 512.5 | 212.49 | 139.8658 | 135.8655 | 144 | 60522.44 | 59419.44 | 61696.01 | 2276.568 | 1103.004 | 1173.564 | 60522.44 | 59419.44 | 61696.01 |
| 4-24 | 508.3 | 208.29 | 457.91 | 348.89 | 512.5 | 212.49 | 462.11 | 353.09 | 149.357 | 146.9184 | 151.9887 | 63267.51 | 62545.03 | 64060.56 | 1515.528 | 722.484 | 793.044 | 63267.51 | 62545.03 | 64060.56 |
| 4-25 | 457.91 | 348.89 | 471.27 | 488.79 | 462.11 | 353.09 | 475.47 | 492.99 | 140.5365 | 136.0088 | 145.166 | 60710.5 | 59458.4 | 62033.16 | 2574.768 | 1252.104 | 1322.664 | 60710.5 | 59458.4 | 62033.16 |
| 4-26 | 471.27 | 488.79 | 513.59 | 628.25 | 475.47 | 492.99 | 517.79 | 632.45 | 145.7397 | 140.529 | 151.0043 | 62200.07 | 60708.4 | 63762.31 | 3053.904 | 1491.672 | 1562.232 | 62200.07 | 60708.4 | 63762.31 |
| 4-27 | 513.59 | 628.25 | 516.8 | 768.1 | 517.79 | 632.45 | 521 | 772.3 | 139.8868 | 135.6536 | 144.2405 | 60528.33 | 59361.9 | 61765.31 | 2403.408 | 1166.424 | 1236.984 | 60528.33 | 59361.9 | 61765.31 |
| 4-28 | 516.8 | 768.1 | 431.95 | 907.93 | 521 | 772.3 | 436.15 | 912.13 | 163.5602 | 162.251 | 165.0729 | 67711.95 | 67285.4 | 68209.06 | 923.664 | 426.552 | 497.112 | 67711.95 | 67285.4 | 68209.06 |
| 4-29 | 431.95 | 907.93 | 618.8 | 68.69 | 436.15 | 912.13 | 623 | 72.89 | 859.7888 | 862.9902 | 856.6165 | 780196.7 | 785712.1 | 774751.9 | 10960.15 | 5515.356 | 5444.796 | 780196.7 | 785712.1 | 774751.9 |
| 4-30 | 618.8 | 68.69 | 682.38 | 208.58 | 623 | 72.89 | 686.58 | 212.78 | 153.6608 | 148.114 | 159.2359 | 64571.63 | 62897.76 | 66316.06 | 3418.296 | 1673.868 | 1744.428 | 64571.63 | 62897.76 | 66316.06 |
| 4-31 | 682.38 | 208.58 | 652.76 | 348.06 | 686.58 | 212.78 | 656.96 | 352.26 | 142.5904 | 139.4434 | 145.9113 | 61292.01 | 60404.47 | 62250.12 | 1845.648 | 887.544 | 958.104 | 61292.01 | 60404.47 | 62250.12 |
| 4-32 | 652.76 | 348.06 | 655.22 | 487.94 | 656.96 | 352.26 | 659.42 | 492.14 | 139.9016 | 135.6912 | 144.2338 | 60532.47 | 59372.09 | 61763.4 | 2391.312 | 1160.376 | 1230.936 | 60532.47 | 59372.09 | 61763.4 |
| 4-33 | 655.22 | 487.94 | 633.38 | 628.86 | 659.42 | 492.14 | 637.58 | 633.06 | 142.6024 | 139.1777 | 146.1882 | 61295.43 | 60330.44 | 62330.98 | 2000.544 | 964.992 | 1035.552 | 61295.43 | 60330.44 | 62330.98 |
| 4-34 | 633.38 | 628.86 | 686.66 | 768 | 637.58 | 633.06 | 690.86 | 772.2 | 148.9923 | 143.5885 | 154.4354 | 63158.7 | 61577.65 | 64810.31 | 3232.656 | 1581.048 | 1651.608 | 63158.7 | 61577.65 | 64810.31 |
| 4-35 | 686.66 | 768 | 609.82 | 908.85 | 690.86 | 772.2 | 614.02 | 913.05 | 160.4466 | 158.8732 | 162.2223 | 66703.11 | 66200.7 | 67276.07 | 1075.368 | 502.404 | 572.964 | 66703.11 | 66200.7 | 67276.07 |
| 4-36 | 609.82 | 908.85 | 792.12 | 68.57 | 614.02 | 913.05 | 796.32 | 72.77 | 859.8278 | 863.0562 | 856.6283 | 780263.8 | 785826.1 | 774772 | 11054.06 | 5562.312 | 5491.752 | 780263.8 | 785826.1 | 774772 |
| 4-37 | 792.12 | 68.57 | 785.54 | 208.09 | 796.32 | 72.77 | 789.74 | 212.29 | 139.6751 | 135.7487 | 143.7397 | 60469.13 | 59387.71 | 61621.1 | 2233.392 | 1081.416 | 1151.976 | 60469.13 | 59387.71 | 61621.1 |
| 4-38 | 785.54 | 208.09 | 719.38 | 348.78 | 789.74 | 212.29 | 723.58 | 352.98 | 155.4697 | 153.558 | 157.5822 | 65130.82 | 64540.05 | 65792.15 | 1252.104 | 590.772 | 661.332 | 65130.82 | 64540.05 | 65792.15 |
| 4-39 | 719.38 | 348.78 | 818.14 | 488.9 | 723.58 | 352.98 | 822.34 | 493.1 | 171.4268 | 165.5773 | 177.2823 | 70347.15 | 68375.84 | 72389.02 | 4013.184 | 1971.312 | 2041.872 | 70347.15 | 68375.84 | 72389.02 |
| 4-40 | 818.14 | 488.9 | 808.13 | 628.82 | 822.34 | 493.1 | 812.33 | 633.02 | 140.2776 | 136.4619 | 144.2371 | 60637.81 | 59581.84 | 61764.33 | 2182.488 | 1055.964 | 1126.524 | 60637.81 | 59581.84 | 61764.33 |
| 4-41 | 808.13 | 628.82 | 737.9 | 768.84 | 812.33 | 633.02 | 742.1 | 773.04 | 156.6456 | 154.877 | 158.6171 | 65497.85 | 64946.9 | 66119.37 | 1172.472 | 550.956 | 621.516 | 65497.85 | 64946.9 | 66119.37 |
| 4-42 | 737.9 | 768.84 | 804.59 | 908.86 | 742.1 | 773.04 | 808.79 | 913.06 | 155.0908 | 149.5061 | 160.701 | 65013.16 | 63312.07 | 66784.8 | 3472.728 | 1701.084 | 1771.644 | 65013.16 | 63312.07 | 66784.8 |
| 4-43 | 804.59 | 908.86 | 857.21 | 68.61 | 808.79 | 913.06 | 861.41 | 72.81 | 841.896 | 845.837 | 837.9786 | 749748.9 | 756400.3 | 743168.1 | 13232.18 | 6651.372 | 6580.812 | 749748.9 | 756400.3 | 743168.1 |
| 4-44 | 857.21 | 68.61 | 886.53 | 208.26 | 861.41 | 72.81 | 890.73 | 212.46 | 142.6947 | 137.7596 | 147.7038 | 61321.78 | 59937.72 | 62776.41 | 2838.696 | 1384.068 | 1454.628 | 61321.78 | 59937.72 | 62776.41 |
| 4-45 | 886.53 | 208.26 | 864.61 | 348.78 | 890.73 | 212.46 | 868.81 | 352.98 | 142.2194 | 138.7998 | 145.8008 | 61186.36 | 60225.4 | 62217.88 | 1992.48 | 960.96 | 1031.52 | 61186.36 | 60225.4 | 62217.88 |
| 4-46 | 864.61 | 348.78 | 875.9 | 487.97 | 868.81 | 352.98 | 880.1 | 492.17 | 139.6471 | 135.1761 | 144.2242 | 60461.32 | 59232.57 | 61760.63 | 2528.064 | 1228.752 | 1299.312 | 60461.32 | 59232.57 | 61760.63 |
| 4-47 | 875.9 | 487.97 | 889.77 | 628.58 | 880.1 | 492.17 | 893.97 | 632.78 | 141.2924 | 136.7523 | 145.9331 | 60923.55 | 59661.2 | 62256.46 | 2595.264 | 1262.352 | 1332.912 | 60923.55 | 59661.2 | 62256.46 |
| 4-48 | 889.77 | 628.58 | 883.32 | 768.79 | 893.97 | 632.78 | 887.52 | 772.99 | 140.3583 | 136.4263 | 144.4275 | 60660.45 | 59572.14 | 61819.31 | 2247.168 | 1088.304 | 1158.864 | 60660.45 | 59572.14 | 61819.31 |
| 4-49 | 883.32 | 768.79 | 878.58 | 908.65 | 887.52 | 772.99 | 882.78 | 912.85 | 139.9403 | 135.9543 | 144.061 | 60543.29 | 59443.56 | 61713.58 | 2270.016 | 1099.728 | 1170.288 | 60543.29 | 59443.56 | 61713.58 |
| 5-1 | -2.1 | -2.1 | 20.86 | 67.97 | 2.1 | 2.1 | 25.06 | 72.17 | 73.73579 | 68.48938 | 79.08033 | 46396.97 | 45650.79 | 47213.7 | 1562.904 | 746.172 | 816.732 | 46396.97 | 45650.79 | 47213.7 |
| 5-2 | 20.86 | 67.97 | 27.45 | 208.45 | 25.06 | 72.17 | 31.65 | 212.65 | 140.6345 | 136.301 | 145.0818 | 60738.06 | 59537.95 | 62008.73 | 2470.776 | 1200.108 | 1270.668 | 60738.06 | 59537.95 | 62008.73 |
| 5-3 | 27.45 | 208.45 | 111.77 | 348.7 | 31.65 | 212.65 | 115.97 | 352.9 | 163.6457 | 157.8886 | 169.4154 | 67739.92 | 65888.82 | 69661.59 | 3772.776 | 1851.108 | 1921.668 | 67739.92 | 65888.82 | 69661.59 |
| 5-4 | 111.77 | 348.7 | 102.62 | 488.63 | 115.97 | 352.9 | 106.82 | 492.83 | 140.2288 | 136.385 | 144.215 | 60624.13 | 59560.86 | 61757.96 | 2197.104 | 1063.272 | 1133.832 | 60624.13 | 59560.86 | 61757.96 |
| 5-5 | 102.62 | 488.63 | 75.49 | 628.8 | 106.82 | 492.83 | 79.69 | 633 | 142.7714 | 139.5328 | 146.1796 | 61343.67 | 60429.41 | 62328.48 | 1899.072 | 914.256 | 984.816 | 61343.67 | 60429.41 | 62328.48 |
| 5-6 | 75.49 | 628.8 | 97.22 | 768.43 | 79.69 | 633 | 101.42 | 772.63 | 141.3108 | 136.5598 | 146.1487 | 60928.73 | 59608.59 | 62319.43 | 2710.848 | 1320.144 | 1390.704 | 60928.73 | 59608.59 | 62319.43 |
| 5-7 | 97.22 | 768.43 | 25.39 | 908.81 | 101.42 | 772.63 | 29.59 | 913.01 | 157.6899 | 155.9665 | 159.6158 | 65826.09 | 65285.55 | 66437.19 | 1151.64 | 540.54 | 611.1 | 65826.09 | 65285.55 | 66437.19 |
| 5-8 | 25.39 | 908.81 | 165.05 | 67.98 | 29.59 | 913.01 | 169.25 | 72.18 | 852.3497 | 855.8184 | 848.9084 | 767460 | 773385.1 | 761605.5 | 11779.66 | 5925.108 | 5854.548 | 767460 | 773385.1 | 761605.5 |
| 5-9 | 165.05 | 67.98 | 155.74 | 208.24 | 169.25 | 72.18 | 159.94 | 212.44 | 140.5686 | 136.7291 | 144.5504 | 60719.54 | 59654.84 | 61854.8 | 2199.96 | 1064.7 | 1135.26 | 60719.54 | 59654.84 | 61854.8 |
| 5-10 | 155.74 | 208.24 | 210.57 | 348.83 | 159.94 | 212.44 | 214.77 | 353.03 | 150.9035 | 145.4841 | 156.3608 | 63731.88 | 62125.63 | 65408.69 | 3283.056 | 1606.248 | 1676.808 | 63731.88 | 62125.63 | 65408.69 |
| 5-11 | 210.57 | 348.83 | 255.97 | 488.38 | 214.77 | 353.03 | 260.17 | 492.58 | 146.7493 | 141.4817 | 152.0665 | 62495.36 | 60977.06 | 64084.22 | 3107.16 | 1518.3 | 1588.86 | 62495.36 | 60977.06 | 64084.22 |
| 5-12 | 255.97 | 488.38 | 156.86 | 627.97 | 260.17 | 492.58 | 161.06 | 632.17 | 171.1963 | 170.3039 | 172.2889 | 70268.16 | 69963.41 | 70643.47 | 680.064 | 304.752 | 375.312 | 70268.16 | 69963.41 | 70643.47 |
| 5-13 | 156.86 | 627.97 | 225.32 | 768.51 | 161.06 | 632.17 | 229.52 | 772.71 | 156.3274 | 150.7247 | 161.9541 | 65398.26 | 63677.94 | 67189.14 | 3511.2 | 1720.32 | 1790.88 | 65398.26 | 63677.94 | 67189.14 |
| 5-14 | 225.32 | 768.51 | 161.29 | 908.71 | 229.52 | 772.71 | 165.49 | 912.91 | 154.1294 | 152.1556 | 156.3042 | 64715.88 | 64111.33 | 65390.99 | 1279.656 | 604.548 | 675.108 | 64715.88 | 64111.33 | 65390.99 |
| 5-15 | 161.29 | 908.71 | 315.17 | 68.44 | 165.49 | 912.91 | 319.37 | 72.64 | 854.244 | 857.6326 | 850.8833 | 770692.7 | 776493.7 | 764962.3 | 11531.35 | 5800.956 | 5730.396 | 770692.7 | 776493.7 | 764962.3 |
| 5-16 | 315.17 | 68.44 | 305.13 | 208.14 | 319.37 | 72.64 | 309.33 | 212.34 | 140.0603 | 136.2462 | 144.0185 | 60576.89 | 59523.03 | 61701.32 | 2178.288 | 1053.864 | 1124.424 | 60576.89 | 59523.03 | 61701.32 |
| 5-17 | 305.13 | 208.14 | 376.28 | 348.69 | 309.33 | 212.34 | 380.48 | 352.89 | 157.5329 | 151.9 | 163.1876 | 65776.63 | 64033.63 | 67590.19 | 3556.56 | 1743 | 1813.56 | 65776.63 | 64033.63 | 67590.19 |
| 5-18 | 376.28 | 348.69 | 333.47 | 487.97 | 380.48 | 352.89 | 337.67 | 492.17 | 145.7107 | 143.0264 | 148.5841 | 62191.61 | 61416.55 | 63037.24 | 1620.696 | 775.068 | 845.628 | 62191.61 | 61416.55 | 63037.24 |
| 5-19 | 333.47 | 487.97 | 308.2 | 628.01 | 337.67 | 492.17 | 312.4 | 632.21 | 142.3017 | 139 | 145.7708 | 61209.77 | 60280.99 | 62209.12 | 1928.136 | 928.788 | 999.348 | 61209.77 | 60280.99 | 62209.12 |
| 5-20 | 308.2 | 628.01 | 360.32 | 768.86 | 312.4 | 632.21 | 364.52 | 773.06 | 150.1839 | 144.8087 | 155.6003 | 63515.22 | 61929.55 | 65171.44 | 3241.896 | 1585.668 | 1656.228 | 63515.22 | 61929.55 | 65171.44 |
| 5-21 | 360.32 | 768.86 | 327.49 | 908.61 | 364.52 | 773.06 | 331.69 | 912.81 | 143.5544 | 140.517 | 146.7695 | 61567.87 | 60705.02 | 62501.28 | 1796.256 | 862.848 | 933.408 | 61567.87 | 60705.02 | 62501.28 |
| 5-22 | 327.49 | 908.61 | 516.14 | 68.89 | 331.69 | 912.81 | 520.34 | 73.09 | 860.65 | 863.8419 | 857.4875 | 781678.5 | 787182.8 | 776244.8 | 10937.98 | 5504.268 | 5433.708 | 781678.5 | 787182.8 | 776244.8 |
| 5-23 | 516.14 | 68.89 | 457.4 | 208.74 | 520.34 | 73.09 | 461.6 | 212.94 | 151.6852 | 149.5405 | 154.0293 | 63968.41 | 63322.37 | 64685.01 | 1362.648 | 646.044 | 716.604 | 63968.41 | 63322.37 | 64685.01 |
| 5-24 | 457.4 | 208.74 | 456.76 | 348.24 | 461.6 | 212.94 | 460.96 | 352.44 | 139.5015 | 135.3865 | 143.7441 | 60420.66 | 59289.52 | 61622.36 | 2332.848 | 1131.144 | 1201.704 | 60420.66 | 59289.52 | 61622.36 |
| 5-25 | 456.76 | 348.24 | 467.65 | 488.54 | 460.96 | 352.44 | 471.85 | 492.74 | 140.722 | 136.2643 | 145.2858 | 60762.68 | 59527.97 | 62067.96 | 2539.992 | 1234.716 | 1305.276 | 60762.68 | 59527.97 | 62067.96 |
| 5-26 | 467.65 | 488.54 | 423.05 | 628.15 | 471.85 | 492.74 | 427.25 | 632.35 | 146.561 | 143.9351 | 149.377 | 62440.11 | 61677.31 | 63273.48 | 1596.168 | 762.804 | 833.364 | 62440.11 | 61677.31 | 63273.48 |
| 5-27 | 423.05 | 628.15 | 468.36 | 767.99 | 427.25 | 632.35 | 472.56 | 772.19 | 146.9974 | 141.733 | 152.3114 | 62568.22 | 61048.24 | 64158.76 | 3110.52 | 1519.98 | 1590.54 | 62568.22 | 61048.24 | 64158.76 |
| 5-28 | 468.36 | 767.99 | 542.07 | 908.72 | 472.56 | 772.19 | 546.27 | 912.92 | 158.865 | 153.206 | 164.5438 | 66198.1 | 64432.08 | 68034.67 | 3602.592 | 1766.016 | 1836.576 | 66198.1 | 64432.08 | 68034.67 |
| 5-29 | 542.07 | 908.72 | 666.44 | 68.37 | 546.27 | 912.92 | 670.64 | 72.57 | 849.5034 | 853.0566 | 845.977 | 762616 | 768665.5 | 756637.1 | 12028.46 | 6049.512 | 5978.952 | 762616 | 768665.5 | 756637.1 |
| 5-30 | 666.44 | 68.37 | 581.73 | 208.87 | 670.64 | 72.57 | 585.93 | 213.07 | 164.0611 | 162.735 | 165.5897 | 67876.03 | 67442.68 | 68379.95 | 937.272 | 433.356 | 503.916 | 67876.03 | 67442.68 | 68379.95 |
| 5-31 | 581.73 | 208.87 | 652.76 | 348.52 | 585.93 | 213.07 | 656.96 | 352.72 | 156.676 | 151.0396 | 162.3341 | 65507.38 | 63772.95 | 67312.38 | 3539.424 | 1734.432 | 1804.992 | 65507.38 | 63772.95 | 67312.38 |
| 5-32 | 652.76 | 348.52 | 583.94 | 488.84 | 656.96 | 352.72 | 588.14 | 493.04 | 156.2879 | 154.4687 | 158.3091 | 65385.89 | 64820.57 | 66021.77 | 1201.2 | 565.32 | 635.88 | 65385.89 | 64820.57 | 66021.77 |
| 5-33 | 583.94 | 488.84 | 692.05 | 628.06 | 588.14 | 493.04 | 696.25 | 632.26 | 176.2668 | 170.3751 | 182.1616 | 72029.98 | 69987.69 | 74142.83 | 4155.144 | 2042.292 | 2112.852 | 72029.98 | 69987.69 | 74142.83 |
| 5-34 | 692.05 | 628.06 | 578.51 | 768.52 | 696.25 | 632.26 | 582.71 | 772.72 | 180.611 | 180.0819 | 181.3333 | 73580.34 | 73389.5 | 73841.75 | 452.256 | 190.848 | 261.408 | 73580.34 | 73389.5 | 73841.75 |
| 5-35 | 578.51 | 768.52 | 604.39 | 908.05 | 582.71 | 772.72 | 608.59 | 912.25 | 141.9098 | 137.0556 | 146.8439 | 61098.4 | 59744.23 | 62523.12 | 2778.888 | 1354.164 | 1424.724 | 61098.4 | 59744.23 | 62523.12 |
| 5-36 | 604.39 | 908.05 | 767.42 | 68.29 | 608.59 | 912.25 | 771.62 | 72.49 | 855.4389 | 858.7756 | 852.1305 | 772735.6 | 778455.5 | 767086.4 | 11369.06 | 5719.812 | 5649.252 | 772735.6 | 778455.5 | 767086.4 |
| 5-37 | 767.42 | 68.29 | 734.4 | 208.09 | 771.62 | 72.49 | 738.6 | 212.29 | 143.6467 | 140.6154 | 146.8557 | 61594.36 | 60732.69 | 62526.59 | 1793.904 | 861.672 | 932.232 | 61594.36 | 60732.69 | 62526.59 |
| 5-38 | 734.4 | 208.09 | 827.9 | 348.56 | 738.6 | 212.29 | 832.1 | 352.76 | 168.7426 | 162.9233 | 174.57 | 69434.07 | 67504 | 71434.7 | 3930.696 | 1930.068 | 2000.628 | 69434.07 | 67504 | 71434.7 |
| 5-39 | 827.9 | 348.56 | 825.93 | 488.56 | 832.1 | 352.76 | 830.13 | 492.76 | 140.0139 | 135.9401 | 144.2172 | 60563.88 | 59439.71 | 61758.61 | 2318.904 | 1124.172 | 1194.732 | 60563.88 | 59439.71 | 61758.61 |
| 5-40 | 825.93 | 488.56 | 750.27 | 628.84 | 830.13 | 492.76 | 754.47 | 633.04 | 159.3829 | 157.7827 | 161.1862 | 66362.91 | 65855.39 | 66941 | 1085.616 | 507.528 | 578.088 | 66362.91 | 65855.39 | 66941 |
| 5-41 | 750.27 | 628.84 | 733.51 | 768.46 | 754.47 | 633.04 | 737.71 | 772.66 | 140.6223 | 137.0325 | 144.3674 | 60734.64 | 59737.9 | 61801.95 | 2064.048 | 996.744 | 1067.304 | 60734.64 | 59737.9 | 61801.95 |
| 5-42 | 733.51 | 768.46 | 744.5 | 908 | 737.71 | 772.66 | 748.7 | 912.2 | 139.9721 | 135.5102 | 144.5404 | 60552.19 | 59323.02 | 61851.92 | 2528.904 | 1229.172 | 1299.732 | 60552.19 | 59323.02 | 61851.92 |
| 5-43 | 744.5 | 908 | 925.89 | 68.02 | 748.7 | 912.2 | 930.09 | 72.22 | 859.342 | 862.5753 | 856.1378 | 779428.7 | 784996.2 | 773931.9 | 11064.31 | 5567.436 | 5496.876 | 779428.7 | 784996.2 | 773931.9 |
| 5-44 | 925.89 | 68.02 | 933.58 | 208.63 | 930.09 | 72.22 | 937.78 | 212.83 | 140.8201 | 136.4546 | 145.2973 | 60790.31 | 59579.87 | 62071.31 | 2491.44 | 1210.44 | 1281 | 60790.31 | 59579.87 | 62071.31 |
| 5-45 | 933.58 | 208.63 | 861.26 | 347.99 | 937.78 | 212.83 | 865.46 | 352.19 | 157.0076 | 155.3175 | 158.9019 | 65611.39 | 65083.54 | 66209.81 | 1126.272 | 527.856 | 598.416 | 65611.39 | 65083.54 | 66209.81 |
| 5-46 | 861.26 | 347.99 | 922.7 | 488.72 | 865.46 | 352.19 | 926.9 | 492.92 | 153.5572 | 148.0434 | 159.1016 | 64539.81 | 62876.86 | 66273.31 | 3396.456 | 1662.948 | 1733.508 | 64539.81 | 62876.86 | 66273.31 |
| 5-47 | 922.7 | 488.72 | 903.86 | 628.42 | 926.9 | 492.92 | 908.06 | 632.62 | 140.9647 | 137.4449 | 144.6428 | 60831.04 | 59851.09 | 61881.54 | 2030.448 | 979.944 | 1050.504 | 60831.04 | 59851.09 | 61881.54 |
| 5-48 | 903.86 | 628.42 | 883.29 | 768.76 | 908.06 | 632.62 | 887.49 | 772.96 | 141.8395 | 138.375 | 145.464 | 61078.44 | 60107.65 | 62119.79 | 2012.136 | 970.788 | 1041.348 | 61078.44 | 60107.65 | 62119.79 |
| 5-49 | 883.29 | 768.76 | 937.41 | 908.83 | 887.49 | 772.96 | 941.61 | 913.03 | 150.1618 | 144.7503 | 155.6119 | 63508.58 | 61912.66 | 65175.06 | 3262.392 | 1595.916 | 1666.476 | 63508.58 | 61912.66 | 65175.06 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | **838600.7** | **412773.6** | **425827.2** |  |  |  |

The value of R, E\_charge, E\_ts, and Erx has been considered 4096 bits, 50000 Pico-Joules, 10 Pico-Joules, and 204800000 Pico-Joules respectively. Similarly, we have calculated the average energy, minimum energy, and maximum energy for random as well as square deployment. The below table shows the comparison of results.

Table **3:** Comparison of results of 3 deployments strategies.

|  |  |  |  |
| --- | --- | --- | --- |
| Deployments | Maximum Energy (pJ) | Minimum Energy (pJ) | Average Energy (pJ) |
| S-shaped | 838600.7 | 412773.6 | 425827.2 |
| Random | 864823.7 | 426308.4 | 438525.9 |
| Spiral | 848969 | 418425.9 | 430717.5 |

**6. RESULT ANALYSIS**

We have used the data from Table 3 for experimental purposes. As it is visible in Table 3 that the S-shaped in performing better than the other 2 deployment strategies. So, we have compared the data of S-shaped deployment with the data taken from existing literature [39]. Applying our strategies (deployment strategies and clustering process) we have obtained a large set of results as depicted in Tables 2, 3, and 4.

**Applying Random Deployment Strategy and Area wise Clustering Process**

The calculations of the energy saved are shown in table 2. There are five iterations and the energy saved has been calculated for every node which sums up to 864823.7 Pico-Joules in case of maximum energy saving. Considering the initial energy of nodes as 1 Joule and not taking duty cycle into account we have calculated the number of days by using the formula

  (13)   
Where Es=Energy saved and 1day=86400 seconds.

Putting the value of ES as 864823.7 we get 13 days and 3 hours or 315 hours.

So, this network can save up to 267.75 hours to 362.25 hours or 11.15 days to 15.09 days.

**Applying Spiral Deployment Strategy and Area wise Clustering Process**

The calculations of the energy saved are shown in table 3. There are five iterations and energy saved that have been calculated for every node which sums up to 848969.0 Pico-Joules in case of maximum energy saving. Considering the initial energy of nodes as 1 Joule and not taking duty cycle into account we have calculated the number of days by using the formula

(14)   
  
Where Es=Energy saved and 1day=86400 seconds.

Putting the value of ES as 864823.7 we get 13 days and 6 hours or 318 hours.

So this network can save up to 270.3 hours to 365.7 hours or 11.25 days to 15.23 days.

**Applying S-pattern Deployment Strategy and Area wise Clustering Process**

The calculations of the energy saved are shown in table 2. There are five iterations and energy saved that have been calculated for every node which sums up to 838600.7 Pico-Joules in case of maximum energy saving. Considering the initial energy of nodes as 1 Joule and not taking duty cycle into account we have calculated the number of days by using the formula

(15) 

Where Es=Energy saved and 1day=86400 seconds.

Putting the value of ES as 864823.7 we get 13 days and 8 hours or 320 hours. So, it can be concluded that the concept can save up to 272 hours to 368 hours or 11.33 days to 15.33 days of a lifetime of WSN. Therefore, from the above calculations, we can say that the s-pattern deployment is performing better than the other two deployments as the network will remain active for a longer time in the case of s-pattern deployment. Inthis research work, the obtained result (the lifetime of WSN) has been compared with the paper of [38] by scaling up the external environmental parameters like covered area size, several nodes deployed, several rounds have also been compared and it has been seen that the life-time saving can be done 10 to 11 days by applying their method which can be increased 1 to 5 days in case of random deployment strategies using modified ACO. Lifetime saving can be increased.

We have compared our work with other literature [39] to prove that our experiments have yielded better results than other papers.

Table **4**. Comparison of results obtained by our proposed algorithm and existing literature [39].

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameters | Totalxy  (max) | Totalxy  (min) | Energy Saved | Days |
| Algorithms |
| ACO and  Random Deployment | 100389425972.31 | 100389269395.97 | 864823.68 | 13.38 |
| ACO and  Spiral Deployment | 100388152202.95 | 100387999246.18 | 848969.016 | 13.63 |
| ACO and S-pattern Deployment | 36589595.82 | 36436618.21 | 838600.728 | 13.8 |
| DE-QPSO | 17214960557260.80 | 17215930368000.00 | 969810739.2 | 7 |
| DE | 21862999907721.216 | 21864231567360 | 1,231,659,638.784 | 5.5 |
| QPSO | 19280755824132.096 | 19281842012160 | 1086188027.904 | 6.2 |

In this table, we have compared our work to another literature [38] and found out that our experiment has performed better than the existing literature [39]. We have obtained a value of about 13 days which is 6 days more than the value obtained by applying the DE-QPSO algorithm. In our experiment, we have covered a large area (1 km2) than the existing literature [39]. Other than that, we have also deployed more nodes and have more clusters as well.

Some parameters such as equivalent distribution, number of iterations, maximum energy have been set to a permissible range to get a better result set. In practical life, the level may not match with the theoretical result due to physical dependencies like external environmental factors.

**7. CONCLUSION**

In this paper, efficient Wireless Sensor Networks have been configured taking energy minimization as the prime concern. To minimize the energy consumption a modified ACO algorithm has been proposed. In this research minimization of energy consumption leads to an increment of the lifetime of WSN to a significant margin theoretically. The obtained result has been compared with the existing literature and it has been found that the proposed algorithm produced better results than the existing literature. There are some challenges present in the research work and one of the prime challenges is the selection of the type of deployment techniques to get the minimum energy consumption. One can use fuzzy logic and fuzzy inference rule in the future to decide which type of deployment should be applied to get the minimum energy consumption and increasing the lifetime of the overall network. There is some difference between the theoretical result and the practical because of physical dependencies like some external environmental factors in practical life, which is not considered in the theoretical experimental environment. One can incorporate those parameters in their experiment and think about future work related to WSN. In this research work, some physical dependencies like different environmental hazards as well as physical hazards have been considered. To implement those hazards in the experimental environment an allowable level of tolerance percentage should be incorporated, which is also another challenge in this research work. In the future, one can work on these challenges. One can incorporate uncertainty and random function in the obtained experimental result to make the situation more realistic because the reality is full of uncertainty and randomness. Fuzzy system configuration can be a good choice to figure out the situation.

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