

# **An Appraisal of Gravity Model for Kurundwad Town and Its Surrounding Villages in Kolhapur District (Maharashtra: India)**

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## **Abstract**

The theory of gravity was introduced by Issac Newton in 1686. Newton postulated that the gravitational force, which acts between two bodies in space, was directly proportion to the mass of the two bodies and inversely proportion to the square of the distance between the bodies. It was second half of the 19th Century that the theory of gravity was applied to human interaction. The gravity model is aimed at formalising, studying and predicting geography of flows or interactions. The model has first been formulated in analogy with Newton's law of universal gravitation: two objects attract each other directly proportional to their masses and inversely proportional to the distance separating them. For decades, social scientists have also been using a modified version of Isaac Newton's Law of Gravitation to predict movement of people, information, and commodities between cities and even continents. The gravity model, as social scientists refer to the modified law of gravitation, takes into account the population size of two places and their distance. Since larger settlements attract people, ideas, and commodities more than smaller settlements and places closer together have a greater attraction. An application of the gravity model at the local level helps to examine the interaction between Kurundwad town and its surrounding villages. The magnitude of social interaction and the flow analysis indicate the degree of centrality of town. For the flow analysis two main criteria undertaken are city bus frequencies and Newspaper circulation. The present paper, therefore, mainly focused on how this gravity model works at local level and also in context with development planning of urban centers to mitigate the increasing pressure of population.

**Key words-** Gravity model, applicability, reliability, social interaction, interaction magnitude.

## 1. Introduction

In the study of spatial interaction, it is easy to detect some regularity in spatial flows and making accurate models of spatial interaction. The gravity model, as social scientists refer to the modified law of gravitation, takes into account the population size of two places and their distance. Since larger places attract people, ideas, and commodities more than smaller places and places closer together have a greater attraction, the gravity model incorporates these two features. The relative strength of a bond between two places is determined by multiplying the population of city A by the population of city B and then dividing the product by the distance between the two cities squared (<http://people.hofstra.edu>). The Spatial interaction is a broad term encompassing any movement over space that results from a human process. It includes journey-to-work, migration, information and commodity flows, student enrolments and conference attendance, the utilization of public and private facilities, and even the Transmission of knowledge. Gravity models are the most widely used types of interaction models. They are mathematical formulations that are used to analyse and forecast spatial interaction patterns (Haynes and Fortheringham, 1984).

An application of the gravity model at the local level helps to examine the interaction between Kurundwad town and its surrounding villages. For the flow analysis the main criteria undertaken are city bus frequencies and newspaper circulation. Therefore, the present study mainly focused on testing of gravity model at local level.

## 2. Objectives

- To test the gravity model at local level.
- To investigate the interaction between Kurundwad town and its surrounding villages.
- To discover the applicability and reliability of gravity model by flow analysis.

## 3. Data Base

The present investigation is based on secondary sources of data. The secondary data is collected from Kurundwad S.T. stand control cabin, Shirol tahesildar office, Grampanchayat of the selected villages, etc. in order to examine the interaction between Kurundwad town and its surrounding villages. Besides that, the map of Kurundwad town is also used to identify the role of physiography in population interaction. Some websites are also used to obtain the information about Kurundwad town and surrounding areas.

#### 4. Methodology

The present study is mainly done to find out the social interaction between settlements. In order to discover the interaction between settlements modified version of Newton's law of Gravitation was used by social scientists. For the present investigation the gravitational law introduced by Matt T. Rosenberg is employed-

$\frac{\text{Population}_1 \times \text{Population}_2}{\text{Distance}^2}$
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By using this formula, the degree of interaction between two places is calculated by multiplying the population  $_1$  by population  $_2$  and then dividing the answer by the square of distance between two selected places. By applying this method, the degree of interaction between the Kurundwad town and its surrounding villages was determined. The census data of year 2012 was used for the above mentioned calculations. The degree of interaction was determined by multiplying the population of Kurundwad town by the population of selected village, then the answer was divided by the square of distance between the Kourundwad town and selected village.

#### 5. Study Area

The present study is restricted to Kurundwad town and its surrounding villages. The Kurundwad town is located between  $16^{\circ} 40' 47''$  north latitude and  $74^{\circ} 34' 47''$  east longitudes. The Kurundwad town is located at the northern part of Shirol tehsil and the Shirol tehsil is the eastern part of the Kolhapur district of Maharashtra (India). This town has efficient road link with important cities like Sangli, Miraj, etc. Besides that, at the local level a town is also well connected with its surrounding villages. Therefore, the Kurundwad town and its seven surrounding villages viz; Nrusihwadi, Aurwad, Terwad, Herwad, Bastwad, Majarewadi, Shirdhon villages were selected for the present investigation.

#### 6. Definition of Gravity Model in Terms of Social Interaction

The gravity model is aimed at formalizing, studying and predicting geography of flows or interactions. The model has first been formulated in analogy with Newton's law of universal gravitation: two objects attract each other directly proportional to their masses and inversely proportional to the distance separating them (<http://www.hypergeo.eu/spip.php?article255>). For decades, social scientists have also been using a modified version of Isaac Newton's Law of Gravitation to predict movement of people, information, and

commodities between cities and even continents. The gravity model, as social scientists refer to the modified law of gravitation, takes into account the population size of two places and their distance. Since larger settlements attract people, ideas, and commodities more than smaller settlements and places closer together have a greater attraction (<http://geography.about.com>).

### *6.1. Testing of Gravity Model at Local Level*

By using the formula given by Matt T. Rosenberg; the degree of interaction between the Kurundwad town and its surrounding villages was determined. For those calculations the Kurundwad town is considered as Population 1, while the population of its neighboring village was put as Population 2. And after the multiplication of Population 1 and population 2, the obtained answer was divided by square of distance between Population 1 and population 2. The interaction between the Kurundwad town and Nrusihwadi village is computed by multiplication of their total populations of 2012 (35230 and 4159 respectively) and the product is (146521570) divided by the square of distance between them (6.25 km). Therefore, the interaction between the Kurundwad town and Nrusihwadi village is 23443451.2. This figure is converted into million for better understanding. In this way the interaction /gravity between the Kurundwad town and Nrusihwadi is 23.4. Same method is applied to find out the interaction between Kurundwad town and its remaining selected surrounding villages, all the values of interactions are presented in the following Table 1.

As per the Table 1, the value of interaction between Kurundwad town and Nrusihwadi village is highest (23.4), which is followed by Terwad village (17.73). It is because of the fact that both the villages have biggest population size and their distance from the Kurundwad town is also low as compared to other villages. Therefore, as per rule of gravitation, the interaction between these two biggest settlements (as compared to remaining villages) is more than the remaining villages. The interaction value or gravitational force between Kurundwad town and Bastwad village is very low (1.9). Because, the Bastwad is very small village as compared to other selected villages in terms of population size. And its distance from the Kurundwad town is also 6.4 km, which is too long than others. Besides that, the lowest interaction of Bastwad village is followed by Majarewadi (2.30) due to the above mentioned same two reasons; one is smaller population size and another is longer distance from Kurundwad town. Further noticeable thing related to the above analysis is that, the Shirdhon village has highest population size but interaction value between Kurundwad town and Shirdhon is only 8.6, which is three times lesser as compared to interaction values of Nrusihwadi and Terwad village. The major cause behind the lower interaction value is the longer distance between Shirdhon and Kurundwad town (6.2km).

## 6.2. Determination of Interaction by Using Flow Analysis

After the application of gravity model, there is need to find out the actual flow of commodities between the Kurundwad town and its surrounding villages. As per the flow analysis, if the flow of commodities between the selected places is highest then the degree of interaction between selected places is also high. For the flow analysis the S.T. (State Transport) circulation and Newspaper (Sakal, Pudhari) circulation was taken into consideration. As per the data of S.T. daily bus circulation, the highest bus circulation is found between the Nrusihwadi village and Kurundwad town i.e. 170 trips in a day, because it is a famous religious place and also well connected to the cities like Sangli, Miraj, etc. This highest bus circulation was followed by bus circulation between Terwad (50), Herwad (50) and Kurundwad town. There was a lowest bus circulation between the Kurundwad town and the Bastwad (9), Aurwad (14), Shirdhon (15) villages (Table 2). As per the survey the newspaper circulation is highest between those places which represent highest interaction value obtained from Gravity model. The comparative study made it clear that Pudhari has the highest circulation in the study area. The Interaction value is highest between Kurundwad town and Nursihawadi village, therefore, the newspaper circulation between Kurundwad and Nursihawadi (Pudhari-800, Sakal-200) is also high. The paper circulation between Bastwad village and Kurundwad town is very low (Pudhari-40, Sakal-20) which represents the lower interaction (Table 2).

## 7. Conclusion

It is found that the interaction between Nrusihwadi village and Kurundwad town (23.44) is highest, followed by Terwad village (17.73). These villages have highest interaction value due to their biggest population size and lower distance from the Kurundwad town as compared to other villages. As per the flow analysis, the highest bus circulation (170 trips in a day) and newspaper circulation is found between Nrusihwadi village and Kurundwad town. Therefore, the flow analysis also denotes that if the degree of interaction between the places is highest then the commodities circulation is also highest. The interaction value or gravitational force is very low between Kurundwad town and Bastwad (1.99) village. The Lowest interaction value of Bastwad village leads to smaller population size of village as compared to other selected villages. And also its distance from the Kurundwad town is too lengthier (6.4) than other villages. Thus above analysis reveals that, still the gravity model is applicable and reliable for the study of interaction between settlements. The villages with biggest population size and lowest distance from the main center (Kurundwad town) have the highest interaction value between them and vice versa.

Flow analysis shows that, all the villages that have highest interaction value as per the gravity model are also having the highest bus and Newspaper circulations. And the circulation of buses reduces as the value of interaction declines. It is inferred that larger the size of settlement with lesser the distance between them, larger would be interaction.

## 8. Suggestions

- 1) The market and other related facilities should be shifted to places that indicate the lower interactions, in order to avoid the congestion of traffic and overcrowdings at places containing high interaction.
- 2) All the roads between the places that containing high interaction value should be widen and traffic flow should be properly managed to control the excessive traffic flow during the peak hours.
- 3) There should be diversion of heavy vehicles transport flows and commute flows to avoid burden on congested roads.

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**Table 1. Interaction between Kurundwad Town and Its Selected Surrounding Villages**

Sr. No.	Interaction Between Population 1 and Population 2		Distance		Interaction Value
	Population 1	Population 2	Km	(Km) <sup>2</sup>	
1	35230 [Kurundwad Town]	4541 (Aurwad)	3.3	10.89	14.69
2	35230 [Kurundwad Town]	4159 (Nrusihwadi)	2.5	6.25	23.44
3	35230 [Kurundwad Town]	2320 (Bastwad)	6.4	40.96	1.99
4	35230 [Kurundwad Town]	9400 (Shirdhon)	6.2	38.44	8.61
5	35230 [Kurundwad Town]	2276 (Majarewadi)	5.9	34.81	2.30
6	35230 [Kurundwad Town]	4526 (Terwad)	3.0	09.00	17.73
7	35230 [Kurundwad Town]	7585 (Herwad)	4.8	30.25	8.83

Source: Shirol Tehsildar Office, Kurundwad Depot S.T. Control Cabin.

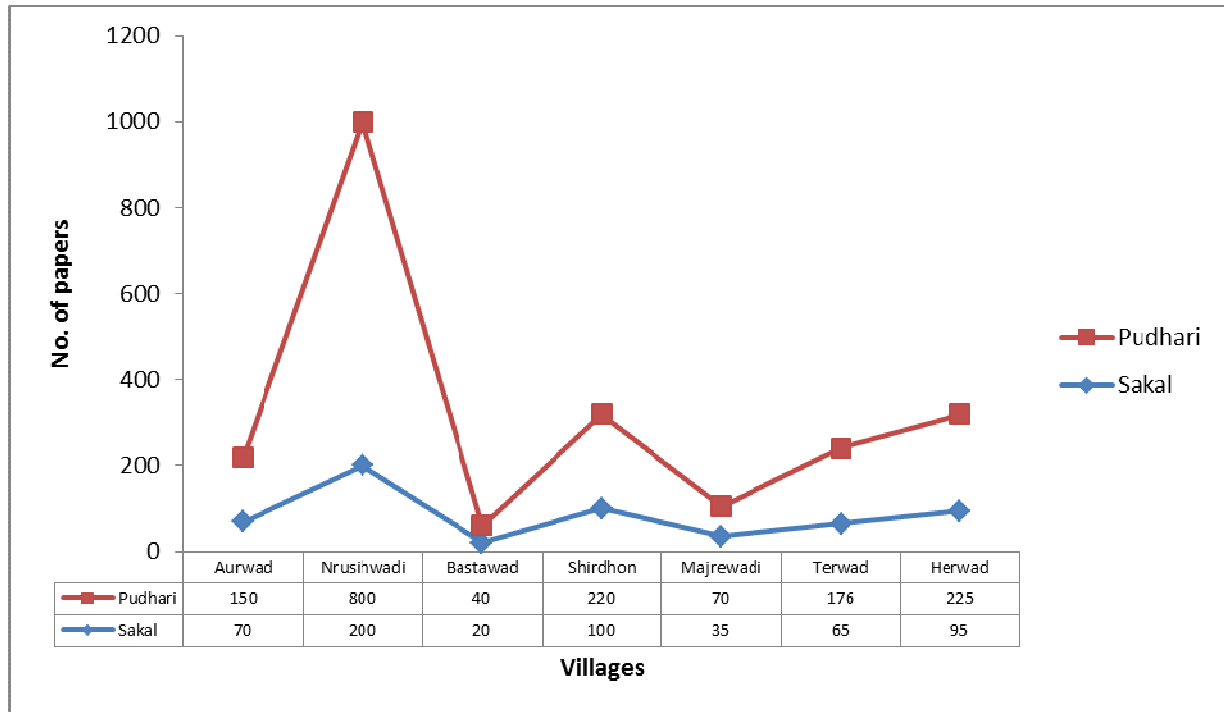
**Table 2. Flow Analysis: Buses and Newspaper Circulation, 2012**

Sr. No.	Bus trips and newspaper circulation from Kurundwad town to its surrounding villages	Total bus trips in a day	Newspaper circulation in a day		
			Sakal	Pudhari	Total
1	Aurwad	14	70	150	220
2	Nrusihwadi	170	200	800	1000
3	Bastawad	9	20	40	60
4	Shirdhon	15	100	220	320
5	Majarewadi	20	35	70	105
6	Terwad	50	65	176	241
7	Herwad	50	95	225	320

**(Buses and News Paper Circulation between Kurundwad town to its surrounding villages, 2012)**

Source: Kurundwad S.T. Stand Control Cabin, Sakal & Pudhari Newspapers Office Kurundwad.





**Newspaper circulation from Kurundwad town to its surrounding villages**

Source: Sakal & Pudhari Newspapers Office, Kurundwad

**Figure 1**

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