International Journal of Mathematics and Statistics Invention (IJMSI)
E-ISSN: 2321 – 4767 P-ISSN: 2321 - 4759
www.ijmsi.org Volume 11 Issue 4 || July - August, 2023 || PP 35-43

Sum and Product Connectivity Gourava Domination Indices of Graphs

V.R.Kulli
[3]*Department of Mathematics, Gulbarga University, Gulbarga-585106*
Corresponding Author: V.R.Kulli

***ABSTRACT**: In this paper, we propose the sum and product connectivity Gourava domination indices and their corresponding exponentials of a graph. Furthermore, we compute these newly defined Gourava domination indices their corresponding exponentials of some standard graphs, French windmill graphs, friendship graphs, book graphs.*

***KEYWORDS**: sum connectivity Gourava domination index, product connectivity Gourava domination index, windmill graphs, friendship graphs.*

Date of Submission: 25-08-2023 Date of acceptance: 08-09-2023

I. Introduction

The graph *G= (V(G), E(G)),* where *V(G)* be the vertex set and *E(G)* be the edge set. $d_G(u)$ be the degree of a vertex *u*. For undefined term and notation, we refer the books [1, 2]. Graph indices have their applications in various disciplines of Science and Engineering. Recently some new graph indices were studied, for example, in [3, 4, 5].

The domination degree $d_d(u)$ of a vertex *u* [6] in a graph *G* is defined as the number of minimal dominating sets of *G* which contains *u*.

The first and second Gourava domination indices [7] of a graph are defined as

$$GOD_1(G) = \sum_{uv\in E(G)} \left[d_d(u) + d_d(v) + d_d(u)d_d(v) \right].$$

$$GOD_2(G) = \sum_{uv\in E(G)} \left(d_d(u) + d_d(v) \right)\left(d_d(u)d_d(v) \right).$$

Recently some domination indices were studied in [8, 9, 10, 11, 12, 13, 14, 15, 16].

We propose the sum connectivity Gourava domination index of a graph and it is defined as

$$SGOD(G) = \sum_{uv\in E(G)} \frac{1}{\sqrt{d_d(u) + d_d(v) + d_d(u)d_d(v)}}.$$

We introduce the product connectivity Gourava domination index of a graph and it is defined as

$$PGOD(G) = \sum_{uv\in E(G)} \frac{1}{\sqrt{\left(d_d(u) + d_d(v) \right)\left(d_d(u)d_d(v) \right)}}$$

Considering the sum and product connectivity Gourava domination indices, we define the sum and product connectivity Gourava domination exponentials of a graph *G* as

$$SGOD(G,x) = \sum_{uv\in E(G)} x^{\frac{1}{\sqrt{d_d(u)+d_d(v)+d_d(u)d_d(v)}}}.$$

$$PGOD(G,x) = \sum_{uv\in E(G)} x^{\frac{1}{\sqrt{\left(d_d(u)+d_d(v)\right)\left(d_d(u)d_d(v)\right)}}}.$$

Recently, some domination parameters were studied in [17, 18, 19, 20, 21, 22, 23, 24].

In this paper, we determine the sum and product connectivity Gourava domination indices of some standard graphs, French windmill graphs and friendship graphs.

II. Results for Some Standard Graphs

Proposition 1. If K_n is a complete graph with *n* vertices, then

(i) $$SGOD(K_n) = \frac{n(n-1)}{2\sqrt{3}}.$$

(ii) $$PGOD(K_n) = \frac{n(n-1)}{2\sqrt{2}}.$$

Proof: If K_n is a complete graph, then $d_d(u) = 1$. From definition, we have

(i) $$SGOD(K_n) = \sum_{uv\in E(K_n)} \frac{1}{\sqrt{d_d(u)+d_d(v)+d_d(u)d_d(v)}}$$

$$= \frac{n(n-1)}{2\sqrt{1+1+(1\times 1)}} = \frac{n(n-1)}{2\sqrt{3}}.$$

(ii) $$PGOD(K_n) = \sum_{uv\in E(K_n)} \frac{1}{\sqrt{(d_d(u)+d_d(v))(d_d(u)d_d(v))}}$$

$$= \frac{n(n-1)}{2\sqrt{(1+1)(1\times 1)}} = \frac{n(n-1)}{2\sqrt{2}}.$$

Proposition 2. If S_{n+1} is a star graph with $d_d(u) = 1$, then

(i) $$SGOD(S_{n+1}) = \frac{n}{\sqrt{3}}.$$

(ii) $$PGOD(S_{n+1}) = \frac{n}{\sqrt{2}}.$$

Proposition 3. If $S_{p+1,q+1}$ is a double star graph with $d_d(u) = 2$, then

(i) $$SGOD(S_{p+1,q+1}) = \frac{p+q+1}{2\sqrt{2}}.$$

(ii) $$PGOD(S_{p+1,q+1}) == \frac{p+q+1}{4}.$$

Proposition 4. Let $K_{m,n}$ be a complete bipartite graph with $2 \le m \le n$. Then

(i) $$SGOD(K_{m,n}) = \frac{mn}{\sqrt{mn+2m+2n+3}}.$$

(ii) $PGOD\left(K_{m,n}\right)=\dfrac{mn}{\sqrt{(m+n+2)(m+1)(n+1)}}$.

Proof: Let $G=K_{m,n}$, $m, n\geq 2$ with
$d_d(u) = m+1$
$= n+1$, for all $u\in V(G)$.
From definition, we have

(i) $$SGOD\left(K_{m,n}\right) = \sum_{uv\in E\left(K_{m,n}\right)} \frac{1}{\sqrt{d_d(u)+d_d(v)+d_d(u)d_d(v)}}$$

$$=\frac{mn}{\sqrt{(m+1+n+1)+(m+1)(n+1)}}$$

$$=\frac{mn}{\sqrt{mn+2m+2n+3}}.$$

(ii) $$PGOD\left(K_{m,n}\right) = \sum_{uv\in E\left(K_{m,n}\right)} \frac{1}{\sqrt{\left(d_d(u)+d_d(v)\right)\left(d_d(u)d_d(v)\right)}}$$

$$=\frac{mn}{\sqrt{(m+1+n+1)(m+1)(n+1)}}$$

$$=\frac{mn}{\sqrt{(m+n+2)(m+1)(n+1)}}.$$

In the following proposition, by using definition, we obtain the sum and product connectivity Gourava domination exponentials of K_n, S_{n+1}, $S_{p+1,q+1}$ and $K_{m,n}$.

Proposition 5. The sum and product connectivity Gourava domination exponentials of K_n, S_{n+1}, $S_{p+1,q+1}$ and $K_{m,n}$ are given by

(i) $$SGOD\left(K_n,x\right)=\sum_{uv\in E\left(K_n\right)} x^{\frac{1}{\sqrt{d_d(u)+d_d(v)+d_d(u)d_d(v)}}}$$

$$=\frac{n(n-1)}{2}x^{\frac{1}{\sqrt{1+1+(1\times 1)}}}=\frac{n(n-1)}{2}x^{\frac{1}{\sqrt{3}}}.$$

(ii) $SGOD\left(S_{n+1},x\right)=nx^{\frac{1}{\sqrt{3}}}$.

(iii) $SGOD\left(S_{p+1,q+1},x\right)=\left(p+q+1\right)x^{\frac{1}{2\sqrt{2}}}$.

(iv) $SGOD\left(K_{m,n},x\right)=mnx^{\frac{1}{\sqrt{mn+2m+2n+3}}}$.

(v) $PGOD(K_n, x) = \sum_{uv \in E(K_n)} x^{\frac{1}{\sqrt{(d_d(u)+d_d(v))(d_d(u)d_d(v))}}}$

$$= \frac{n(n-1)}{2} x^{\frac{1}{\sqrt{(1+1)(1\times 1)}}} = \frac{n(n-1)}{2} x^{\frac{1}{\sqrt{2}}}.$$

(vi) $PGOD(S_{n+1}, x) = nx^{\frac{1}{\sqrt{2}}}.$

(vii) $PGOD(S_{p+1,q+1}, x) = (p+q+1)x^{\frac{1}{4}}.$

(viii) $PGOD(K_{m,n}, x) = mnx^{\frac{1}{\sqrt{(m+n+2)(m+1)(n+1)}}}.$

III. Results for French Windmill Graphs

The French windmill graph F_n^m is the graph obtained by taking $m \geq 3$ copies of K_n, $n \geq 3$ with a vertex in common, see Figure 1. The French windmill graph F_3^m is called a friendship graph.

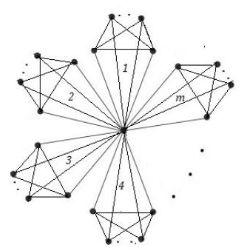

Figure 1. French windmill graph F_n^m

Let F be a French windmill graph F_n^m. Then

$d_d(u)$ =1, if *u is in center*

$=(n-1)^{m-1}$, otherwise.

Theorem 1. Let F be a French windmill graph F_n^m. Then

$$SGOD(F) = \frac{m(n-1)}{\sqrt{1+2(n-1)^{(m-1)}}} + \frac{(mn(n-1)/2) - m(n-1)}{\sqrt{(n-1)^{(m-1)}[2+(n-1)^{(m-1)}]}} .$$

Proof: In F, there are two sets of edges. Let E_1 be the set of all edges which are incident with the center vertex and E_2 be the set of all edges of the complete graph. Then

$$SGOD(F) = \sum_{uv \in E(F)} \frac{1}{\sqrt{d_d(u) + d_d(v) + d_d(u)d_d(v)}}$$

$$= \sum_{uv \in E_1(F)} \frac{1}{\sqrt{d_d(u) + d_d(v) + d_d(u)d_d(v)}} + \sum_{uv \in E_2(F)} \frac{1}{\sqrt{d_d(u) + d_d(v) + d_d(u)d_d(v)}}$$

$$= \frac{m(n-1)}{\sqrt{1+(n-1)^{(m-1)} + 1(n-1)^{(m-1)}}} + \frac{(mn(n-1)/2) - m(n-1)}{\sqrt{(n-1)^{(m-1)} + (n-1)^{(m-1)} + (n-1)^{(m-1)}(n-1)^{(m-1)}}}$$

$$=\frac{m(n-1)}{\sqrt{1+2(n-1)^{(m-1)}}}+\frac{(mn(n-1)/2)-m(n-1)}{\sqrt{(n-1)^{(m-1)}[2+(n-1)^{(m-1)}]}}.$$

Corollary 1.1. Let F_3^m be a friendship graph. Then

$$SGOD\left(F_3^m\right)=\frac{2m}{\sqrt{1+2^m}}+\frac{m}{\sqrt{2^{m-1}\left(2+2^{m-1}\right)}}.$$

In the following theorem, by using definitions, we obtain the sum connectivity Gourava domination exponentials of F_n^m and F_3^m.

Theorem 2 . The first Gourava domination polynomials of F_n^m and F_3^m are given by

(i) $$SGOD\left(F_n^m,x\right)=\sum_{uv\in E\left(F_n^m\right)} x^{\frac{1}{\sqrt{d_d(u)+d_d(v)+d_d(u)d_d(v)}}}$$

$$=m(n-1)\,x^{\frac{1}{\sqrt{1+2(n-1)^{(m-1)}}}}+[(mn(n-1)/2)-m(n-1)]x^{\frac{1}{\sqrt{(n-1)^{(m-1)}[2+(n-1)^{(m-1)}]}}}.$$

(ii) $$SGOD\left(F_3^m,x\right)=\sum_{uv\in E\left(F_3^m\right)} x^{\frac{1}{\sqrt{d_d(u)+d_d(v)+d_d(u)d_d(v)}}}=2mx^{\frac{1}{\sqrt{(1+2^m)}}}+mx^{\frac{1}{\sqrt{2^{m-1}(2+2^{m-1})}}}$$

Theorem 3. Let F be a French windmill graph F_n^m. Then

$$PGOD(F)=\frac{m(n-1)}{\sqrt{\left(1+(n-1)^{(m-1)}\right)(n-1)^{(m-1)}}}+\frac{(mn(n-1)/2)-m(n-1)}{(n-1)^{m-1}\sqrt{2(n-1)^{m-1}}}.$$

Proof: In F, there are two sets of edges. Let E_1 be the set of all edges which are incident with the center vertex and E_2 be the set of all edges of the complete graph. Then

$$PGOD(F)=\sum_{uv\in E(F)}\frac{1}{\sqrt{\left(d_d(u)+d_d(v)\right)\left(d_d(u)d_d(v)\right)}}$$

$$=\sum_{uv\in E_1(F)}\frac{1}{\sqrt{\left(d_d(u)+d_d(v)\right)\left(d_d(u)d_d(v)\right)}}+\sum_{uv\in E_2(F)}\frac{1}{\sqrt{\left(d_d(u)+d_d(v)\right)\left(d_d(u)d_d(v)\right)}}$$

$$=\frac{m(n-1)}{\sqrt{\left(1+(n-1)^{(m-1)}\right)1(n-1)^{(m-1)}}}+\frac{(mn(n-1)/2)-m(n-1)}{\sqrt{\left((n-1)^{m-1}+(n-1)^{m-1}\right)\left((n-1)^{m-1}(n-1)^{m-1}\right)}}$$

$$=\frac{m(n-1)}{\sqrt{\left(1+(n-1)^{(m-1)}\right)(n-1)^{(m-1)}}}+\frac{(mn(n-1)/2)-m(n-1)}{(n-1)^{m-1}\sqrt{2(n-1)^{m-1}}}.$$

Corollary 3.1. Let F_3^m be a friendship graph. Then

$$PGOD\left(F_3^m\right)=\frac{2m}{\sqrt{2^{m-1}\left(1+2^{(m-1)}\right)}}+\frac{m}{2^{m-1}\sqrt{2^m}}.$$

In the following theorem, by using definitions, we obtain the product connectivity Gourava domination exponentials of F_n^m and F_3^m .

Theorem 4. The second Gourava domination polynomials of F_n^m and F_3^m are given by

(i) $$PGOD\left(F_n^m, x\right) = \sum_{uv\in E\left(F_n^m\right)} x^{\frac{1}{\sqrt{(d_d(u)+d_d(v))(d_d(u)d_d(v))}}}$$

$$= m(n-1)\, x^{\frac{1}{\sqrt{\left(1+(n-1)^{(m-1)}\right)(n-1)^{(m-1)}}}} + [(mn(n-1)/2) - m(n-1)]\, x^{\frac{1}{(n-1)^{m-1}\sqrt{2(n-1)^{m-1}}}}.$$

(ii) $$PGOD\left(F_3^m, x\right) = \sum_{uv\in E\left(F_3^m\right)} x^{\frac{1}{\sqrt{(d_d(u)+d_d(v))(d_d(u)d_d(v))}}}$$

$$= 2mx^{\frac{1}{\sqrt{2^{m-1}\left(1+2^{(m-1)}\right)}}} + mx^{\frac{1}{2^{m-1}\sqrt{2^m}}}.$$

IV. Results for GoK_p

Theorem 5. Let H=GoK_p, where G is a connected graph with n vertices and m edges; and K_p is a complete graph. Then

(i) $$SGOD(H) = \frac{(2m+np^2+np)}{2\sqrt{(p+1)^{n-1}\left[2+(p+1)^{n-1}\right]}}.$$

(ii) $$PGOD(H) = \frac{(2m+np^2+np)}{2\sqrt{2(p+1)^{3(n-1)}}}.$$

Proof: If H=GoK_p, then $d_d(u) = (p+1)^{n-1}$. In F, there are $\frac{p(p-1)}{2}$. edges. Thus H has $\frac{1}{2}(2m+np^2+np)$ edges. Thus

(i) $$SGOD(H) = \sum_{uv\in E(H)} \frac{1}{\sqrt{d_d(u)+d_d(v)+d_d(u)d_d(v)}}$$

$$= \frac{1}{2}(2m+np^2+np) + \frac{1}{\sqrt{(p+1)^{n-1}+(p+1)^{n-1}+(p+1)^{n-1}(p+1)^{n-1}}}$$

$$= \frac{(2m+np^2+np)}{2\sqrt{(p+1)^{n-1}\left[2+(p+1)^{n-1}\right]}}.$$

(ii) $$PGOD(H) = \sum_{uv\in E(H)} \frac{1}{\sqrt{(d_d(u)+d_d(v))(d_d(u)d_d(v))}}$$

$$= \frac{1}{2}(2m+np^2+np)\frac{1}{\sqrt{\left[(p+1)^{n-1}+(p+1)^{n-1}\right](p+1)^{n-1}(p+1)^{n-1}}}$$

$$= \frac{(2m + np^2 + np)}{2\sqrt{2(p+1)^{3(n-1)}}}.$$

In the following theorem, by using definitions, we obtain the sum and product connectivity Gourava domination exponentials of *H*.

Theorem 6. The sum and product connectivity Gourava domination exponentials of *H* are given by

(i) $$SGOD(H,x) = \frac{1}{2}(2m + np^2 + np)x^{=\frac{1}{\sqrt{(p+1)^{n-1}\left[2+(p+1)^{n-1}\right]}}}.$$

(ii) $$PGOD(H,x) = \frac{1}{2}(2m + np^2 + np)x^{\frac{1}{\sqrt{2(p+1)^{3(n-1)}}}}.$$

V. Results for B_n

The book graph B_n, $n\geq3$, is a cartesian product of star S_{n+1} and path P_2.

For B_n, $n\geq3$, we have

$d_d(u) = 3$, if *u* is the center vertex,

$= 2^{n-1}+1$, otherwise.

Theorem 7. If B_n, $n\geq3$, is a book graph, then

(i) $$SGOD(B_n) = \frac{1}{\sqrt{15}} + \frac{2n}{\sqrt{(7+4\times2^{n-1})}} + \frac{n}{\sqrt{(2^{n-1}+1)(2^{n-1}+3)}}.$$

(ii) $$PGOD(B_n) = \frac{1}{\sqrt{54}} + \frac{2n}{\sqrt{3(2^{n-1}+4)(2^{n-1}+1)}} + \frac{n}{\sqrt{2(2^{n-1}+1)^3}}.$$

Proof: In B_n, there are three types of edges as follow:

$E_1 = \{uv \in E(B_n) \mid d_d(u)=d_d(v)=3\}$, $|E_1| = 1$.

$E_2 = \{uv \in E(B_n) \mid d_d(u) = 3, d_d(v)= 2^{n-1}+1\}$, $|E_2| = 2r$.

$E_3 = \{uv \in E(B_n) \mid d_d(u) = d_d(v)= 2^{n-1}+1\}$, $|E_3| = r$.

(i) By definition, we have

$$SGOD(B_n) = \sum_{uv\in E(B_n)} \frac{1}{\sqrt{d_d(u)+d_d(v)+d_d(u)d_d(v)}}$$

$$= \frac{1}{\sqrt{[3+3+(3\times3)]}} + \frac{2n}{\sqrt{[3+(2^{n-1}+1)+3(2^{n-1}+1)]}}$$

$$+ \frac{n}{\sqrt{[(2^{n-1}+1)+(2^{n-1}+1)+(2^{n-1}+1)(2^{n-1}+1)]}}$$

$$=\frac{1}{\sqrt{15}}+\frac{2n}{\sqrt{\left(7+4\times 2^{n-1}\right)}}+\frac{n}{\sqrt{\left(2^{n-1}+1\right)\left(2^{n-1}+3\right)}}.$$

(ii) By definition, we have

$$PGOD\left(B_n\right)=\sum_{uv\in E\left(B_n\right)}\frac{1}{\sqrt{\left(d_d(u)+d_d(v)\right)\left(d_d(u)\,d_d(v)\right)}}$$

$$=\frac{1}{\sqrt{\left[(3+3)(3\times 3)\right]}}+\frac{2n}{\sqrt{\left[\left(3+\left(2^{n-1}+1\right)\right)3\left(2^{n-1}+1\right)\right]}}$$

$$+\frac{n}{\sqrt{\left(\left(2^{n-1}+1\right)+\left(2^{n-1}+1\right)\right)\left(2^{n-1}+1\right)\left(2^{n-1}+1\right)}}$$

$$=\frac{1}{\sqrt{54}}+\frac{2n}{\sqrt{3\left(2^{n-1}+4\right)\left(2^{n-1}+1\right)}}+\frac{n}{\sqrt{2\left(2^{n-1}+1\right)^3}}.$$

In the following theorem, by using definitions, we obtain the sum and product connectivity Gourava domination exponentials of B_n.

Theorem 8. The sum and product connectivity Gourava domination exponentials of B_n are given by

(i) $$SGOD\left(B_n,x\right)=x^{\frac{1}{\sqrt{15}}}+2nx^{\frac{1}{\sqrt{\left(7+4\times 2^{n-1}\right)}}}+nx^{\frac{1}{\sqrt{\left(2^{n-1}+1\right)\left(2^{n-1}+3\right)}}}.$$

(ii) $$PGOD\left(B_n,x\right)=x^{\frac{1}{\sqrt{54}}}+2nx^{\frac{1}{\sqrt{3\left(2^{n-1}+4\right)\left(2^{n-1}+1\right)}}}+nx^{\frac{1}{\sqrt{2\left(2^{n-1}+1\right)^3}}}.$$

VI. CONCLUSION

In this study, we have defined the sum and product connectivity Gourava domination indices and their corresponding exponentials of a graph. Also the sum and product connectivity Gourava domination indices and their corresponding exponentials of some standard graphs, windmill graphs, book graphs are computed.

REFERENCES

[1]. V.R.Kulli, College Graph Theory, Vishwa International Publications, Gulbarga, India (2012).
[2]. V.R.Kulli, Theory of Domination in Graphs, Vishwa International Publications, Gulbarga, India (2010).
[3]. V.R.Kulli, Gourava Sombor indices, International Journal of Engineering Sciences and Research Technology, 11(11) (2022) 29-38.
[4]. V.R.Kulli, Gourava Nirmala indices of certain nanostructures, International Journal of Mathematical Archive, 14(2) (2023) 1-9.
[5]. V.R.Kulli, G.N.Adithya and N.D.Soner, Gourava indices of certain windmill graphs, International Journal of Mathematics Trends and Technology, 68(9) (2022) 51-59
[6]. A.M.Hanan Ahmed, A.Alwardi and M.Ruby Salestina, On domination topological indices of graphs, International Journal of Analysis and Applications, 19(1) (2021) 47-64.
[7]. V.R.Kulli, Gourava domination indices of graphs, International Journal of Mathematics and Computer Research, 11(8) (2023) 3680-3684.
[8]. S.Raju, Puttuswamy and A.Alsinai, Different type’s domination topological indices of some chemical drugs graph, Eur. Chem. Bull. 12(5) (2023) 4334-4345.
[9]. V.R.Kulli, Domination Nirmala indices of graphs, International Journal of Mathematics and Computer Research, 11(6) (2023) 3497-3502.
[10]. V.R.Kulli, Multiplicative domination Nirmala indices of graphs, International Journal of Mathematics And its Applications, 11(3) (2023) 11-20.
[11]. V.R.Kullli, Domination Dharwad indices of graphs, submitted.
[12]. V.R.Kulli, Domination product connectivity indices of graphs, Annals of Pure and Applied Mathematics, 27(2) (2023) 73-78.
[13]. V.R.Kulli, Domination augmented Banhatti, domination augmented Banhatti sum indices of certain chemical drugs, International Journal of Mathematics and Computer Research, 11(7) (2023) 3558-3564.

[14]. V.R.Kulli, Domination atom bond sum connectivity indices of certain nanostructures, International Journal of Engineering sciences and Research Technology, 11(7) (2023).
[15]. V.R.Kulli, Irregularity domination Nirmala and domination Sombor indices of certain drugs, International Journal of Mathematical Archive, 14(8) (2023) 1-7.
[16]. A.A.Shashidhar. H.Ahmed, N.D.Soner and M.Cancan, Domination version: Sombor index of graphs and its significance in predicting physicochemical properties of butane derivatives, Eurasian Chemical Communications,5 (2023) 91-102.
[17]. B.Basavanagoud, V.R.Kulli and V.V.Teli, Equitable dominating graph, International Journal of Mathematical Sciences and Engineering Applications, 9(2) (2015) 109-114.
[18]. V.R.Kulli and B.Janakiram, The block nonsplit domination number of a graph, International Journal of Management of Systems, 20(2004) 219-228.
[19]. V.R.Kulli and R.R.Iyer, The total minimal dominating graph, Advances in Domination Theory-I, (2012) 121-126.
[20]. V.R.Kulli, The disjoint total domination number of a graph, Annals of Pure and Applied Mathematics, 11(2) (2016) 33-38.
[21]. V.R.Kulli, Inverse and disjoint secure dominating sets in graphs, International Journal of Mathematical Archive, 7(8) (2016) 13-17.
[22]. V.R.Kulli, On entire domination transformation graphs and fuzzy transformation graphs, International Journal of Fuzzy Mathematical Archive, 8(1) (2015) 43-49.
[23]. V.R.Kulli and N.D.Soner, The connected total domination number of a graph, Journal of Analysis and Computation, 2(2) (2006) 183-189.
[24]. V.R.Kulli, Inverse and disjoint restrained domination in graphs, International Journal of Fuzzy Mathematical Archive, 11(1) (2016) 9-15.