JOURNAL OF CONTEMPORARY SOUTH ASIA
Vol. 1, No. 2, 2025, pp. 201-224 • ISSN: 3107-5517

URL: www.arfjournals.com
https://doi.org/10.47509/JCSA.2025.v01i02.05

Prevalence and Factors Associated with Anaemia among Rural Women and Children in the Desertified and Degraded Districts of India

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To Cite this Article

Manikandan A.D. & Sayeed Unisa (2025). Prevalence and Factors Associated with Anaemia among RuralWomen and Children in the Desertified and Degraded Districts of India. *Journal of Contemporary South Asia,* 1: 2, pp. 201-224.

Abstract: We conducted a study on the association between the extent of land degradation and the prevalence of anaemia among women and children in 75 dryland and non-dryland districts in India. Statistical tools like multiple linear regression were applied. The regression results clearly showed that land degradation had a significant effect on the prevalence of anaemia among rural women aged between 15 and 49 years (Beta = .416, $p<.05$) and children aged between 6 and 59 months (Beta = .254, $p<.05$) in drylands. Likewise, land degradation had a significant effect on the prevalence of anaemia among women (Beta = .343, $p<.05$) and children (Beta = .387, $p<.05$) in non-drylands.

Keywords: Anaemia, Women, Children, Degradation, Desertification

Introduction

Aldo Leopold introduced the seminal concept of *Land health* and defined *it* as 'the capacity of the land for self-renewal' (Leopold, 1989). In wake of growing land degradations concerns over the threat to the health of land and the human health are being widely discussed. Land degradation is commonly understood as the outcome of the set of processes that lower the current and potential capability of the land to produce (quantitatively or qualitatively) goods and services (Food and Agriculture Organisation, 2008). Deforestation, commercialisation of agriculture, lack of soil

Received : 10 November 2025 • **Revised :** 08 December 2025 • **Accepted :** 13 December 2025 • **Published :** 30 December 2025

and water conservation, soil erosion, exploitation of groundwater, and unsustainable waste management are the major contributors to the land degradation. Scholes *et al.* (2018) noted that 75% of the earth's lands are degraded, affecting roughly 3 billion people. It can make a substantial negative implications on livelihood, food supply, availability of the safe drinking water, nutrition, conservation of nature, sustainable development and mitigating and adapting to climate change (Lal, 2009; Laban *et al.* 2015; Food and Agriculture Organization, 2015). The economic cost of land degradation accounts billions of U.S. dollars per year (Nkonya *et al.* 2016; Food and Agriculture Organization, 2018). It undermines the overall growth and development of the world in general and third world countries in particular. Least developed countries (LDCs) like the Sub Saharan countries are more likely to be affected by land degradation and its adverse effects on environment, economy and wellbeing.

Land degradation in drylands (arid, semiarid and dry sub-humid areas) is called desertification (Darkoh, 2003). The term desertification was first used by Lavauden in 1927 to portray the severely overgrazed land (Dregne, 2000), and was thereafter popularized by Andre Aubreville (1949), a French botanist, who used it to describe the transformation of productive agriculture land in the northern Africa into desert - like, uncultivable fallow land. However, it is to be understood that desertification has a different meaning from "desertation" (the formation of desert) (Kertesz, 2009). Degradation of Land in non-drylands (humid, per-humid and moist sub-humid areas) is generally called the Land Degradation. About 41% of the earth's land areas are drylands, providing living space to 34% of the world's total population- roughly two billion people (World Ecology Report, 2009). Number of people living in drylands are likely to be increased upto 3 to 4 billion by 2050. Desertification can have far-reaching impact on human race in general and rural poorest of poor in particular.

Agriculture land, including forests in both dryland and non-dryland areas have been experiencing severe degradation. This land covers one-fourths of the world's total land and accounts for 95% of all animal, plant protein and 99% calories consumed by people (Global Environment Facility, 2009). Moreover, agricultural land degradation in both drylands and non drylands impacts nutrition and health adversely in three ways: i) agriculture land degradation adversely affects the income and quality of food intake of people depending on cultivation, resulting in nutrition deficiency; ii) land degradation reduces quality of soil, air, water, vegetation and other ecological goods and services- those who consume such low quality ecological goods and services will more likely to be diseased; and iii) land degradation which increases the risk of infections due to low vegetation cover also heightens the risk of anaemia among malnourished people. Women and children belonging to poor, poorest of poor, marginal and small farmers and other socially weaker sections are more likely to be affected by land degradation. Studies have shown the links between malnutrition and anaemia among women and children (Olivares *et al*. 1999; Osorio 2002; Kotecha, 2011; World Health Organization, 2017); land degradation and malnutrition (Karlen and Rice, 2015) and also low vegetation cover and infectious diseases such as malaria and yellow fever (Barrow, 1991). It is, thus, logical to say that desertification and land degradation have a strong effect on anaemia among women and children. While India's about 30% of total geographical area (TGA) is undergoing severe land degradation and more than two-fourths of women and children are suffering from anemia, a study on the association between land degradation and anaemia among women and children in drylands and non-drylands assumes much significance.

Conceptual framework

Land degradation in both drylands and non-drylands caused by natural and human activities such as commercialisation of agriculture, climate change, soil erosion, deforestation, industrial waste, over exploitation of ground water, urbanization, land pollution etc., can have far reaching impact on the human health. Figure 1 shows that land degradation has a substantial adverse impacts on human health; particularly, it affects the health condition of rural people who depending on degraded land fall victim for anaemia through hidden hunger, infection, malnutrition, inadequate food intake, low healthcare for mothers and children, low maternal schooling, high workload for women through fetching water and collection of firewood, and gender and community violences. In its severe form, land degradation induced anaemia increases the risk for morbidity, mortality and disability among women and children in both drylands and non-drylands.

Methods

Data sources

Districtwise data of the land degradation extent were collected from the *Desertification and Land Degradation Atlas of Selected Districts of India (Based on IRS LISS III data of*

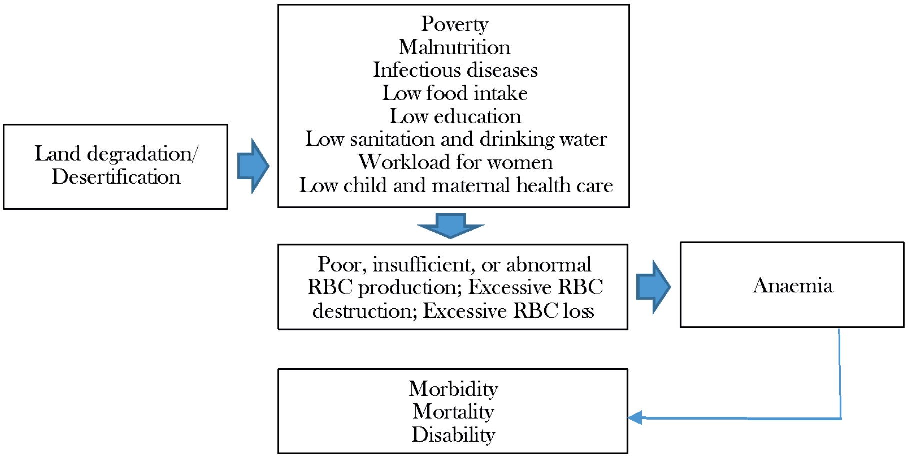


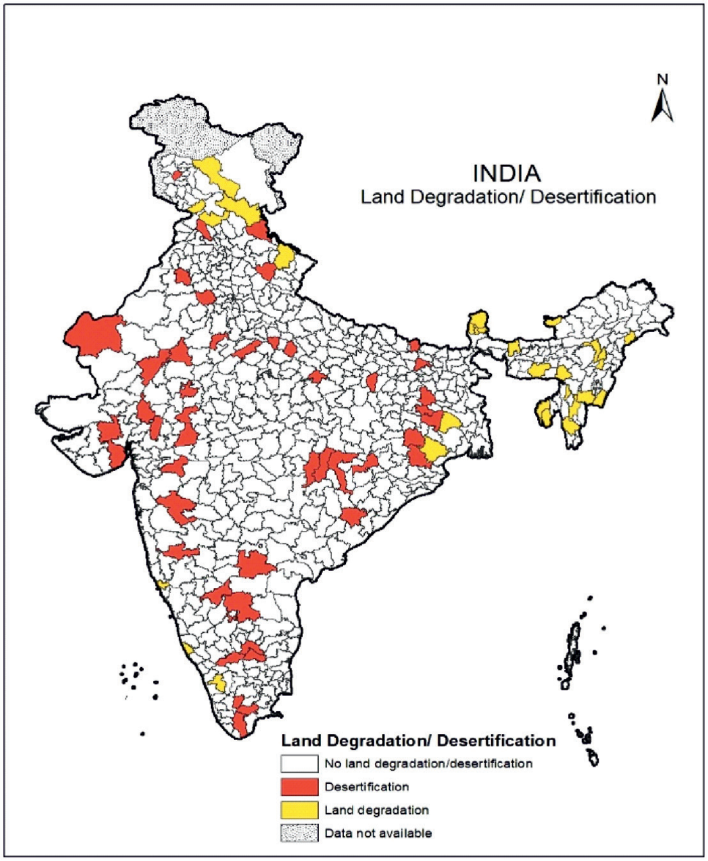
Figure 1: Association of land degradation and anaemia and its human health effects among women and children in rural areas

Source: Adapted from the United Nations Convention to Combat Desertification (2014); The United States Agency for International Development (2013); and Balarajan *et al.* (2012).

2011-13 and 2003-05), Volume-2, 2018 prepared by Space Applications Centre (SAC), Indian Space Research Organisation (ISRO), Ahmedabad under the Department of Space, Government of India. Multi-temporal digital IRS LISS III data, ancillary information, collateral data and forest cover layer of Forest Survey of India (FSI) were used to prepare districtwise data of the desertification and land degradation. Besides, limited field data was also used to support image interpretation (Space Applications Centre 2016, 2018). Many organisations have given districtwise data of the extent of land degradation in India namely, National Bureau of Soil Survey and Land Use Policy (NBSS &LUP) and Soil and Land Use Survey of India. However, we used land degradation data published by SAC for the following reasons: i) SAC is one of the distinguished institutions; and ii) SAC has given districtwise extent of land degradation data of two different periods 2003-05 and 2011-13. Districtwise data of agroclimatic zones were collected from the *District Database of Agricultural Statistics: A Database Management System* published by Raju *et al.* (2014), CRIDA a premier research institution under Indian Council of Agricultural Research, Government of India. We also used *National Family Health Survey 2015-2016* (NFHS 4), a nationally representative data, conducted by International Institute for Population Sciences IIPS) under the stewardship of the Ministry of Health and Family Welfare, Government of India.

Selection of the districts

The Space Applications Centre Ahmedabad has prepared the desertification and land degradation atlas of 76 districts and two sub-basins (Nubra and Shyok, Leh district) in India. These districts and two sub-basins have been selected from all the states based on the lists of districts identified as drought prone districts under the Drought Prone Areas Programme (DPAP) by the Department of Land Resources, the Union Ministry of Rural Development (MoRD), Government of India (GoI) and the concerned state departments/academic institutions. From this atlas, we omitted Pathankot district and two sub-basins due to lack of data in the NFHS 2015-16. The Union Territories (UTs) were also removed from the study due to lack of data in the report prepared by SAC. Thus a total of 75 districts from 29 states were included in the study (see Map 1).



Map 1: Selected desertified and degraded districts in India

Measuring desertification and land degradation

Land degradation can be divided into: physical, chemical and biological degradations. Physical degradation includes soil erosion caused by water and wind, loss of soil organic carbon (SOC), and change in physical structure of the soil (waterlogging and compaction).Chemical degradation suggests nutrient imbalances, leaching, salinisation, acidification, and fertility depletion. Biological degradation refers to the vegetation cover loss, loss of biodiversity, including soil organic matter (SOM), and rangeland degradation (von Braun *et al*. 2013; The Energy and Resources Institute 2018). Physical degradation by water and wind is the major category of land degradation in India in general and in the study areas in particular.

Extent of desertification and land degradation

About 96.5 million hectares (mha) of land currently undergo land degradation in India. Out of this, desertified and degraded areas are 82.6 mha and 13.8 mha, respectively (The Space Applications Centre, 2018). There are six climatic zones in India namely, arid, semiarid, dry sub-humid, humid, per-humid and moist sub-humid. The climate prevailing in each district was calculated using moisture index (MI). It is equal to average annual rainfall (P) minus average annual potential evapotranspiration (PET) divided by PET, multiplied by 100 (Raju *et al*. 2014). Accordingly, 75 districts were rearranged into 6 groups: arid districts, semiarid districts, dry subhumid districts, humid districts, per-humid districts, and moist sub-humid districts. The number of arid, semiarid, dry sub-humid, humid, per-humid, and moist sub-humid districts were 8, 21, 17, 9, 14, and 6, respectively. Then, arid, semiarid and dry sub-humid districts were grouped into one category i.e. drylands (desertified districts) whereas humid, per-humid and moist sub-humid districts were classified into another category: non-drylands (degraded districts). The number of dryland and non-dryland districts were 46 and 29, respectively (Table 1).

The extent of land degradation refers to the area of the mapping unit affected by land degradation i.e. the spatial extent. The extent of land degradation was divided into five groups: 0-5%, 5-10%, 10-25%, 25-50% and 50-100% (Bot, Nachtergaele and Young, 2000; Food and Agriculture Organization 2002). For the convenience of the study, the extent of land degradation was regrouped into three: 0-25% (low), 25-50% (medium) and 50-100% (high).

Table 1: Districtwise extent of land degradation in the desertified and degraded districts in India,%

S. No.	*Drylands*					*Non-drylands*				
		Extent of desertification (as percent of mapping unit affected)					*Extent of land degradation (as percent of mapping unit affected)*			
	States	*Low (0–25%)*	*Medium (25–50 %)*	*High (50–100 %)*	*Total districts*	*States*	*Low (0–25%)*	*Medium (25–50 %)*	*High (50–100 %)*	*Total districts*
1	Andhra Pradesh			Anantapur (64.41)	1	Arunachal Pradesh	Tirap (14.97)	Tawang (45.49)		2
2	Bihar	Sitamarhi (2.01), Samastipur (3.16)	Bhabua (31.70)		3	Assam	Kokrajhar (10.60), Golaghat, (15.80), Hailakandi (17.74)			3
3	Chhattisgarh	Durg (8.01), Rajnandgaon (10.73), Raipur (16.70)			3	Goa			North Goa (50.25)	1
4	Gujarat		Bhavnagar (35.64), Sabar Kantha (31.63),	Panch Mahals (52.07), Surendranagar (51.47)	4	Himachal Pradesh	Kangra (19.62)		Lahul & Spiti (80.54)	2
5	Haryana	Sirsa (10.34), Bhiwani (15.85)			2	Jammu & Kashmir		Kathua (48.69)	Kargil (78.23)	3
6	Himachal Pradesh			Kinnaur (72.33)	1	Kerala	Palakkad (7.50), Kasaragod (11.57),			2
7	Jammu & Kashmir		Badgam (37.16)		1	Manipur		Churachandpur (49.10), Chandel (33.98)		2
8	Jharkhand		Paschim Singhbum (46.49)	Giridih (73.79), Bokaro (67.25)	3	Meghalaya	Jaintia Hills (23.16)		West Khasi Hills (53.01)	2
9	Karnataka		Chamarajanagar (47.10), Bellary (41.88)		2	Mizoram		Lunglei (32.32)	Aizawal (52.83)	2
10	Madhya Pradesh	Ratlam (21.09)	Morena (35.73), Neemuch (34.63) Dhar (25.56)		4	Nagaland		Wokha (36.59)	Kohima (62.43)	2
11	Maharashtra		Sangli (45.81)	Dhule (64.20), Ahmednagar (56.50)	3	Odisha		Mayurbhanj (43.22)		4
12	Odisha			Bargarh (61.36), Koraput (55.35), Kendujhar (52.97)	3	Sikkim	North Sikkim (15.95), West Sikkim (15.95), South Sikkim (15.95), East Sikkim (15.95)			4

13	Punjab	Hoshiarpur (3.32)			1	Tripura		West Tripura (47.34), South Tripura (31.88)		2
14	Rajasthan	Dausa (23.93)	Pali (37.51), Ajmer (31.70)	Jailsalmer (92.96)	4	Uttarakhand		Chamoli (32.25)		2
15	Tamil Nadu	Virudhunagar (10.07), Thirunelveli (18.29)	Krishnagiri (48.05), Dharmapuri (44.00)	Theni (51.06)	5	West Bengal		Bankura (33.35)		2
16	Telangana		Mahabubnagar (25.79)		1					
17	Uttar Pradesh		Etawah (42.06), Chitrakoot (27.67), Kanpur (25.78)		3					
18	Uttarakhand	Pauri Garwal (5.08)			1					
19	West Bengal			Purulia (57.09)	1					
	Total	13	19	14	46		12	11	6	29

Source: Space Applications Centre, 2018 and Raju *et al.* 2014.

Note: * the extent of land degradation is classified into three groups based on Bot, Nachtergaele and Young (2000).

Table 2: Districtwise prevalence of anaemia among women aged 15–49 years in the desertified and degraded districts in India,%

S. No.	*Extent of desertification (as percent of mapping unit affected)*						*Extent of land degradation (as percent of mapping unit affected)*					
	Low (0–25%)		*Medium (25–50%)*		*High (50–100%)*		*Low (0–25%)*		*Medium (25–50%)*		*High (50–100%)*	
	Districts	*Women*	*Districts*	*Women*	*Districts*	*Women*	*Districts*	*Women*	*Districts*	*Women*	*Districts*	*Women*
1	*Hoshiarpur*	*59.7%*	*Badgam*	*67.7%*	*Kinnaur*	*80.8%*	*Kangra*	*61.4%*	*Kathua*	*37.3%*	*Kargil*	*75.0%*
2	*Garhwal*	*43.8%*	*Pali*	*49.6%*	*Jaisalmer*	*34.3%*	*North district*	*43.1%*	*Chamoli*	*36.7%*	*Lahul and Spiti*	*83.2%*
3	*Sirsa*	*60.4%*	*Ajmer*	*56.8%*	*Puruliya*	*80.6%*	*West district*	*37.4%*	*Tawang*	*44.0%*	*Kohima*	*27.4%*
4	*Bhiwani*	*64.3%*	*Etawah*	*26.6%*	*Giridih*	*69.9%*	*South district*	*31.1%*	*Wokha*	*37.0%*	*Aizawl*	*22.5%*
5	*Dausa*	*27.3%*	*Kanpur Dehat*	*63.1%*	*Bokaro*	*78.1%*	*East district*	*35.0%*	*Churachandpur*	*20.3%*	*West khasi hills*	*48.7%*
6	*Sitamarhi*	*61.1%*	*Chitrakoot*	*67.9%*	*Bargarh*	*69.2%*	*Tirap*	*47.5%*	*Chandel*	*21.9%*	*North Goa*	*31.6%*
7	*Samastipur*	*59.2%*	*Kaimur (Bhabua)*	*57.8%*	*Kendujhar*	*40.4%*	*Jaintia hills*	*47.7%*	*Lunglei*	*40.9%*		
8	*Rajnandgaon*	*44.5%*	*Pashchimi Singhbhum*	*75.4%*	*Koraput*	*67.6%*	*Kokrajhar*	*51.6%*	*West Tripura*	*54.2%*		
9	*Durg*	*51.0%*	*Morena*	*57.4%*	*Surendranagar*	*62.9%*	*Golaghat*	*46.5%*	*South Tripura*	*54.1%*		
10	*Raipur*	*52.3%*	*Neemuch*	*52.2%*	*Panchmahal*	*51.3%*	*Hailakandi*	*46.6%*	*Bankura*	*68.5%*		
11	*Ratlam*	*55.9%*	*Dhar*	*57.5%*	*Dhule*	*53.3%*	*Kasaragod*	*36.0%*	*Mayurbhanj*	*42.0%*		
12	*Virudhunagar*	*59.4%*	*Sabarkantha*	*68.6%*	*Ahmadnagar*	*44.8%*	*Palakkad*	*41.6%*				
13	*Tirunelveli*	*63.4%*	*Bhavnagar*	*54.2%*	*Anantapur*	*49.7%*						
14			*Sangli*	*49.3%*	*Theni*	*50.8%*						
15			*Mahbubnagar*	*51.1%*								
16			*Bellary*	*55.4%*								
17			*Chamarajanagar*	*42.6%*								
18			*Dharmapuri*	*61.7%*								
19			*Krishnagiri*	*47.4%*								
Total	*13*	*55.10%*	*19*	*55.40%*	*14*	*58.40%*	*12*	*46.50%*	*11*	*53.80%*	*6*	*40.70%*

Source: Space Applications Centre, 2018; Raju *et al.* 2014; and NFHS (2015-16).

Note: * the extent of land degradation is classified into three groups based on Bot, Nachtergaele and Young (2000).

Table 3: Districtwise prevalence of anaemia among children aged 6–59 months in the desertified and degraded districts in India,%

S. No.	*Extent of desertification (as percent of mapping unit affected)*						*Extent of land degradation (as percent of mapping unit affected)*					
	Low (0–25%)		*Medium (25–50%)*		*High (50–100%)*		*Low (0–25%)*		*Medium (25–50%)*		*High (50–100%)*	
	Districts	*Children*	*Districts*	*Children*	*Districts*	*Children*	*Districts*	*Children*	*Districts*	*Children*	*Districts*	*Children*
1	Hoshiarpur	66.5%	Badgam	74.7%	Kinnaur	75.3%	Kangra	64.5%	Kathua	40.0%	Kargil	73.5%
2	Garhwal	44.4%	Pali	49.5%	Jaisalmer	42.5%	North district	36.3%	Chamoli	42.9%	Lahul and Spiti	89.3%
3	Sirsa	71.0%	Ajmer	57.9%	Puruliya	83.1%	West district	36.7%	Tawang	44.0%	Kohima	36.9%
4	Bhiwani	64.6%	Etawah	38.8%	Giridih	72.9%	South district	40.3%	Wokha	49.3%	Aizawl	27.8%
5	Dausa	33.7%	Kanpur Dehat	70.8%	Bokaro	81.2%	East district	36.8%	Churachandpur	31.0%	West khasi hills	54.6%
6	Sitamarhi	61.9%	Chitrakoot	74.1%	Bargarh	66.0%	Tirap	45.0%	Chandel	25.1%	North Goa	28.5%
7	Samastipur	60.0%	Kaimur (Bhabua)	63.3%	Kendujhar	39.0%	Jaintia hills	53.2%	Lunglei	41.8%		
8	Rajnandgaon	47.6%	Pashchimi Singhbhum	74.8%	Koraput	70.1%	Kokrajhar	58.6%	West Tripura	49.5%		
9	Durg	52.1%	Morena	63.0%	Surendranagar	68.9%	Golaghat	47.8%	South Tripura	58.0%		
10	Raipur	57.7%	Neemuch	54.3%	Panchmahal	61.8%	Hailakandi	56.3%	Bankura	67.3%		
11	Ratlam	63.1%	Dhar	64.5%	Dhule	63.0%	Kasaragod	44.4%	Mayurbhanj	51.8%		
12	Virudhunagar	69.7%	Sabarkantha	70.4%	Ahmadnagar	53.0%	Palakkad	37.1%				
13	Tirunelveli	65.4%	Bhavnagar	50.9%	Anantapur	48.7%						
14			Sangli	50.4%	Theni	61.1%						
15			Mahbubnagar	42.5%								
16			Bellary	51.2%								
17			Chamarajanagar	42.5%								
18			Dharmapuri	60.5%								
19			Krishnagiri	49.9%								
Total	13	58.9%	19	57.6%	14	62.9%	12	49.2%	11	55.5%	6	46.6%

Source: Space Applications Centre, 2018; Raju *et al.* 2014; and NFHS (2015-16).

Note: * the extent of land degradation is classified into three groups based on Bot, Nachtergaele and Young (2000).

Sample size

After omitting missing values, a total of 59,460 women aged 15-49 years were selected from 75 degraded and desertified districts using women file NFHS 2015-16. Number of woman samples from desertified and degraded districts were 36,763 and 22,697, respectively. Likewise, a total of 18,569 children aged 6-59 months were selected from 75 degraded and desertified districts using kids file NFHS 2015-16. The sample sizes of children aged 6-59 months from desertified and degraded were 12,052 and 6,517, respectively.

Tools

Multiple linear regression (MLR) was applied using enter method to study factors independently associated with anaemia among rural women aged 15-49 years and children aged 6-59 months. The prevalence of anaemia was taken as a dependent variable and socioeconomic, demographic and health variables were taken as independent variables. A total of 4 multiple linear regressions were performed for women and children. Regression coefficients and statistical significance ($P<0.05$) were tabulated to present findings in the study (Osorio *et al*. 2004; Osorio *et al*. 2001).

Data analysis

National Family Health Survey 2015-16 was the first national health survey to have carried out at both state and district levels, with data of 601,509 households from 640 districts in India (Nguyen *et al*. 2018). First of all, 640 districts were divided into two groups: degraded districts (75) and non-degraded districts (565) using SAC's (2018) data that give districtwise extent of land degradation. Non-degraded districts were then omitted from the study. Degraded districts were further divided into two groups: desertified (drylands) districts and degraded (non drylands) districts using climatic zones data prepared by Raju and others (2014). Desertified (drylands) and degraded (non-drylands) districts were then divided into three groups: low, medium and high districts based on the extent of desertification and land degradation. We omitted urban samples of women and children from the study. We then removed missing values. Thus, a total of 59,460 women (15-49 years) and 18,617 children (6-59 months) were included in the final analysis. All analyses were conducted separately for women and children in low, medium and high districts of drylands and non-drylands. Statistical analyses were done with the statistical package IBM

SPSS Statistics, version 20. Statistical significance was taken as P≤0.05. Sampling weights were used in the analyses.

Results

The weighted prevalence of anaemia among rural women aged between 15 and 49 years in drylands and non-drylands was 56.2% and 49.8%, respectively. It was observed that anaemia among women was relatively high in drylands. Because of improved sanitation facility and schooling of mothers ≥5 years were low in drylands. Besides, poverty, household size (≥5) and low BMI (body mass index) were high in drylands compared with non-drylands (Table 4).

As per the extent of desertification, the prevalence of anaemia among women in low, medium and high desertified districts were 55.1%, 55.4% and 58.4% respectively (Table 2).The prevalence of anaemia remained a huge challenge for women in high desertified districts. As a result of improved sources of drinking water (77%), improved sanitation facility (28%) and schooling of mothers ≥5 years (55%) were relatively low. Besides, poverty (56.6%) and dependence on unclean cooking fuel like firewood (64.1%) were relatively high in high desertified district (Table 4). The prevalence of anaemia among rural women in low, medium and high degraded districts were 46.5%, 53.8%, and 40.7% respectively (Table 2). Medium degraded districts had more anaemic women as compared to low and high degraded districts due to poverty (67.4%) and high dependence on firewood (66.6%). Furthermore, the availability of improved sanitation facility (43.4%) and schooling of mothers ≥5 years (61%) were relatively low in medium degraded districts (Table 4).

The prevalence of anaemia among children aged between 6 and 59 months in drylands and non-drylands were 61.7% and 41.8%, respectively. The difference between these two areas was very high. Schooling of mothers ≤4 years, diarrhea, stunting, wasting and underweight were high in drylands (desertified districts) compared with non-drylands (degraded districts) due to maternal anaemia (Table 5). As per the extent of desertification, the prevalence of anaemia among children in low, medium and high desertified districts were 58.9%, 57.6%, and 62.9%, respectively (Table 3). It was found that high desertified districts had more anaemic children as the maternal anaemia (63%) wasting (24.5%) and underweight (43.1%) were relatively high in high desertified districts (Table5).The weighed prevalence of anaemia among children in low, medium and high degraded districts were 49.2%, 55.5%, and 46.6%, respectively (Table 3). Medium degraded districts had relatively

Table 4: Background characteristics and health status of women in desertified and degraded districts in India,%

S. No.	*Variables*	*Extent of desertification as percent of the mapping unit affected*				*Extent of land degradation, as percent of the mapping unit affected*			
		Low (0–25%)	*Medium (25–50%)*	*High (50–100%)*	*Total*	*Low (0–25%)*	*Medium (25–50%)*	*High (50–100%)*	*Total*
1	Improved sources of drinking water, yes	92.0%	85.1%	77.0%	84.9%	85.8%	87.3%	82.8%	86.4%
2	Improved toilet facility, yes	40.8%	36.4%	27.7%	35.2%	79.0%	43.4%	77.1%	61.3%
3	Sources of cooking fuel: firewood, yes	56.0%	58.3%	64.1%	59.3%	68.8%	66.6%	55.6%	67.1%
4	Religion: Hindu	91.0%	90.7%	92.4%	91.3%	68.5%	85.9%	36.3%	75.5%
5	Caste: SC/ST	32.9%	32.4%	41.9%	35.4%	24.5%	55.9%	66.3%	42.1%
6	Wealth index: poor = (poorest + poorer)	53.8%	46.3%	56.6%	51.8%	26.6%	67.4%	32.1%	47.0%
7	Household size: ≤ 4 ≥ 5	32.7% 67.3%	31.4% 68.6%	34.7% 65.3%	32.8% 67.2%	46.1% 53.9%	47.3% 52.7%	38.2% 61.8%	46.3% 53.7%
8	No. of HH having children < 5 years, yes	41.7%	39.7%	40.8%	40.6%	34.8%	36.1%	40.2%	35.7%
9	No. of ANC visits, yes	75.3%	81.2%	86.0%	80.6%	94.7%	93.3%	87.9%	93.6%
10	Age, years 15-19 20-29 30-39 40-49	 19.3% 34.2% 25.4% 21.2%	 17.7% 34.9% 26.2% 21.2%	 16.8% 34.8% 27.6% 20.7%	 18.0% 34.6% 26.4% 21.0%	 14.1% 32.3% 29.4% 24.2%	 16.1% 34.2% 27.2% 22.6%	 15.3% 31.5% 28.8% 24.4%	 15.1% 33.2% 28.3% 23.4%
11	Years of schooling: ≤ 4 ≥ 5	40.7% 59.3%	43.1% 56.9%	44.9% 55.1%	42.9% 57.1%	17.9% 82.1%	39.1% 60.9%	22.0% 78.0%	28.6% 71.4%
12	Any anaemia	55.1%	55.4%	58.4%	56.2%	46.5%	53.8%	40.7%	49.8%
13	Body mass index ≤18.49 18.5-24.99 ≥25.0	 26.5% 60.2% 13.2%	 27.7% 57.3% 14.9%	 33.2% 55.6% 11.0%	 29.0% 57.7% 13.2%	 18.1% 60.1% 21.7%	 27.3% 62.0% 10.7%	 15.2% 66.4% 18.4%	 22.5% 61.3% 16.1%

Source: Space Applications Centre, 2018; Raju *et al.* 2014; and NFHS (2015-16).

Note: * the extent of land degradation is classified into three groups based on Bot, Nachtergaele and Young (2000).

Table 5: Background characteristics and health status of children in desertified and degraded districts in India, %

S. No.	*Variables*	*Extent of desertification as percent of the mapping unit affected*				*Extent of land degradation, as percent of the mapping unit affected*			
		Low (0–25%)	*Medium (25–50%)*	*High (50–100%)*	*Total*	*Low (0–25%)*	*Medium (25–50%)*	*High (50–100%)*	*Total*
1	Improved sources of drinking water, yes	90.7%	81.4%	74.8%	82.7%	84.6%	84.4%	81.1%	84.3%
2	Maternal age, years								
	15-29	75.6%	77.2%	79.3%	77.3%	63.6%	76.7%	47.7%	69.1%
	30-49	24.4%	22.8%	20.7%	22.7%	36.4%	23.3%	52.3%	30.9%
3	Maternal schooling, years								
	≤4	47.3%	43.7%	41.1%	44.2%	20.2%	37.4%	28.3%	29.2%
	≥5	52.7%	56.3%	58.9%	55.8%	79.8%	62.6%	71.7%	70.8%
4	Maternal anaemia	58.9%	57.6%	62.9%	59.6%	49.2%	55.5%	46.6%	52.1%
5	Age, months								
	6-23	33.0%	33.3%	34.5%	33.5%	32.0%	31.9%	36.6%	32.2%
	24-42	35.0%	36.5%	34.9%	35.5%	35.6%	36.8%	33.7%	36.1%
	43-59	32.0%	30.3%	30.6%	31.0%	32.4%	31.3%	29.7%	31.7%
6	Gender								
	Male	49.7%	52.2%	52.1%	51.3%	52.3%	49.0%	51.2%	50.6%
	Female	50.3%	47.8%	47.9%	48.7%	47.7%	51.0%	48.8%	49.4%
7	Diarrhea over last two weeks, yes	9.2%	7.6%	7.7%	8.2%	5.4%	8.8%	5.5%	7.1%
9	Children anaemia	58.9%	57.6%	62.9%	59.6%	49.2%	55.5%	46.6%	52.1%
10	Birth weight (gram)								
	< 2500	12.1%	14.8%	16.3%	14.3%	13.1%	17.1%	9.3%	14.8%
	≥ 2500	60.9%	66.8%	68.2%	65.2%	73.5%	68.4%	62.4%	70.2%
	Other	27.1%	18.4%	15.5%	20.6%	13.3%	14.6%	28.4%	15.0%
11	Height-for-age (Z-score), stunting								
	< – 2	45.2%	43.4%	42.3%	43.7%	29.7%	36.3%	39.8%	33.6%
	≥ – 2	51.2%	51.5%	52.7%	51.7%	68.2%	60.8%	55.1%	63.6%
	Other	3.4%	4.3%	4.1%	3.9%	2.0%	2.5%	4.8%	2.4%

S. No.	*Variables*	*Extent of desertification as percent of the mapping unit affected*				*Extent of land degradation, as percent of the mapping unit affected*			
		Low (0–25%)	*Medium (25–50%)*	*High (50–100%)*	*Total*	*Low (0–25%)*	*Medium (25–50%)*	*High (50–100%)*	*Total*
12	Weight-for-height (Z-score), wasting								
	< – 2	16.6%	22.9%	24.5%	21.2%	12.3%	19.9%	12.0%	16.0%
	≥ - 2	79.8%	72.0%	70.6%	74.3%	85.6%	77.2%	82.8%	81.2%
	Other	3.4%	4.3%	4.1%	3.9%	2.0%	2.5%	4.8%	2.4%
13	Weight-for-age (Z-score), underweight								
	< – 2	37.7%	41.5%	43.1%	40.6%	23.2%	35.0%	24.7%	29.1%
	≥ - 2	58.7%	53.4%	51.9%	54.8%	74.7%	62.1%	70.2%	68.1%
	Other	3.4%	4.3%	4.1%	3.9%	2.0%	2.5%	4.8%	2.4%

Source: Space Applications Centre, 2018; Raju *et al.* 2014; and NFHS (2015-16).

Note: * the extent of land degradation is classified into three groups based on Bot, Nachtergaele and Young (2000).

high percentage of anaemic children due to diarrhea, wasting, underweight, schooling of mothers≤4 years. Maternal anaemia is also reported high in medium degraded districts, as compared to low and high degraded districts (Table 5).

Multiple linear regression (MLR) was performed to study how factors independently associated with anemia among women aged between 15-49 years in the desertified and degraded districts. An analysis of Table 6 made it clear that the two independent variables in the standard model are significantly predictive of the dependent variable Anemia to the ANOVA statistics [F(8, 37) = 2.691, p<.05]. In the standard regression analysis, the model's degree of predicting the dependent variable was found to be R = .606. The model's degree of explaining the variance in the independent variable was R^2 = .368. Looking at these coefficients, it may be said that the model predicts the dependent variable (any anemia) well. The absolute value of β (Beta) in Table 6 indicates the order of importance of the independent variables. The variable with the highest β value is relatively the most important independent variable. The standardized coefficients β showed that the prevalence of anemia among women aged between 15-49 years in the desertified districts was found to be significantly explained by desertification (β = .416, p<.05) and women eat meat / chicken occasionally (β = .593, p<.05). On examining the contributions made by the independent variables in the model, it was found that women eat meat or chicken occasionally (β = .593), followed by desertification have made the biggest

Table 6: Multiple linear regression result of anaemia among rural women aged 15–49 years and its explanatory variables (β-coefficients) in the desertified districts in India

Model 1	*Unstandardized Coefficients*		*Standardized Coefficients*	*T*	*Sig.*
	B	*Std. Error*	*Beta*		
(Constant)	518.70	187.775		2.762	.009
Desertification,%	.235	.106	.416	2.228	.032
Improved sources of drinking water,%	.389	.210	.363	1.853	.072
Maternal schooling≥5 years,%	-.165	.129	-.199	-1.285	.207
Women eat pulses/ beans daily,%	-5.099	1.905	-8.431	-2.677	.011
Women eat pulses/ beans weekly,%	-4.792	1.872	-6.013	-2.559	.015
Women eat pulses/beans occasionally,%	-5.815	2.063	-4.223	-2.818	.008
Women eat egg weekly,%	-.207	.095	-.361	-2.169	.037
Women eat chicken or meat occasionally,%	.363	.094	.593	3.847	.000
a. Dependent variable: any anaemia					

R = .606 R^2 = .368 F (8, 37) = 2.691, p = 0.019

contributions. Inadequate food intake seems to be one of the important causes of nutrition deficiency / anemia among women belonging to the desertified districts of India. Thus, women should eat food which contains haem and non haem iron, such as meat, egg, fish, cereals, beans, dark green leafy vegetables and lentils.

An analysis of Table 7 made it clear that the four independent variables in the standard model are significantly predictive of the dependent variable Anemia to the ANOVA statistics [$F(6, 22) = 3.298$, $p<.05$]. In the standard regression analysis, the model's degree of predicting the dependent variable was found to be $R = .688$. The model's degree of explaining the variance in the independent variable was $R^2 = .474$. Looking at these coefficients, it may be said that the model predicts the dependent variable (any anemia) well. The absolute value of β (Beta) in Table 7 indicates the order of importance of the independent variables. The variable with the highest β value is relatively the most important independent variable. The standardized coefficients β showed that the prevalence of anemia among women aged 15-49 years in the degraded districts was found to be significantly explained by land degradation ($\beta = .343$, $p<.05$), years of schooling (≤4) ($\beta = .357$, $p<.05$), women eat pulses or beans daily ($\beta = .502$, $p<.05$), and women eat meat or chicken occasionally ($\beta = .352$, $p<.05$). On examining the contributions made by the independent variables in the model, it was found that women eat pulses or beans daily ($\beta = .502$), followed by years of schooling, women eat meat occasionally and land degradation have made the biggest contribution. Inadequate food intake seems to be one of the important

Table 7: Multiple linear regression result of anaemia among rural women aged 15–49 years and its explanatory variables (β-coefficients) in the degraded districts in India

Model 1	*Unstandardized Coefficients*		*Standardized Coefficients*	*T*	*Sig.*
	B	*Std. Error*	*Beta*		
(Constant)	-24.993	17.668		-1.415	.171
Land degradation,%	.256	.122	.343	2.099	.047
Improved sources of drinking water,%	.181	.170	.196	1.068	.297
Years of schooling≤4,%	.381	.169	.357	2.249	.035
Women eat pulses or beans daily,%	.291	.122	.502	2.379	.026
Women eat chicken or meat occasionally,%	.328	.161	.352	2.041	.053
Women eat dark green leafy vegetables weekly,%	.288	.210	.257	1.371	.184
a. Dependent variable: any anaemia					

$R = .688$ $R^2 = .474$ $F(6, 22) = 3.298$, $p = 0.018$

causes of nutrition deficiency among women belonging to the degraded districts in India. Thus, women should eat food which contains haem and non haem iron, such as meat, egg, fish, cereals, beans, dark green leafy vegetables and lentils.

Multiple linear regression (MLR) was performed to study how factors independently associated with anemia among children aged between 6-59 months in the desertified and degraded districts. An analysis of Table 8 made it clear that the three independent variables in the standard model are significantly predictive of the dependent variable Anemia to the ANOVA statistics [$F(5, 38) = 6.085$, $p<.05$]. In the standard regression analysis, the model's degree of predicting the dependent variable was found to be $R = .667$. The model's degree of explaining the variance in the independent variable was $R^2 = .445$. Looking at these coefficients, it may be said that the model predicts the dependent variable (any anemia) well. The absolute value of β (Beta) in Table 8 indicates the order of importance of the explanatory variables. The variable with the highest β value is relatively the most important explanatory variable. The standardized coefficients β showed that the prevalence of anemia among children aged between 6-59 months in the desertified districts was found to be significantly explained by desertification ($\beta = .254$, $p<.05$), maternal schooling ≤4 years ($\beta = .924$, $p<.05$), and children eat food made from beans, peas, etc. ($\beta = .489$, $p<.05$). On examining the contributions made by the explanatory variables in the model, it was found that maternal schooling ($\beta = .924$), followed by consumption of food and desertification have made the largest contributions.

Table 8. Multiple linear regression result of anaemia among rural children aged 6–59 months and its explanatory variables (β-coefficients) in the desertified districts in India

Model 1	*Unstandardized Coefficients*		*Standardized Coefficients*	*T*	*Sig.*
	B	*Std. Error*	*Beta*		
(Constant)	49.089	5.086		9.651	.000
Desertification,%	.161	.079	.254	2.049	.047
Maternal schooling≤4 years,%	.548	.108	.924	5.058	.000
Wealth index: poor,%	-.288	.094	-.572	-3.069	.004
Children eat egg,%	-.326	.172	-.444	-1.901	.065
Children eat food made from beans, peas, etc,%	.576	.280	.489	2.056	.047
Dependent variable: any anaemia Jaisalmer and Kendujhar districts were excluded because of outliers.					

$R = .667$ $R^2 = .445$ $F(5, 38) = 6.085$, $p = 0.00$

An analysis of Table 9 made it clear that the two independent variables in the standard model are significantly predictive of the dependent variable Anemia to the ANOVA statistics [F(5, 23) = 2.483, p<.05]. In the standard regression analysis, the model's degree of predicting the dependent variable was found to be R = .592. The model's degree of explaining the variance in the independent variable was R^2 = .352. Looking at these coefficients, it may be said that the model predicts the dependent variable (any anemia) well. As noted, the absolute value of β (Beta) in Table 9 indicates the order of importance of the explanatory variables. The variable with the highest β value is relatively the most important explanatory variable. The standardized coefficients β clearly showed that the prevalence of anemia among children aged between 6-59 months in the degraded districts was found to be significantly explained by land degradation (β = .387, p<.05) and improved sources of drinking water (β = .509, p<.05). On examining the contributions made by the explanatory variables in the model, it was found that improved sources of drinking water (β = .509), followed by land degradation (β = .387) have made the largest contributions.

Table 9: Multiple linear regression result of anaemia among rural children aged 6–59 months and its explanatory variables (β-coefficients) in the degraded districts in India

Model 1	*Unstandardized Coefficients*		*Standardized Coefficients*	*t*	*Sig.*
	B	*Std. Error*	*Beta*		
(Constant)	-12.395	23.027		-.538	.596
Land degradation,%	.350	.164	.387	2.135	.044
Improved sources of drinking water,%	.539	.200	.509	2.691	.013
Diarrhea over last two weeks, yes, %	-.786	.650	-.214	-1.209	.239
Maternal age 15–29 years,%	.061	.290	.041	.211	.834
Maternal schooling ≤4 years,%	.112	.184	.110	.605	.551
a. Dependent variable: any anaemia					

R = .592 R^2 = .352 F (5, 23) = 2.483, p = 0.061

Discussion

Drylands accounts 70 percent of India's TGA. About 35 percent of drylands in India experiences land degradation (i.e. desertification) due to natural and human activities. Vegetation degradation and soil erosion are the main contributors to desertification of land. Physical degradation is yet another major problem in drylands in India.

India's dryland agriculture occupies 40 percent of India's total population and it also includes 60 percent of the livestock population and 69 percent of cultivated area. It produces 44 percent of food requirements. Thus, physical degradation in drylands can have a devastating impacts on the farm, non-farm and livestock based livelihood in rural dryland areas. Drylands are more susceptible to climate change and physical degradation. Besides, desertified areas undergo drought and weather aberration frequently, resulting in agrarian crisis. Thus, desertification increases the risk for poverty and push for forceful migration from drylands. According to the wealth index, the number of poor people (poorest + poorer) is high in desertified district compared with degraded district (Table 4). Desertification inflicted poverty increases risk of the likelihood of becoming sick or having ill- health which in turn is a potential factor for poverty. Women and children are the first to suffer from adverse consequences of poverty and illness in desertified districts (drylands). A combined effects of poverty, low education, unclean energy (e.g. firewood, dung and kerosene), increased workload (fetching water and collection of firewood) and inadequate consumption of fish or meat might have contributed to anaemia among women aged 15-49 years in rural desertified or dryland areas in India.

In India, women who cannot afford eating haem iron rich food items like meat or chicken and fish regularly will mainly depend on non haem and other sources like grains, green vegetables, lentils, nuts, seeds, dried fruits, pulses and beans for iron. The results of the study have clearly substantiated these correlations. In drylands, the prevalence of anaemia among women was found to be significantly but, negatively associated with consumption of pulses or beans daily, weekly or occasionally. However, the prevalence of anaemia was found to be significantly and positively associated with the consumption of meat or chicken occasionally. Those women who ate meat or chicken occasionally were more likely to be affected by iron deficiency anaemia (IDA). Among the associated factors of anaemia, egg consumption was negatively associated with anaemia among women in drylands. It is thus logical to say that inadequate haem iron intake in food is a major contributing factor of IDA among women in desertified districts or drylands in India.

Drylands are rain shadow regions, where drought is a common phenomenon. Thus, these regions are more exposed to production, price and income uncertainties, affecting land, labour, credit and input/output markets. This is why drylands are home to a large number of poor in India. Anaemia in such a context largely affects the cognitive and physical development of children, productivity of adults, and increase the risk of morbidity and mortality among children and women and, surgical patients too (World Health Organization and United Nations Children's Fund, 2004). The prevalence of anaemia among women and children in desertified areas will increase child and maternal mortality rates. Forest degradation and other fragile environmental factors also causes for bad child health and nutrition conditions in desertified areas. However, the association of poverty, morbidity, and mortality in desertified areas needs to be verified by more studies.

Soil erosion is one of the major causes of non-dryland degradation. Soil erosion induced by water and wind impacts the health of the soil adversely through removal of fertile topsoils or depth of the soils. It reduces the quality of the soil and its nutrient properties, affecting productivity and quality of food supply. Loss of productive properties of the soils by erosion is known as on-site effect. In non-drylands, the on-site effect induced by water erosion is the main cause of land degradation. Soil erosion also leads to off-site effect. Major consequences of off-site effects include flooding, sedimentation and pollution of waterbodies such as ponds, rivers, reservoirs, and lakes, and decreases in groundwater recharge. Both the on-site and off-site effects impact the human health adversely. The off-site effect leads to water pollution, which in turn, results in waterborne diseases. The on-site effect causes poor quality of food supply through reduced productive properties of the soils, which in turn, results in poor nutrient intake in food, leading to protein-energy malnutrition (PEM).

Conclusion

Land degradation and anaemia are man-made disasters to a larger extent. The association of these two variables is proven positive and significant. This association is a potential detrimental factor for good health and well-being in both drylands and non drylands. Therefore, the status and effects of desertification and land degradation are to be taken into consideration in the anti-anaemia programmes for women and children. The formulation of a specific policy to tackle land degradation inflicted anaemia in drylands and non-drylands is essential for eradicating anaemia and related health problems in rural India. Soil and water conservation and iron and folic acid supplementation programmes should be implemented in degraded and desertified districts on a war footing basis for improving the health and nutrition conditions of women and children. In order to enhance the theoretical and operational knowledge on desertification and land degradation inflicted anaemia among rural women and children, more studies have to be proposed and initiated.

Acknowledgements

This paper is derived from my Post-Doctoral Research work on "Exploring the association of land degradation and health outcomes in India" at the Department of Mathematical Demography and Statistics, International Institute for Population Sciences, Mumbai, India.

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