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# Editorial

*Research Management Cell at Rammani Multiple Campus stands at a crucial juncture in time. Higher academic institutions in Nepal and around the world face twin pressures to stay relevant – first, by conducting quality research and second, by preparing job-ready graduates. Since its establishment in 2045 B.S. Rammani Multiple Campus has made a marked contribution in the community by providing quality higher education in the fields of management, education, humanities and science. Now the challenge is to take it to the next level where Rammani graduates are competitive and highly sought after in the market. This is only possible if Rammani faculty are active in research and bring their research-informed expertise to classrooms and students.*

*Research Management Cell at Rammani is aware of the gravity of this situation and is committed towards getting more faculty involved in research, and increasing the quality of research output. The continuity of its journal – The Journal of Academic Development – and the publication of the current volume - Vol.7 No. 1 - on March, 2022 is a testament to this commitment. Being a multidisciplinary journal, it is organized with APA and MLA methods of references. The editorial team is not liable for the data/information, literatures and other materials used by authors in this journal.*

*The editors would like to thank all the scholars, authors, and readers for their valuable reviews, comments, and feedback for continual improvement of the journal.*

**March 2022**

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# POWER OF A SMILE: FACIAL AND EMOTIONAL EXPRESSIONS OF LEADERS AND ITS EFFECT ON LEADERSHIP PERCEPTIONS

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## ABSTRACT

L*eaders reflect their organizations, and vis-à-vis organizations are a reflection of their leaders. Leaders matter and what they do affects not only their organization, but also shapes individual's perceptions about the leader. What leaders say matters, but how they say it, their non-verbal communication, specifically their facial and emotional expressions, speaks volumes. However, research is fragmented and fails to provide clarity in documenting the relationship between non-verbal communication and leadership perceptions. Through a systematic review of findings, this article describes the current state of research on this important topic. Empirical articles from 2001 through 2021 are carefully analyzed to establish the relationship between leader facial and emotional expressions and its perceptual consequences on followers.*

**Key Words:** *Perceptions, facial expressions, emotions, non-verbal communication, leadership*

## INTRODUCTION

Dramatic facial and emotional displays of leaders are in chock full display in main stream media and social media sites, vying to cater excitement to their audience. From Donald Trump's signature grimace to Gordon Ramsay's vitriolic anger, from Warren Buffet's reassuring smile to Elon Musk's ambiguous smirk, leader non-verbal expressions are commonplace. Despite the plethora of anecdotal references to leader facial and emotional expressions, the consequences of their expressions are far less understood. Specifically, how leaders' non-verbal communications shape leadership perceptions of followers is unclear. Non-vocal aspects of communication (such as body language, facial expression, emotions etc.) as well as vocal aspects of communication (such as pitch, volume, speaking rate etc.) are included in this study of leader non-verbal communication.

Not all great leaders are great managers, and not all great managers are great leaders. Yet, leadership skills, specifically, the skill to communicate effectively, are relevant to anyone working with people, whether it's a leader or a manager. Considering these issues, in this study I take the approach that leadership and management go hand-in-hand, that they are merely two sides of the same coin. Therefore, when I talk about leaders, I implicitly assume they have managerial responsibilities to fulfill, and vice-versa.

## Leadership Non-Verbal Expression

Leadership is the ability to influence followers towards the realization and attainment of goals. Leaders, in their truest sense, are politicians who are able to negotiate the political processes necessary to help establish the significance of their organizations (Selznick, 1984). More specifically, leaders are individuals who are able to influence others through who they are (power, authority), what they say (vision, information), what they can do (offer reward, administer punishment), what they know (knowledge, expertise) and who they know (network, association) (French & Raven, 1959). Importantly, leaders' managerial ability is one of the factors that affect the growth of their organization (Penrose & Penrose, 2009). To grow, a firm needs competitive advantage, and the root to a firm's competitive advantage lies within its managerial and organizational processes, specifically how things are done in the firm (Teece et al., 1997). Therefore, organizational outcomes including performance levels are to some degree predicted by the background characteristics of its top executives (Hambrick & Mason, 1984). Needless to say, organizations need strong leadership and management to grow, and excel.

The most basic role of a leader is to articulate the vision of the organization clearly to their followers and motivate them to move past the status quo towards realizing the vision (Robbins & Judge, 2013). When it comes to communicating, leader verbal communication has its place, but leader non-verbal communication is equally significant if not more. Generally, more meaning is generated from non-verbal communication compared to verbal. It is agreed that we generate up to 65% of meaning from non-verbal communication (Guerrero & Floyd, 2006). Nonverbal communication includes vocal elements such as pitch, volume, and rate, referred to as paralanguage, and non-vocal elements such as gestures, facial expressions, and eye contact, referred to as body language. Among the variety of non-verbal communication techniques, facial expressions and emotions have a special significance. This is partly because our limbic brain automatically processes facial expressions and emotional cues to make sense of the situation, and readies a first impression - an unfiltered evaluation of what we actually think and feel. A leader's credibility is often assessed by their non-verbal communication, such as whether they are confident and poised or fidgety; whether they are maintaining eye contact or avoiding it. A message that is incongruent with the facial and emotional expression of the presenter is not only awkward, but lacks credibility. And possibly the least desirable thing for a leader is to be seen as someone lacking credibility. Non-verbal communication is generally involuntary or subconscious in nature, which means it can't be faked and is seen as having higher credibility (Argyle, 2013). Non-verbal communication can serve to reinforce verbal communication, for example frowning while sharing a depressing story. In some situations, non-verbal communication can be used as a substitute for verbal communication, for example maintaining eye contact to indicate attentiveness. Often, non-verbal communication can even contradict verbal communication, for example, smiling when sharing a gruesome detail. To summarize, non-verbal communication – grimace, frown, smile, grin, and laugh – can serve to enrich verbal

communication and make it much more meaningful if used well, and can even substitute for the verbal communication. However, if not used in a congruent manner, non-verbal communication can distort and create confusion.

### Leadership Perception

Perception is defined as a "process by which individuals organize and interpret their sensory impressions in order to give meaning to their environment" (Robbins & Judge, 2013). Leadership perception is the evaluation of a concerning situation and the judgment of the leader's response to the situation. As such, people observe and evaluate the ability and effectiveness of the leader's response to an evoking situation, and that becomes their reality about the leader. Emotions and non-verbal behavior of leaders and the influence they have on their followers are poignant social issues which are at the core of leadership perception. Facial expressions and emotional displays of leaders are socially important stimuli (Masters et al., 1986) with significant consequences. Facial expressions are commonly used to generate first impressions about individuals (Slepian & Carr, 2019). Specifically, leader's facial expression affects the emotional responses of followers (Trichas et al., 2017). Also, leaders' display of emotion is known to have a significant impact on subordinates who observe and interact with the leader (Titrek et al., 2014).

## RESEARCH ANALYSIS

Google Scholar (scholar.google.com) was used to search for empirical research articles from 2001 to 2021, spanning a period of two decades. The following combinations of keywords were used in search:

1. 'Leadership perception'
2. 'Affect' & 'leader perception'
3. 'Facial expression' & 'leaders'
4. 'Smile' & 'leaders'
5. 'Happy' & 'leaders'

Full-text articles that were accessible were used in the study. Unfortunately, most articles required institutional login to get access to full-text, which the author or the author's institution did not have. Only articles that were available freely were thus used in the study. This yielded a total of 10 empirical research articles, which are listed in Table 1. These articles are summarized next in chronological order.

**TABLE 1**: Studies on Leader Facial and Emotional Expression and Leadership Perceptions (2001-2021)

| **Author(s) (year)** | **Leader non-verbal communication** | **Study Design** | **Key constructs and outcomes** |
|---|---|---|---|
| Cherulnik et al. (2001) | Smile and visual attention to audience | Experiment with stimulus response | Followers were found to display positive facial expressions and emotions similar to their leaders while watching their leaders, aka the emotional contagion. |
| Newcombe and Ashkanasy (2002) | Facial affect (positive/negative) | Experiment with stimulus response | In leaders giving feedback (positive or negative), message-congruent leader affect resulted in positive perceptions of the leader among members. Message-incongruent leader affect (for example, positive feedback delivered angrily) was perceived negatively. |
| Van Kleef et al. (2010) | Facial display of anger, neutrality, happiness | Scenario based experiment | Participants responded more favorably towards an angry leader when participants were low on agreeableness. However, participants who were high on agreeableness responded better towards a leader who displayed emotional neutrality |
| Chi et al. (2011) | Positive mood (interested, enthusiastic, excited, proud, active) | Survey | Leader positive moods increased team performance directly, and indirectly. Specifically, leaders in positive moods engaged in transformational leadership activities, and were able to increase team performance through their actions. |
| Horiuchi et al. (2011) | Facial expression (smiling or not) | Archival data, correlational research | Candidate smile is significantly related to the share of votes they receive, independent of other factors such as participants' subjective evaluation of candidates' attributes. |

**TABLE 1** (continued)

| **Author(s) (year)** | **Leader non-verbal communication** | **Data source** | **Key constructs and outcomes** |
|---|---|---|---|
| Clegorne et al. (2014) | Facial expression (neutral, anger, fear, disgust, fear, joy, sadness, and surprise) | Experiment with multiple treatment groups | Leader's facial expression had some impact on participant's opinion of the leader and that facial expression and leadership factors were related. |
| Trichas et al. (2017) | Facial expression (happy vs. nervous emotions) | Experiment with stimulus response | Leader's expression of happy emotions resulted in higher ratings of leadership, and higher ratings of leadership traits and leadership perceptions in a problem-solving context. |
| Slepian and Carr (2019) | Variability in facial expressions (high/low and positive/negative) | Experiment with Amazon Mechanical Turk | High variability in emotional expression resulted in positive perceptions of authenticity, and influenced judgments of perceived happiness, trustworthiness, leadership, and team-member desirability. |
| Yun et al. (2020) | Anger intensity (intense/moderate/none) | Quasi-experiment | Perceptions of higher leader effectiveness found for leaders demonstrating no anger compared to leaders showing either moderate or intense anger. |
| Masch et al. (2021) | Displays of happiness | Case study with observational data | Among candidate characteristics, appearance was important during elections for electoral success. Smiling candidates who are also physically attractive were found to have positive election outcomes. |

**Charisma is Contagious: The Effect of Leader's Charisma on Observers' Affect** (Cherulnik et al., 2001). Authors were interested in studying the effect of leaders on followers, specifically whether followers imitated leader non-verbal behavior during interactions. Two experimental studies were conducted by authors - one where observers were made to watch a simulated campaign speech and another where observers watched actual televised speech of presidential candidate Bill Clinton and then-president George Bush during election debates. As observers watched the speeches, observer's behavior, specifically their non-verbal response, were also recorded. Observers were asked to evaluate whether the person shown was a charismatic or non-charismatic leader. Authors found that observers were found to display positive facial expressions and emotions similar to their leaders while watching charismatic leaders, i.e., there was the evidence of emotional contagion in observers from watching leaders.

**The Role of Affect and Affective Congruence in Perceptions of Leaders: An Experimental Study** (Newcombe & Ashkanasy, 2002). Authors were interested in studying how emotional exchanges by leaders influence followers' perceptions of the leaders. Specifically, authors hypothesize that leader's positive and congruent affect leads to higher ratings of the leader by the followers. The experimental setup consisted of 1-minute long video vignettes of supervisors giving feedback on performance. The video vignette was developed using professional actors, and showed the actor from head-to-shoulders. Vignettes varied in the type of feedback (positive or negative) and message-congruency (emotionally congruent or incongruent with the message). After viewing the video vignettes, participants completed ratings of the leader. Higher ratings signified a more positive relationship with the leader, and vice versa. From the experiment, authors found that in leaders giving feedback (positive or negative), message-congruent leader affect resulted in positive perceptions of the leader among members. Message-incongruent leader affect (for example, positive feedback delivered angrily) was perceived negatively.

**On Angry Leaders and Agreeable Followers: How Leader Emotion and Follower Personality Shape Motivation and Team Performance** (Van Kleef et al., 2010). Authors were interested in finding whether followers perform better when their leaders expressed anger or happiness. In an experimental setup, through random assignment participants saw a scenario about a company where the leader provided feedback on performance – either in an angry way (participants saw a visibly angry leader) or in a neutral way (participants saw a neutral leader) or in a happy way (participants saw a happy, cheerful leader). Agreeableness was measured using a 12-item instrument and administered on a 5-point Likert scale. Sample items include "I try to be courteous to everyone I meet," and "I generally try to be thoughtful and considerate." Follower performance was measured from team-based performance of the followers in a military command-and-control simulation game. Authors found from the experimental study that participants responded more favorably towards an angry leader when participants were low on agreeableness. However, participants who were high on agreeableness responded better towards a leader who displayed emotional

neutrality. Also, small teams (four-person teams) performed better when leader expressed anger and participants were low on agreeableness. For participants high on agreeableness, small teams performed better when participants were high on agreeableness.

**How Do Happy Leaders Enhance Team Success? The Mediating Roles of Transformational Leadership, Group Affective Tone, and Team Processes** (Chi et al., 2011). Authors were interested in understanding the relationship between leader positive moods and team performance. Sales teams from five insurance firms in Taiwan were used as sample for the survey based study. Leader's positive mood were obtained from the 10 positive mood descriptors from the Positive and Negative Affect Schedule (PANAS) which includes – attentive, active, alert, excited, enthusiastic, determined, inspired, proud, interested, and strong (Watson et al., 1988). Leaders were asked to respond to each PANAS item regarding how they had felt during team meetings during the last 2 weeks. Likert 5-point scale was used to record responses, with 1 (not at all) to 5 (extremely). Separately, team member's positive moods were also measured with the 10 positive mood items from the PANAS on a 5-point Likert scale. Transformational leadership was measured using a questionnaire which reflects the four primary components of transformational leadership – idealized influence, inspirational motivation, intellectual stimulation, and individualized consideration. Team members were asked to rate their leaders in the past two weeks on whether they exhibited transformational leadership characteristics, using a 5-point Likert scale. Structural equation modeling (SEM) technique was used for data analysis since the model is a mediation model. Authors found from the survey-based study that leader positive moods increased team performance directly, and indirectly. Specifically, leaders in positive moods engaged in transformational leadership activities, and were able to increase team performance through their actions.

**Should Candidates Smile to Win Elections? An Application of Automated Face Recognition Technology** (Horiuchi et al., 2012). Authors were interested in evaluating objectively the impact of facial expression of candidates on their election outcomes. To do this, authors developed a smile index of candidates in election of the Lower House in Japan and Australia using automated face recognition technology. The smile index produces a smile score, which ranges from 0 (no smile, 0%) to 1 (full smile, 100%). Smile index is used as an independent (causal) variable, and vote share of each candidate is used as the dependent (outcome) variable. Authors utilized ordinary least squares (OLS) regression analysis for their data analysis. From the analysis of election performance in Japanese and Australian contexts, authors found that that candidate smile is significantly related to the share of votes they receive, independent of other factors such as participants' subjective evaluation of candidates' attributes.

**The Effects of Affect: How Implicit Facial Expressions Impact Projections of Transformational Leadership** (Clegorne et al., 2014). Authors wanted to study whether facial expressions have an impact on participant's opinions of the leader. Also, authors wanted

to study whether human facial expressions and leadership (specifically transformational leadership) factors were related. In an experimental setup, authors utilized a trained actress to deliver audio/visual script using different facial and vocal effects. Facial expression of the actress ranged from – joy, surprise, fear, anger, disgust, sadness – to neutral facial expression. After watching and listening to the script from the actress, participants were asked to rate the actress, specifically, whether they would want to hire her as their boss. The responses were collected using a scale from 1 (very unlikely) to 6 (very likely). Authors concluded from the experimental study that leader's facial expression had some impact on participant's opinion of the leader and that facial expression and leadership factors were related.

**"Facing" Leaders: Facial Expression and Leadership Perception** (Trichas et al., 2017). Authors were interested in finding the effect of a leader's facial expressions of emotions and how that affects perceptions of leaderships and rating of leadership traits by followers. For the study, authors conducted experiment on employees of a large Cypriot bank. Half of the participants were shown video and photographs of a leader with a happy facial expression and the other half were shown video and photographs of a leader with a nervous facial expression. Participants were then asked to rate leadership perceptions of the specific individual, and also answer questions about actor's leadership attributes. Authors found through the experimental study that leader's expression of happy emotions resulted in higher ratings of leadership, and higher ratings of leadership traits and leadership perceptions in a problem-solving context.

**Facial Expressions of Authenticity: Emotion Variability Increases Judgments of Trustworthiness and Leadership** (Slepian & Carr, 2019). Authors were interested in figuring out how variability in facial emotion of individuals influenced their social evaluations by those observing them. To test this, authors created 41 different levels of facial expressions of each individual: 100% angry – neutral – 100% happy in increments of 5%. Authors did this by morphing of facial expressions of 6 individuals through graphic image manipulation. Participants were randomly assigned to both targets - target with high variability of facial expression and target with low variability of facial expression. Afterwards participants were asked to provide overall ratings of each target about how authentic, happy, powerful, and trust-worthy they seemed. Authors found that high variability in emotional expression resulted in positive perceptions of authenticity, and influenced judgments of perceived happiness, trustworthiness, leadership, and team-member desirability.

**Dimensions of Leader Anger Expression Unveiled: How Anger Intensity and Gender of Leader and Observer Affect Perceptions of Leadership Effectiveness and Status Conferral** (Yun et al., 2020). Authors sought to find out how leader anger in a situational response influenced the perceptions of leader effectiveness. Authors utilized an experimental setup for the study. A vignette was prepared using a male or a female leader responding to an anger-provoking situation at three anger levels - intense, moderate,

and neutral. The vignette was then read by participants, and asked to provide responses about leader perception. Leadership perception measure was a 4-item instrument for leader effectiveness. Participants rated leader effectiveness on a 7-point Likert scale. Study found that perceptions of leader effectiveness were higher for leaders demonstrating no anger compared to leaders showing either moderate or intense anger.

**Can a Beautiful Smile Win the Vote? The Role of Candidates' Physical Attractiveness and Facial Expressions in Elections** (Masch et al., 2021). Authors sought to examine whether candidates' attractiveness and facial expressions influences their election performance. For the study, authors utilized the 2017 German Federal election as a single case study supplemented with observational data. Dependent variable was the direct vote share for candidates in their electoral districts. Attractiveness data was found from the photographs of candidates, where coders rated the politician's physical attractiveness on a 7-point Likert scale, ranging from unattractive (0) to attractive (6). Displayed emotional expression was classified based on eight distinct emotional states - anger, contempt, disgust, fear, happiness, sadness, surprise, and neutral appearance. A portrait was evaluated for percentage of each emotional expression, with the total summing to 1 for each portrait. From the observational case study of candidate characteristics during elections, authors found that appearance is important for electoral success. Smiling candidates who were also physically attractive were found to have positive election outcomes.

## SYNTHESIS & DISCUSSION

Who is an effective leader is often a matter of perceptions. Leadership is based on followership, and manifested primarily through leader communication and interaction with followers. Although non-verbal communication conveys more meaning than verbal communication (Guerrero & Floyd, 2006), there is a dearth of cumulative understanding on how leader non-verbal communication affects leadership perception. In this study, I conducted a systematic review of empirical articles published in the last two decades to synthesize findings, and address knowledge gaps. Empirical research conducted over the past 20 years has yielded significant insights in the relationship between facial and emotional expressions of leaders and its effects on followers, and follower perception of leaders. Leader facial and emotional expressions have significant consequences which impact individual, team, and organizational outcomes. Researchers, for example, have shown empirically that leaders who displayed no anger, were seen as more effective leaders compared to leaders who displayed anger (Yun et al., 2020). This is significant, because it portrays effective leaders as those who are emotionally stable, and not those who get angry.

In actual election outcomes, positive leader facial expression was rewarded with higher support from followers compared to others who did not have positive facial expression (Horiuchi et al., 2012; Masch et al., 2021). Also, followers were found to imitate the expressions and emotions of their leaders, i.e. there was the presence of emotional contagion

on followers (Cherulnik et al., 2001). Theoretical work in leader-follower interaction confirms what has been found empirically. Specifically, what leaders do non-verbally, and emotionally, affects the response and attitude of followers. There is considerable support for the idea that leaders who are positive and authentic increase the wellbeing and positive attitudes in followers (Simmons, 2014). Leader emotional responses affect the relationship between the leader and followers. Dyadic-level emotional experience between leaders and followers results in a close-knit bond between them, which enabled a high quality relationship that is stable and trusting (Cropanzano et al., 2017). Most of the studies signified a positive relationship between leader facial or emotional experience and leader perception. Specifically, positive leader facial or emotional expression was related to higher perceptions of leader effectiveness or positive outcomes at the individual, group, or organizational level (Chi et al., 2011; Horiuchi et al., 2012; Masch et al., 2021; Trichas et al., 2017; Yun et al., 2020). One of the crucial caveats found in the review of empirical literature was that more than half of the studies employed experimental design, where actors role-played leaders, and followers were recruited participants responding to an artificially generated stimulus.

The experimental design is a proxy for a real exchange between leaders and followers. How well the proxy simulates a real exchange determines the accuracy of the results. Yet, the experimental design allows for measurement of relationships that are at best difficult to do with other methods, such as measures of perception, and therefore valuable on its own might.

## CONCLUSION

My objective in this paper was to provide a systematic overview of empirical research conducted in the past two decades, with a goal of clarifying the relationship between leader facial and emotional expression and follower attitude and perception of the leader. Leader's facial and emotional expressions convey important non-verbal message that is often more meaningful than the verbal message. Review of two decades of empirical research points to an underlying consensus – what leaders express with their faces and emotions holds significance in the eyes of the followers. Followers evaluate the effectiveness of leaders based on their perception of the leaders. Across the studies, followers were more likely to rate leaders who displayed positive facial expressions and positive emotions as more effective compared to those who displayed negative facial expressions and negative emotions.

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# DISASTER MANAGEMENT IN KAUTILIYA ARTHASHASTRA WITH SPECIAL EMPHASIS ON PANDEMICS AND THEIR TREATMENT

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## ABSTRACT

*Disasters are adverse events and misfortunes that occur as a bolt from the blue in the country. Disasters cause physical and mental sufferings to the people. Heavy loss of wealth and infrastructure happens within seconds. With a disaster death of people is another adverse event is that it can never be cured. Since, disasters are beyond human control, the only way to recover from a disaster is to provide immediate relief program to the sufferer and reduce the damage of wealth by helping people. In this connection it will be useful to know how the people used to manage disasters with their limited resources in ancient times. For this the related chapters from Kautiliya Arthashastra, a science of state administration, wealth and welfare, have been selected deliberately because this book describes the disasters and provides way to treat them one by one.*

**Key Words:** *Atharva-Veda,* Disaster, Duties of the Citizens, Evil spirit, Faith Healing, *Kantak,* Pandemic, *Peedan Warga, Stambha Warga, Upanipat, Vyasan*

**Kautiliya vocabulary used in this article:** *Amatya* - Secretary, *Dharma*- The righteous, *Gopa*- Administrator of 5 or 10 villages, *Janapada*- a district of four sections, *Kama*- Pleasure, *Mahakachchha*- God of Sea, *Nalikas*- Approximately 48 minutes, *Pana*- Common coin in Kautiliya Period, *Pradestr*- Coordinator of Central Disaster Management Committee, *Samahartr*- Administrator of Financial Section under *Pradestr*, *Sthanika*- Administrator of one fourth section of a *janapada*

**Names of thinkers cited by *Kautilya* for crisis management:** Bharadwaj, Kaunapadant, Parashar, Pishuna, Vatvyadhi, and Vishalaksha

## INTRODUCTION

Human society is facing natural disasters since time immemorial. All the natural adverse events become disaster if these occur in a high populated area because they cause heavy damages in populated areas. Physical structures, buildings, roads etc have to be reconstructed. But the foremost duty of a state is to provide relief to the people and recover their condition as soon as possible. Loss of family members brings psychology disorder in long run.

At present the whole world is suffering from an infectious viral disease known as Covid-19. All the national and international health institutions, Government officials, and social institutions are doing their best to save people from the disease. In this connection it would

be interesting to know how it was controlled in ancient times, when the resources were very limited. In this article treatment of a disaster in Kautiliya times has been discussed.

## OBJECTIVES

The objective of this paper is to provide policy tools for disaster management at present. Therefore this article analyzes the nature and treatment of various disasters in Maurya period found in Kautiliya Arthashastra. Since Kautilya has given method of the treatment of disasters like pandemics, diseases, flood, fire and other disasters, the study is thought to be useful in policy making at present pandemic hard times.

## METHODOLOGY

Kautiliya Arthashastra deals with the misfortunes and adversities of a country. According to Kautilya- *Vyasati enam iti Vyasan*- that is, which deprives a king is *vyasan.* The word *Kantak* means a thorn- a pain from inside, that is, the event that pains from inside the country is a thorn. Thus, calamities, in Kautiliya view, are pains within the country. He uses the two words for disaster management- *Vyasanadhikarik* to control the adversity and misfortune and *Kantakshodhanam*- quick relief action in a pain situation within the country.

Following two books have been selected for the detailed study of disaster management from Kautiliya Arthashastra:

1. Book Four *Vyasanadhikarik* (Remedy of an Adversity)
2. Book Eight *Kantak Shodhanam* (Pains from inside and action of throwing out)

The contents that have been analyzed are *Upanipat Prakarana* (Remedies during Calamities), of *Vyasanadhikarik and Peedan Warga, Stambha Warga* and *Kosh Sanga Warga* (Affliction, Hindrances, and Loss of Treasury sections) of *Kantakshodhanam*. References of other books of *Arthashastra* have been made wherever necessary. While studying the Kautiliya method of disaster management, the special emphasis has been given to control pandemics and diseases. Along with control of pandemics, efficient management and action of the government administration also has been discussed. For the analysis of this article and conclusion absolute method has been applied.

### Kautiliya Arthashastra

Although the Kautiliya Arthashastra is the original work of 4th century BCE by the author Kautilya or Vishnugupta Chanakya but it became popular only after Shamashastry, who discovered it from a Brahmin of Mysore in 1909 ACE and published after English translation. T Ganapatashstri translated and explained the original text into Sanskrit in 1924 ACE. Vachaspati Gairola translated it in Hindi in 1962 ACE. Kangle edited the Sanskrit text,

translated in English and wrote the commentary in 1960 ACE in three volumes. Nepalese translation was presented by Royal Nepal Academy at first in 1967 ACE.
The composition of the text at a glance is as follows:

**TABLE 1**: Books, Chapters and Sections

| Book | Heading | Chapters | Sections |
|---|---|---|---|
| One | Topic of Training | 21 | 18 |
| Two | Heads of Department | 36 | 56 |
| Three | The Book of Laws | 20 | 75 |
| Four | The Adversities | 13 | 88 |
| Five | Secret Conduct | 6 | 95 |
| Six | Circle of Kings | 2 | 97 |
| Seven | The Six Policies | 18 | 126 |
| Eight | Actions of Relief | 5 | 134 |
| Nine | Invasion | 7 | 146 |
| Ten | During War time | 6 | 159 |
| Eleven | Policy towards Oligarchies | 1 | 161 |
| Twelve | Policy of a Weak ruler | 5 | 170 |
| Thirteen | Policy of a Conqueror | 5 | 176 |
| Fourteen | Secret Practice | 4 | 179 |
| Fifteen | Methodology | 1 | 180 |

**A Disaster and Its Management**

A disaster is a major adverse event resulting from natural process within the country. Examples of disaster are storms, floods, tsunami, earthquakes, volcano, and fire. A natural disaster causes not only economic loss and infrastructure damages but also loss of lives. The severity of the disaster depends on the population density, and the nature of infrastructure. In case of public awareness, cooperation among the people and the efficient relief management the loss can be minimized but sometimes it can have serious physical and psychological consequences that can take years to repair.

In a Densely populated and unsafe area the disaster causes a heavy loss of people andhighly damage of private and government property. Examples are Kathmandu and Gorakha during the 2015 earthquake. The same type of disaster was happened in 1934 in eastern Nepal and Kathmandu. In the past there is a record of earthquake in 1255. Two moderate earthquakes happened in 1980 and 1988. Besides earthquakes Nepal is facing other types of disasters such as landslide, flood, thunderstorm, avalanche, fire, drought, famine, diseases and pandemic.

Before Malaria eradication, in 1975, Tarai of Nepal, especially the Rapti valley, was badly affected by the disease. In the history Nepal suffered from a serious flu pandemic in 1920sand with a famine in 1930s. According to WHO leading cause of death among children were Pneumonia, Diarrhea, and Malaria during 1970s.

The natural disaster influences other dimensions of the society. One interesting example is Malthusian Theory of Population. According to Malthus, generally population rises in a geometric progression and the subsistence grows in a slow arithmetic progression. Thus population growth crosses the subsistence very soon and the gap between subsistence and population becomes so imbalanced that death rates increases and thus nature itself makes balance between the population and subsistence. The process of population control of nature, according to Malthus, is known as positive check. Examples of positive checks, given by Malthus, are famines, epidemics, and wars (Malthus, 1798, Chapter 5).

**Seriousness of a Disaster Within the Country**

Before providing the relief of a disaster Kautilya examines the seriousness of an adversity on different constituent on its priority basis. Since Kautilya state is a giant mechanism of seven constituents- King (The ruler), Ministers (Government), Janapada (People), Fort, Treasury (Economic condition), Army (Force), and Allies (Foreign relations), therefore , he examines seriousness of the adversity on different constituent comparatively.

In his time there were two types views on the basis of importance of constituent of the government- Some teachers have said that of the calamities befalling the king, the ministers, the Janapada, the fort, the treasury, the army, and the ally, that which affects the one mentioned earlier in the order is more serious than that affecting one later. Other teachers, however, hold the view that a calamity of a constituent mentioned lower in order could sometimes be more serious than that of the one immediately preceding (Rangarajan, 1992, P. 122). After analyzing the views of the Acharyas prior to him Kautilya presents his views as follows:

**1. The King and The Ministers-** The word king or swami in ancient literature has been used as a symbol of sovereignty. According to Bharadwaja affliction on ministers is more serious than that of the king because the sovereign king depends mainly on ministers for his decisions, deliberation, implementations, revenue collection, meetings, government expenditure policies, enforcing order, defending the state from enemies, taking remedial measures. In the absence of ministers all the activities cannot be done properly. The king becomes like a bird with clipped wings. Kautilya disagrees with Bharadwaja. He says- The King appoints the ministers and high rank officials. In case of afflicted ministers, he can change with other good and efficient and capable ministers (Kautiliya Arthashastra II. 2003, 8.1.6-18).

**2. The Minister and The Janapada-** According to Vishalaksha, affliction on general public (Janapada) is more serious than that of ministers. If public suffers the economy, production, consumption, labourers, and other means of production also suffer. Poor economy will harm the government.
Kautilya partially agrees with Vishalaksha and says that all the state activities have their origin in the ministers, therefore, affliction on ministers is more serious than that of public. However the disaster of agriculture and food grain is more serious than the disaster of Forts (Kautiliya Arthashastra II. 2003, 8.1.19-23).

**3.The Janapada and The Forts-** In Kautiliya Arthashastra the Fort has been used in two senses- border security and fortified capital city. Parashara gives relatively more important to Fort by saying that the affliction on fortified city is more serious than one to the territory and the people outside the city.

Kautilya disagrees with the view and opines that the calamity of Janapada should be regarded as more serious than that of the Fort. However, when a country is inhabited mostly by agriculturists, the calamity befalling the fortified capital should be regarded as more serious, while if the country is inhabited mostly by fighters, the calamity of the country would be more serious (Kautiliya Arthashastra II. 2003, 8.1.32). It seems the difference lies in the presence or absence of martial qualities in the inhabitants. It cannot be supposed that a country of soldiers would be able to dispense with agriculture together. What Kautilya means is that when there are no martial people on land, the fort assumes a greater importance, while with martial people on land the importance of the fort is reduced (Kangle, 2006, P.167).

**4. The Fort and The Treasury-** The word Treasury has been is used in different senses in the Arthashastra text. In broad sense the prosperity of country is Treasury. In narrow sense it denotes the government's treasury. For example, when Kautilya says that all state activities depend on the Treasury we have to understand it as without wealth, there is no production or acquisition (Rangarajan, 1992, P. 255). The other meaning is an organ of the state when it is known as a *Saptanga.*

Kautilya presents the Pishun's view and gives his opinion in the following way- According to Pishun the affliction on the Treasury is more serious than that of the Fort because the capacity, resources and strength of a Fort depends on the prosperity of a country. Kautilya disagrees and says that a Fort has many uses. The Treasury is kept safe and the army is well protected in it. In the absence of a Fort, the Treasury will fall into the hands of enemies (Kautiliya Arthashastra II. 2003, 8.1-33, 40). Thus he is of the view that both are important for the country but the security of the Fort is more important.

**5. The Treasury and The Army-** Kaunapadanta gives relative importance to Army by saying that a calamities of Army is serious than that of the Treasury because the prosperity

of a country depends on security condition. The country well secured by The Army only can acquire prosperity. Kautilya disagrees with Kaunapadanta. He is of the view that it is the Army which is dependent on finance. If not paid the soldiers either go over to the enemy or kill the king. Thus finance is necessary to undertake any state endeavour and is the chief means for both right conduct (*Dharma*) and pleasure (*Kama*). Men, without wealth, do not attain their objects even with hundreds of efforts; objects are secured through objects, as elephants are through elephants set to catch them (Kautiliya Arthashastra II. 2003, 9.4.27).

**6. The Army and The Ally-** It is an interesting fact that ancient oriental thinkers have included allies as a constituent of the state mechanism because the country with a good foreign relation can prosper easily. Vatvyadhi gives high importance to the Ally by saying that a calamity of an Ally is more serious than that of the Army because an Ally helps without any payment. He also helps the King with money and army in difficult times.

Kautiliya disagrees with this view. He opines that when one has Army the Ally continues to be friendly and even an enemy becomes friend. However, when there is work that can be done equally well by his own Army and that of the Ally, the King should choose the appropriate instrument depending on the circumstances the time, the place and the nature of action and whichever is more profitable. But the king must remember that no Ally can be relied upon in cases of speedy expedition, internal rebellion or subduing jungle tribes. In case both the King and the enemy suffer from troubles or when the enemy grows stronger, an Ally only looks to his own interests and maintains the alliance only if it is profitable to him.

In short, Kautilya generally agrees with the accepted teaching that the disaster on a constituent higher in the order is more serious than that of affecting one lower. There are, however, some important qualifications. The relative importance of the countryside and the Forts depends on whether there is a population balance between the two. His opinion is that calamity to a weaker constituent is more serious one. Though the Treasury is nearly always more important, there may be circumstances when a threat to the Army should be considered more serious. Kings must also remember that five of the other six constituents, except the Ally, are domestic and hence under his control, Allies are not to be considered reliable in all circumstances.

**7. Relative Priority-** Since the major responsibility of a King is provide complete protection to the people therefore it's the duty of a ruler to save misfortunes of the country. A constituent element does not become totally useless just because it is affected. If it is partially affected the King should remove calamity using other constituents with their necessary capacity. If two elements are affected equally, they should be judged according to whether damage is increasing or decreasing, so long as neither of them affects any other element (Kautiliya Arthashastra II. 2003, 8.1.62).

When two elements are equally and simultaneously affected, that which is likely to sufferincreasing damage should be considered more serious. However, if the calamity to one element is likely to affect other elements, then that should be considered more serious (Rangarajan, 1992, P. 126).

Kautilya concludes by saying that the calamity should be removed one by one, in order of their importance; for, it is better that the ally remains in danger but not the army; likewise the army but not the treasury. If the constituent as a whole cannot be saved, at least parts shall be rescued, i.e., in the case of army, the more numerous or the more loyal troops shall be saved leaving out of sharp and the greedy; in the case of the treasury the most valuable or the most useful shall be saved. The least important or parts of constituents shall be saved by peace, inactivity or a dual policy and the most important by other means seeking help, preparing for or actually waging war (Kautiliya Arthashastra II. 2003, 9.7.46-50).

Lastly, a calamity which threatens to destroy all other elements shall be considered as the most serious, irrespective of what position the element affected occupies in the list of priorities (Kautiliya Arthashastra II. 2003, 8.1.62).

**Upanipatas and Their Treatment**

Kautilya uses the word Upanipat for a disaster. He defines Upanipat as follows- Upanipat means an unexpected adverse event. Kautilya divides disasters in eight parts- (Kautiliya Arthashastra II. 2003, 4.3.1):

1. Fire 2. Flood 3. Wild animals 4. Serpents 5. Rats
6. Famine 7. Evil spirits 8. Pandemic and Diseases

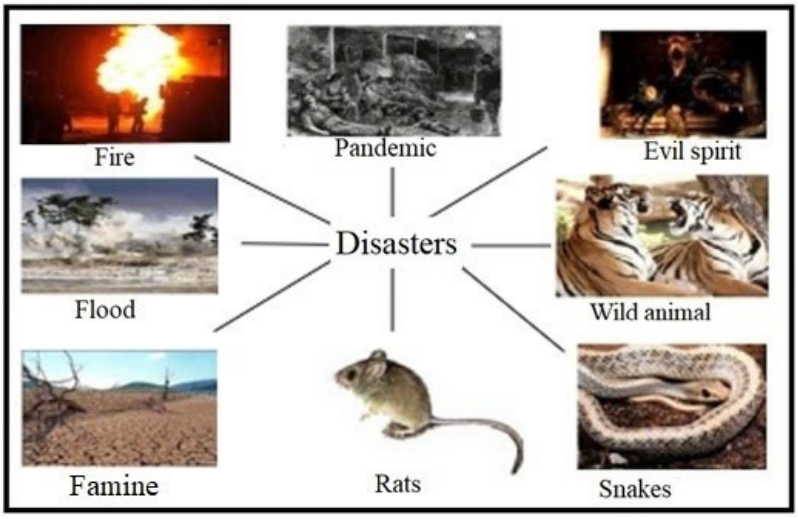


**FIGURE 1.** Types of Disasters

**1. Fire**

The main cause of fire, in Kautiliya Arthashastra, is considered to be cooking firewood in the city and villages. The remedial measures are given as follows (Kautiliya Arthashastra II. 2003,2.36.15-20):

1. Villagers shall do their cooking during the summer months outside their houses, that is fixed by the head of ten villages (Kautiliya Arthashastra II. 2003, 4.3.4).
2. They shall always have the ten firefighting implements (Kautiliya Arthashastra II. 2003, 4.3.3) as follows: water pots, a big jar, a trough, a ladder, an axe for chopping down pillars and beans, a winnowing basket for fanning away the fire, a hook for pulling away burning objects, a hooked rake for pulling away thatch and skin bag, and the cooking place mentioned above.
3. This is the responsibility of the municipal administration to control fire within his area.
4. The citizens shall take steps against an outbreak of fire in summer.
5. Rules of fire control near the crowded area and royal place is given in 1.20.4.

**2. Floods**

Flash floods are caused by rapid and excessive rainfall that raises water level quickly. Kautilya is of the view that the loss of the crops is a greater evil than the loss of sowing, as it involves loss of efforts (Kautiliya Arthashastra II. 2003, 8.2.25). Thus Kautilya wants to say that a short drought is less harmful than sudden flood.

Remedial measures of floods are as follows (Kautiliya Arthashastra II. 2003, 4.3.6-11):

1. During the rainy season, villagers living near river banks shall move to higher ground.
2. The villagers shall keep a collection of wooden planks, bamboo and boats with themselves.
3. Persons carried away by floods shall be rescued using gourds, skin bags, tree trunks, canoes, boats and thick ropes.
4. Persons learned in the Vedas and experts in occult practices shall use prayers and incantations against excessive rain.

**3. Famine**

Inadequate rain or a long draught is the main cause of famine. Since, draught involves loss of livelihood therefore draught is serious than excessive rain (Kautiliya Arthashastra II. 2003, 8.2.25).
The method of counteracting the effects of a famine are as follows (Kautiliya Arthashastra II. 2003, 4.3.12, 17-20):

1. Distribute to the public, on occasional terms, seeds and food from the royal stores.
2. Undertake food for work programs such as building forts or irrigation works.
3. Share out the royal food stocks.
4. Commandeer for public distribution private stocks of food (Rangarajan, 1992, P.130).
5. Seek the help of friendly kings.
6. Shift the affected population to a different region where irrigation facility is available.
7. Encourage temporary migration with King and Court to region of country with abundant harvest or near the sea, lakes or rivers.
8. Supplement the harvest with additional cultivation of grains, vegetables, roots and fruits, by fishing and by hunting deer, cattle, birds and wild animals.
9. Indra, the Ganges, the mountains and the Mahakaccha shall be worshipped in times of drought (Kautiliya Arthashastra II. 2003, 4.3.12).

**4. Rats, locust and other insects**

Although the disaster of rats and locusts is uncommon now a days but it was a common event in ancient times. These were the cause of multiple disasters such as diseases, epidemics and of course famines. Preventing measures and controlling them are given as follows (Kautiliya Arthashastra II. 2003, 4.3.21):

1. In case of danger from rats, locusts, birds or insects, the appropriate animals, for example- cats, mongoose, shall be let loose and these predators protected from being killed or harassed by dogs.
2. Poisoned grain may be strewn around.
3. The rat tax (a quota of dead rats to be brought in by each one) may be fixed.

**5. Wild animals**

Wild animals harms in certain region. Some attack on villagers, while others damages crops. Therefore they should be controlled by the government.
In case of violent attacks from a beast, crocodiles, herds of animals, or flocks of birds the following methods may be adopted (Kautiliya Arthashastra II. 2003, 4.3.28-30):

1. Leave poisoned carcasses of adult or young animals.
2. Get hunters and fowlers, hidden in pits or cages, to trap or kill them.
3. Armoured men, weapons in hand, should kill wild animals.

**6. Serpents**

Now a day serpents are one of the endangered species. But the Kautilya's discussion shows that in his times these were the cause of loss of lives in the countryside area.
The treatment of serpents given by him is as follows (Kautiliya Arthashastra II. 2003,

4.3.35-37)-

1. In case of danger from serpents, experts in poison cure should act with charms and medicines.
2. Persons coming together should kill snakes.
3. Experts in Atharva-Veda lore should use magic spells.

**7. Evil spirits**

In spite of the scientific fact that there is no existence of evil spirits, many people all over the world believe on its existence. Evil spirits are unidentified trouble. Kautiliya Arthashstra presents the treatment of evil spirits as follows (Kautiliya Arthashastra II. 2003, 4.3.40-41):

1. Experts in Atharva-Veda mantra[1] and in occult sciences who perform rites of exorcism.
2. The worship of Chaitya trees with offerings of raised platforms, umbrellas, food, small flags and goats.

**8. Diseases and Pandemics**

Disease broadly refers to any condition that impairs the normal functioning of the body. Commonly, the term is used to refer specifically to infectious diseases, which are clinically evident diseases that result from the presence of pathogenic microbial agents, including viruses, bacteria, fungi, protozoa, or other infections.

Pandemic is an epidemic of an infectious disease that has spread across a large region, for instance multiple continents or worldwide, affecting a substantial number of individuals. A widespread endemic disease with a stable number of infected individuals is not a pandemic. Widespread endemic diseases with a stable number of infected individuals such as recurrences of seasonal influenza are generally excluded as they occur simultaneously in large regions of the globe rather than being spread worldwide.

Throughout human history, there have been a number of pandemics of diseases such as smallpox, cholera, plague, malaria, flu, HIV/ AIDS and present COVID-19. The most fatal pandemic in recorded history was the Black Death- the Plague, which killed an estimated 75–200 million people in the 14th century.

Corona Virus Disease, COVID- 19 is a contagious disease caused by severe acute respiratory syndrome. The first known case was identified in Wuhan, China in December 2019. This disease has since spread worldwide, leading to an ongoing pandemic. The total number of deaths from this disease so far is 56 million. For the control of this virus hand wash, use

[1] Here Mantra indicates *Rakshoghna* Mantras and this Mantra is found in *Durga Shaptisati* also.

of face mask, social distancing, healthy diet, movement control, and self isolation methods is being adopted in all the countries. The hardest remedial measure was a long period lock down of 2020-21.

Kautilya refers the treatment for disease and pandemic in his time. These are as follows (Kautiliya Arthashastra II. 2003, 4.3.13-16):

1. Physicians should perform medicines, ascetics by *Shanti Mantras*, priests with expiatory rites and experts of magic counteract with occult means.
2. Making obligations to or organizing night festivals in honour of Gods, and burning of dummies are other methods of averting the danger of pandemics.
3. The king should go to take sacred bath, perform worship of *Mahakaccha* and milk cows in cremation ground.
4. In case of diseases or pandemics affecting cattle, lustration rites in connection with the objects sheds the special worship of the appropriate deities shall be performed.

**Relative Seriousness. Which of the disaster is more serious?**

Kautilya presents a comparative view of different teachers. According to him, some teachers say that fire is more serious than floods because destruction by fire is irremediable, consuming all; one can escape from floods and its damage can be alleviated. Kautilya however considers floods to be more dangerous because it destroys hundreds of villages while fire destroys one village, or a part of it.

The teachers prior to him say that diseases and pandemics are worse than famine, because pestilence brings all state activities to a stop with men falling ill and dying but during famine all work does not stop and it is still possible to collect revenue in gold or commodities or cattle.

Kautilya disagrees and says that pestilence usually devastates only a region of the country and remedies can be found for the disease. Famine, on the other hand, affects the whole country and deprives the people of their livelihood. The reasoning is, floods and famines, which affect agricultural production, the livelihood of people and state revenue are more serious than fire and disease, the effects of which tend to be more limited.

**General Preventions**

According to Kautilya, all types of disasters can be overcome by propitiating Gods and Brahmins. When there is drought or excessive rain or visitations of evil spirit, the rites prescribed in the Atharva Veda and those recommended by ascetics shall be performed.[2] Therefore, experts in occult practices and holy ascetics shall be honored and thus encouraged

[2] The *Roga Nivarana Sukta* is in 13th Sukta of Fourth Episode, *Krimi Nashak* (removal of virus and germs) Sukta is give in 31, 32 Sukta of Second Episode.

to stay in the country so that they can counteract the calamities of divine origin (Kautiliya Arthashastra II. 2003, 9.7.83, 84; 4.3.44).

Worship with offerings, obligations and recitals of benediction shall be organized on full moon and new moon days against different calamities as shown in Table 2.

**TABLE 2.** Calamity and Worship of Related Deity

| **Calamity** | **Worship of** |
|---|---|
| Fire | God of fire |
| Flood | Rivers |
| Rats | Rats |
| Wild animals | Mountains |
| Serpents | Naga (The Cobra Divinity) |
| Evil spirits | Chaityas |

*Source- Rangarajan, 1992, P. 129*

**Rewards, Punishments and Movement Control**

**1. Rewards**

Reward for supporting the relief actions is a part of disaster management in Katuiliya Arthashastra. These are given as follows (Kautiliya Arthashastra II. 2003, 4.3.31-32):

1. For saving someone from a wild animal was 12 Panas.
2. To the person who kills a wild animal was 12 Panas.

**2. Punishment**

Not helping the government in crisis, not obeying the direction of local officials, and provocative action was punishable. The highest punishment to an incendiary was death (Kautiliya Arthashastra II. 2003, 2.20.25). Other punishment is given in Table 3.

**3. Movement Control**

In the Book 2.36 the Chapter *Nagarik pranidhi* describes the movement control rule in capital city. *Nagarik Pranidhi* means duties of the capital city dwellers. The movement was restricted during night. The time is given as 6 *nalikas* after sunset to 6 *nalikas* before sunrise. Thus the time was approximately 10 p.m. to 4 a.m. A bugle shall be sounded to mark the beginning and the end of the curfew period. But the following are to permitted to move during the curfew period- midwifes attending delivery, doctors attending to illness, those who are obliged to do so due to death in the family, those who go with a lump in their

hand, visitors to the city officials for officials purposes, those summoned by a trumpet call, fire fighters and those having a valid pass. This control was done to maintain law and order in the capital city.

**TABLE 3.** Fines and Punishment

| **Offense** | **Punishment** |
|---|---|
| 1. Disobeying fire precautions of local authority | One quarter or one eighth Pana according to offense. |
| 2. For the owner, not running to save the house on fire | 12 or six Panas for a tenant. |
| 3. In case of houses catching fire through negligence | 54 Panas. |
| 5. Not saving someone carried away by floods, though having a canoe | 12 Panas |
| 6. Catching or killing predatory animals, not restraining dogs from harassing them | 12 Panas |
| 7. Not trying to save someone threatened by a wild animal | 12 Panas |

Source- *Kautiliya Arthashastra II. 2003, 2.20.17-25, 4.3.9, 22, 31*

**Administration Of Disaster Management**

Facing adversity and providing the treatment of a disaster is a part of Yoga-Kshema. Yoga-Kshema implies the idea of welfare, well being, with prosperity and happiness. Yoga-Kshema philosophy is given as follows- In the happiness of people lies the happiness of the king and in what is beneficial to the people his own benefit. What is dear to himself is not beneficial to the king, but what is dear to the people is beneficial to him (Kautiliya Arthashastra II. 2003, 1.19.34).

The administrators who use to control the disasters are explained in Arthashastra 4.1.1 and 2.35.17. He says that a committee of three members of *Pradestrs* or *Amatyas* is formed to control the disaster at central level. For the monitoring of relief work and law and order the *Samahartrs* were at *Janapada* level. While, lower levels, active at the place of disaster, were *Sthaniks* and *Gopas*. The *Samahartr* under whom all these officers work, is, therefore, also something like a collector in modern times. Thus the organization chart of disaster management may be something like in figure 2.

**Pradestrs/Amatyas**
**|**
**Samaharts**
**|**
**Sthaniks**
**|**
**Gopas**

**FIGURE 2.** Disaster Management Organization

Actually it seems a three tier organization because the role of *Samahrtr* is to provide financial support to the project. It is to be noted here that the disaster management seems slightly different in the capital city because *Nagarika*, Administrator of the Capital City, was directly in the under of *Pradestr.*

## CONCLUSION

Kautilya's philosophy of disaster management is a part of his concept of good governance based on his Yoga-Kshema theory. In his own words- In all cases, the king should favor the stricken people like a father (Kautiliya Arthashastra II, 2003, 4.3.43). This may seem to supported by the reference to 'those who have necessarily to be maintained' by the state (Kautiliya Arthashastra II, 2003, 1.12.1) and to the duty of the state to maintain minors, aged persons, and those in distress when these have no one to look after them. (Kautiliya Arthashastra II, 2003, 2.1.26) In this way Kautilya assures his citizens that the king is always ready to help them in all the hardships- natural or manmade.

Kautilya is a realist thinker therefore he doesn't believe in stars for a good fortune. He says confidently- The objects slip away from the foolish person, who continuously consults the stars; the auspicious constellation of the wealth is wealth, what will other stars do? But when he talks about the well being of the people he is ready to apply mantras and worship because here the goal is overall satisfaction of the people. Medical science also sometimes applies this method as faith healing to cure people. In fact, Kautilya's treatment encompasses the overall spiritual, moral, and material well being of the subjects.

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# TOPIC SELECTION AND LITERATURE REVIEW IN BEHAVIOURAL RESEARCH

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## ABSTRACT

*Before starting a research in Behavioural Sciences the researcher faces primary problems of selecting a suitable topic, collecting the reliable study matter and information. The problem starts with the topic. After topic selection the researcher has the problem of the field of study. If the researcher is able to find the field of study he/she faces next problem how to narrow down the study area? Other problems in the beginning are- What should be written in the beginning? What books and articles should be included in the research investigation and what should not? The rest of the activities of the researcher are based on these primary decisions. If these decisions are taken correctly the thesis writing becomes easy. The main focus of this article is to provide an easier approach to a researcher in the process of topic selection and information collection while starting a research.*

**Key Words:** Research topic, concept, variables, indicators, literature review

## INTRODUCTION

Behavioural science explores the cognitive processes of a person or a group to solve their problem in daily life. It involves the systematic analysis and investigation of human behaviour through scientific observations, controlled experiments and mathematical modeling. It attempts to accomplish legitimate, objective conclusions through rigorous formulations and observation. Examples of behavioral sciences are Psychology, Health Science, Sociology, Economics, Political science, Education and Population Analysis. Generally, behavioral science primarily has shown how human action often seeks to generalize about human behavior as it relates to society and its impact on society as a whole. Generally Social Science and Behavioral science is used interchangeable. A research in the field of a behavior science or a social science is known as social or behavioral research. The finding of this research is used to establish a new fact or an idea. It also is used to accept or reject existing theory or to test relevancy of an earlier theory again.

Therefore topic selection is the pivot of a behavioral research. The other next steps involve are collection of information, methodology, analysis of data and finding the conclusions. After finding the conclusions the last step is to provide policy recommendations.

This article analyses the two initial steps in a research- topic selection and information collection for a successful research.

**Selection of a Research Topic**

The expression of a research problem in an attractive, clear, and concise way is known as topic of the research. This is the destination of research journey for a researcher. Therefore it should be clear and precisely expressed. If the research is a long journey, topic is the last station to be reached. It is the destination that decides what means of transportation is to select. Selection of means of transportation is selection of methodology and tools and techniques of analysis.

Since each and every activity of the study depends upon the topic therefore one should be highly cautious while selecting the topic of a research. Following things should be considered while selecting a research topic-

1. One should select topic of great interest. It maintains and encourages your efficiency of work.
2. Narrow the topic down to something manageable, specific and clear.
3. Make sure that you are clear about the fundamental concepts of your work. If you are not being clear revise your literatures available for your study.
4. Make sure that you have adequate level of expertise for the work. For example if you don't have high expertise of mathematical tools don't include in you study. Try to select another field of study.
5. Ensure that your study adds to existing body of knowledge and is useful in policy formation.
6. Before finalizing the topic make sure that sufficient information is available for your study.
7. Make sure that your topic is a new one and other has not done the research on the same topic before.

**How to Formulate Research Objectives?**

Objectives are the goals you set to attain in your study. They inform a reader what you want to attain through the study. If research is a journey then objectives are the main stations in the way. One or more objectives can be formulated according to the nature of the research. In hypothesis testing research, where mathematical tools are being used, single objective is considered better.

**Language of Research Objectives**

Since objective shows your determination towards your research work, it needs decisive vocabulary while writing the objectives. Thus start your objectives with these words-

- to determine

- to analyze
- to evaluate
- to explore
- to compare
- to establish relationship etc.

It is to be noted that the use of the words to study, to know or to describe etc. should be avoided because these vocabulary do not provide the specific task.

**How to Select Concepts, Indicators and Variables in the Research Area?**

If you are using a concept in your research you need to consider its nature, function and measurement. Let you are trying to establish the relationship of quantity demanded with its price of a commodity in a market. Now in this case price and quantity are two variables. If you are taking price as independent variable then quantity becomes dependent variable. After identifying variables now you can denote these variables in symbols- $P_x$ as price of commodity x and $Q_x$ as quantity of same commodity. Since $P_x$ is independent and $Q_x$ is dependent the relationship between price and quantity can be written as $Q_x = f(P_x)$ Here $P_x$ is known as independent variable and $Q_x$ is known as dependent variable. Here f denotes functional relationship between price and quantity.

Take another example of reproductive behavior of women. Let you are interested in finding the relationship of fertility, income and health. Now you need related variables and indicators. These may be as follows:

**TABLE 1**. Concepts, Indicators and Variables in Reproductive Behavior Research

| **Concept** | **Indicators** | **Variable** |
|---|---|---|
| Income | Increase in the wealth<br>Welfare | Measured Income- Y<br>Standard of Living-SL |
| Fertility | Birth rate | Age Specific Fertility Rate- ASFR<br>Total Fertility Rate-TFR |
| Health | Death rate | Crude Death Rate- CDR<br>Life Expectancy- LE<br>Maternal Mortality Rate-MMR |

**Establishing Relationship between Different Variables**

After determining the variables and their indicators the next task is to establish the relationship among these variables. For this you can go through the following steps-

Step 1. Identify a broad field of subject areas interest to you, suppose your field of research

is reproductive behavior of woman generally known as fertility.

Step 2. Dissect the broader area into sub areas. We can have various topics on fertility, such as trends of fertility, impact of income increase and decrease on fertility, impact of reproductive health and availability of health services.

Step 3. Select what is of most interesting to you. Let you are interested to establish the relationship between income and fertility.

Step 4. Let you are interested in the relationship of income and fertility. Now, raise questions before fixing the topic in the following way-

a. What happens to fertility when income is increased?

b. What happens to fertility when income is decreased?

c. Is the impact of income increase for rich and poor group is the same?

d. Is the impact of income is equal in all age group?

Step 5. Now you can formulate one or more objectives for your research according to your area of interest.

Now assess your objectives on the basis of your literature review, available information and your capability of doing research in the field of income fertility relationship.
The complete process of objective formulation is explained in the figure 1.

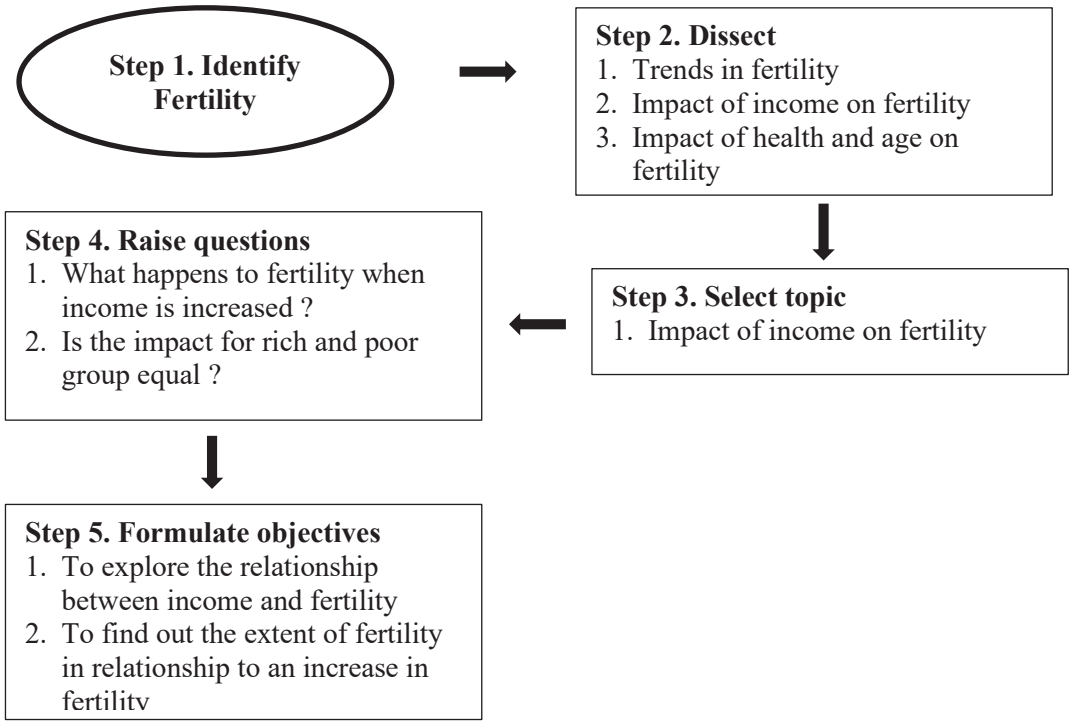


**FIGURE 1.** Topic Selection and Objective Formulation steps

**Formulation of Objectives and Hypothesis**

On the basis of questions raised above, objectives can be formulated as follows:

1. To explore the relationship between income and fertility.
2. To find out the extent of fertility in relationship to an increase in income.

In this example fertility is reproductive behavior and therefore it can be expressed as dependent variable of income, health, and age. Hence we can write this relationship symbolically as follows:

$F = f(Y,H,A)$

Where F is fertility, Y is income, H is health, and A is age.

Since study of multiple variables is a complicate task, you can make simple your study by selecting any one variable you are interested very much.

Let you are interested to establish the relationship between income and fertility then you can exclude other variables. Now the relationship between fertility and income becomes as follows:

F=f(Y), that is, fertility is a function of income.

If you are interested in mathematical tools and have enough data to analyze, you can formulate hypothesis as follows:

$H_0$ = F and Y has no relationship

$H_a$ = F is positively related with Y

$H_b$ = F is negatively related with Y

**Literature Review**

If you do not have a clear idea of a research problem, you should review the literature in your broad area of interest with the aim of gradually narrowing down to what you want to find out about. But if you have clear research topic it becomes very easy to select a topic and collect the research matter. What volume or quantity should be collected it depends on your topic and field of study. Remember, all the collected matters may not be useful for your research. Therefore try to divide them according to their importance.

After finalizing your topic of study you may review your information. You may include some new study matters and avoid older ones. Your depth study and comparative study also changes with your study. Always update your information with the help of a resource person, internet and library searches according to your facility and approach.

For the effectively search for literature in your field of enquiry, it is imperative that you have in mind at least some idea of broad subject area and of the problem you wish to investigate, in order to set parameters for your search. Then compile a bibliography for this broad area from these sources:

**a. Books-** John Best says- Practically all human knowledge can be found in books and

libraries. Unlike other materials that must start a new with each generation, man builds upon the accumulated and recorded knowledge of the past. His constant adding to the vast store of knowledge makes possible progress in all areas of human endeavour. Therefore library books are the main source of knowledge. Visit a library and collect a list of books of your study field. After a short scan of content of any book you will be clear about the books which are of extreme use for your research and which are less important. If contents are not found relevant to your research, delete form your list. After finalizing the list of books related to your research locate the books in the library or borrow from the sources or purchase for your own library.

**b. Journals-** Journals provide you with the most up to date information, even though there is a gap of two to three years between the completion of a research. As with books you need to prepare a list of journals for identifying literature relevant to you research. This can be done as follows:

- Locate the hard copies of the journals that are appropriate to your study
- Use the internet
- Look at the index of research abstracts in the relevant field to identify and read the articles.

**c. Unpublished Research-** Unpublished researches are extremely useful to a first time researcher. These are useful in the following way

- It helps you in formatting of a research.
- It helps you ascertaining the topic.
- It helps you to select research methodology in your field of research.
- It helps you finding research materials.

**d. Video/Photo-** In descriptive research and case studies video/photo related to the field area is useful. You can use information of video as primary data.

**e. Internet-** If you have access to the internet this is the easiest and fastest way of getting information in your field area. Google search can find millions of information within seconds. You-tube provides audio-visual information. Library books and books on demand are also available through internet.

After collecting necessary information include the name of related books/journals, authors/ editors, publishers and year of publication (or number of issue for a journal) with page numbers of related books. If your collection is final you can use them in your research. The name of books must be listed in the form of references at the end of your research.

**f. Other Materials-** If you are trying to write a behavioral research you may need peoples and their activities. You may have direct interviews or may send questionnaires. In some cases you may participate in the programs related to your research field. In some cases,

voice record, TV serials, plays and movies are also useful. Now a day mobile phone is helpful for collecting primary information.

If you have enough materials for your research, try to select only those materials which are widely used for your research.

**Importance of Literature Review**

Although the sphere of human knowledge is infinite but this is never started from zero. We march ahead of our past knowledge. Its therefore literature review is done. It helps you to understand the subject area better and thus helps you to conceptualize your research problem clearly and precisely.

a. It tells you if others have used procedures and methods similar to the ones that you are proposing which procedures and methods have worked well for them and you can improve your methodology
b. It ensures you to read widely around the subject area in which you intend to conduct your research study. As you are expected to be an expert in your area of study, it helps to fulfill this expectation.

## CONCLUSION

Literature Review and finalizing a topic are the initial steps in a research work. If these two steps are completed successfully your further tasks become easier and smooth. It is said that well begun is half done. No sooner a researcher starts his/her journey in a beautiful way then he/she will find that the destination is becoming more and more close. If the journey of research is started with the tips described above, the research journey will be very easy and interesting. When a task becomes interesting you can complete successfully.

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# THE COVID-19 CONTAINMENT AND POLICY RESPONSES AND THEIR EFFECTIVENESS IN SOUTH ASIA AND CHINA

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## ABSTRACT

*The COVID-19 pandemic has forced societies worldwide to create consequential policy decisions with limited information. After containment of the initial outbreak failed, attention turned to implementing non-pharmaceutical interventions designed to slow contagion of the virus. To bring down COVID-19-related infections and deaths in the pandemic thus far, governments have responded with a number of interventions. Among others, non-pharmaceutical interventions including border restrictions, quarantine and isolation, distancing, and changes in population behavior were associated with reduced transmission of COVID-19 in south Asia. This paper investigates the relationships of government's containment and testing policy response to respond to the COVID-19 pandemic across South Asian countries and China. Using daily data from December 30, 2019 to July 10, 2020 for 8 countries and relying on conducted policies, we find that government interventions is ineffective in slowing down or reversing the growth rate of transmission. South Asian economies are so connected that the delay in the response in one country has increased the number of import cases in others as there is irregular, cross-border migration. Also, a national security lens has distorted policy responses to conditions on the ground. This paper has used two sources of data: OxCGRT Index and WHO Coronavirus Disease (COVID-19) Dashboard. The paper concludes that government's responses in these countries are ineffective in curbing down the transmission and death rates resulting from COVID-19.*

**Key Words:** COVID-19, South Asia, containment, OxCGRT Index, effectiveness, government responses

## INTRODUCTION

The rampant corona-virus pandemic has affected the world economy, let alone South Asia. The economic damage has increased the levels of poverty and inequality, and it is likely to exacerbate rather than mitigate social and political conflict. On the domestic front, authoritarian tendencies have increased during crisis management (Wagner & Scholz, 2020). The health care system in South Asia is seriously underfinanced and consequently very underdeveloped. Sri Lanka spends about 3.81 percent of the Gross Domestic Products (GDP) in the health sector; similarly other nations of South Asia such as; India spends 3.53 percent of its GDP, Nepal spends 5.6 percent of its GDP, Bangladesh spends 2.27 percent of its GDP, Pakistan 2.9 percent of its GDP, Bhutan 3.2 percent of its GDP, Afghanistan 11.78

percent of its GDP, Maldives 9.03 percent of its GDP in the health sector, in comparison in South Asia Afghanistan is in top rank.

According to the 2018/019 data India has 7 hospital beds per 1,000 persons, Pakistan has 6 beds, Bangladesh has 8, Nepal has only approximately 3 beds per 10000 persons, and China has 42. In all countries, there is a lack of respiratory equipment and adequate protective equipment for health professionals. In addition to modern medical facilities are mainly found in urban centers, whereas rural areas are significantly worse off. These structural deficits are more acute than ever in the current crisis. The low infection figures officially reported in mid-April were mainly due to a lack of testing capacity. At that time, only 291 tests per million inhabitants were carried out in India, 506 in Pakistan, 302 in Sri Lanka, and 162 in Bangladesh. At the beginning of April, India reported a mortality rate of 3 percent, Pakistan 1 percent, and Bangladesh 10 percent.

To bring down COVID-19-related infections and deaths in the pandemic thus far, governments have responded with some other interventions. Among them, Cowling et al. (2020) shows that non-pharmaceutical interventions (including border restrictions, quarantine and isolation, distancing, and changes in population behavior) were associated with the reduced transmission of COVID-19. Chudik et al. (2020) rely on an epidemiological model for some Chinese provinces and ten countries to find that it takes about 21 days from infection to recovery or death rather than the 14 days typically assumed in designing quarantine policies.

The COVID-19 global pandemic, which started as a health crisis, has become an economic and a 'human crisis,' as described by Mr Antonio Guterres, the United Nations Secretary General. As governments across the globe closed international borders, abandoned transport systems, and took steps to lockdown their population to contain the pandemic, economic activities have faltered, global and regional value chains have been disrupted, millions of people have lost their jobs, with many of them facing hunger and falling into extreme poverty, and the world economy has plunged into the most serious recession since the Great Depression of the 1930s.

South Asian countries have also been seriously affected, with the cases rising fast and yet to peak, even though the per capita incidence and mortality may be lower, due to demographic characteristics. However, the economic impact is much more severe given the vast proportion of population in these countries living at the margins, fragmented coverage of social protection, pervasive informality in economic activities and employment, and wide gaps in public health infrastructure. Millions of workers have been rendered jobless, inequalities have been accentuated, and the crisis is likely to reverse years, if not decades, of gains in poverty reduction, undermining the progress made by the sub-region towards achieving the Sustainable Development Goals (SDGs). Moreover, Asian countries adapted four types of measures to control the pandemic. They are monetary policy measure, fiscal

policy measure, public health measure and human control measure (UNDP). However, one can regroup them into containment policy and testing policy only.

As the first wave of the COVID-19 outbreak appears to be easing in many countries around the globe, it is extremely crucial to provide an initial quantitative assessment of the impact that ongoing government interventions have had on controlling the pandemic. As noted by a recent communication news article in Nature (Gibney, 2020), "working out the effectiveness of the measures implemented worldwide to limit the corona virus's spread is now one of the most pressing questions". Some of the questions like, (a) How effectively a prompt and strict government response curb the mortality curve of the epidemic? (b) Does the severity of interventions are capable of dragging down the death rate?; and (c) Can harsher containment measures be the policy options that guarantee the lower the death rate where the infection is already high?, are still contesting. A comprehensive review on the effectiveness of some of the policy measures adopted by the neighboring countries might help policy makers designing intervention packages to return to a 'new normal' and, at the same time, fight against further waves of the COVID-19 outbreak if any.

The objective of this paper is to study the containment and testing policies of China and South Asian countries and to analyze the likely impacts on respective economies.

## METHODOLOGY AND DATA SOURCES

This paper attempts to address these critical questions in a quantitative manner. To do so, we first define two critical concepts: (i) the strength of the policies and (ii) the early stage implementation of these policies. In particular, we define the policy strength of any certain day as the average value of the Government Response Tracker index (developed by the University of Oxford) for the preceding 14 days (Lauer et al. 2020, estimate that the incubation period of the virus is 14 days). Early stage refers to any day that precedes or is equal to the first observed day in which the number of confirmed deaths. That is, if COVID-19 policy measures are effective, then the strength of these measures taken at an early stage should be related positively to the probability of attaining a statistically insignificant trend in deaths attributable to COVID-19. Upon realization of a positive significant trend in deaths, and under the assumption that the COVID-19 related policy measures taken at an early stage have been effective, then the strength of these measures should still inversely affect the trend slope shaped by the COVID-19 deaths. "Speed of adjustment matters" is our third hypothesis. As countries that initially responded with "low strength" policy measures progressively increase the strength of their response, a significant reduction in the trend slope should take place after a certain breakpoint in time. Thus, for countries with a break in the trend slope, if COVID-19 policy measures are effective then the difference in the strength of the policy measures (between the break time and the early stage) should be related inversely to the difference of the slopes in the observed trends (after and before the break).

To examine, we use daily data on COVID-19 related deaths for 9 countries. We rely on the panel regression test to endogenously determine the effectiveness of the government policy and growth in cases and number of deaths per country. We then assess the impact of government interventions on the trend slope shaped by the daily number of deaths.Finally, governments that initially respond with "low strength" policy measures but progressively increase the strength of their response, succeed in slowing down or reversing the growth rate of deaths after a certain breakpoint in time. We find that the greater the strength of government interventions at an early stage, the more effective these are in slowing down or reversing the growth rate of deaths. Additionally, the evidence suggests that school closures, does nothave a significant impact – albeit, one which is less powerful in reducing the growth rate of deaths than that achieved by pooling together a number of government interventions. Overall, governments can use some of the results of this paper to respond to future COVID-19 outbreaks or to other pandemics not least because further waves of COVID-19 infections and deaths are likely to emerge as policymakers progressively relax their interventions.

We focus on 7 countries of south Asia and china using daily data on the total number of confirmed deaths attributed to COVID-19. Our sample covers the January1 st, 2020 to June 10, 2020 period. The accuracy of official confirmed cases of COVID-19- related infections is limited by how effectively a country is testing people to confirm cases and accurately reporting results. Countries have, in fact, approached COVID-19 testing in different ways. This paper also uses 'stringency index' developed by the researchers that describes the overall severity of a country's response to the coronavirus outbreak and allows responses to be compared. The index takes into account seven control measures, such as school closures and restrictions on people's movements.

## RESULTS AND DISCUSSION

### Response to COVID-19 by different Countries in south Asia and China

### India

The first COVID-19 case in India was detected on January 30, the same day that WHO declared it a public health emergency of international concern. India went into lockdown almost two months later. On June 8, after 10 weeks of lockdown, India started a phased reopening of its economy. With Unlock 1.0, the country is trying to balance attempts to revive the economy while dealing with increasing caseloads and new hotspots. On June 30, official COVID-19 cases stood at over 585,000, and more than 17,500. While recovery rates have improved to 60 percent and the death rate is relatively low considering that India is the fourth most-impacted country globally, COVID-19 in India is nowhere close to the peak

To amid the transmission of corona virus on 24 March 2020, the Government of India under Prime Minister Narendra Modi ordered a nationwide lockdown for 21 days, limiting movement of the entire 1.3 billion population of India as a preventive measure against the COVID-19 pandemic in India. It was ordered after a 14-hour voluntary public curfew on 22 March, followed by enforcement of a series of regulations in the country's COVID-19 affected regions. The lockdown was placed when the number of confirmed positive coronavirus cases in India was approximately 500. Observers stated that the lockdown had slowed the growth rate of the pandemic by 6 April to a rate of doubling every six days and by 18 April, to a rate of doubling every eight days.

**Sri Lanka**

Sri Lanka got the first confirmed case of corona virus on January 27 2020, who was a 44 year old Chinese women from Hubei province in China. She had arrived as a tourist with another group of travelers and had been screened at the Bandaranayake International Airport after having a high fever. While these incidents were happening the government formed a presidential task force in relation with fighting the covid-19 virus which seek cooperation of all sections of the society. The first quick sessions "emphasize the disastrous consequences of behave in irresponsible manners and importance of the cooperation of everyone to the quarantine process commenced with the objective of protecting citizens of SL" The health ministry which was led by the director general of health services and the defense ministry who featured the commander of the Sri Lanka army contributed to the covid-19 prevention body in cooperation of other sectors

According to the decisions carried out by the Presidential task force around 685 people have been quarantined at two centers in Batticaloa. Army and health officials have taken steps to provide them with maximum possible facilities within a short period of time. Another 2 centers have also been prepared to use for the purpose of quarantine. The Sri Lankans as well as foreigners arriving from South Korea, Italy and Iran has been sent to these centers for 14-day quarantine period and issue a certificate after the period. [Which later considered as mandatory for them to provide when going out of country again]. Requested other people who arriving from other countries to SL to cooperate with this process by living in isolation in their own houses.

**Bangladesh**

The COVID-19 pandemic in Bangladesh is part of the worldwide pandemic of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory syndrome coronavirus (SARS-CoV-2). The virus was confirmed to have spread to Bangladesh in March 2020. The first three known cases were reported on 8 March 2020 by the country's epidemiology institute, IEDCR. Since then, the pandemic has spread day by day over the whole nation and the number of affected people has been increasing.

In order to protect the population, the government declared "lockdown" throughout the nation from 23 March to 30 May and prepared some necessary steps to spread awareness to keep this syndrome away from them. Infections remained low until the end of March but saw a steep rise in April. In the week ending on 11 April, new cases in Bangladesh grew by 1,155 percent, the highest in Asia, ahead of Indonesia, with 186 percent. On 6 May, cases were confirmed in all districts. Rangamati was the last district to report confirmed cases of COVID-19. On 13 June, the number of cases in Bangladesh exceeded the number of cases in China, the country where the outbreak began. Bangladesh reached two grim milestones of 160,000 cases and 2,000 deaths on 5 July and overtook France in terms of the number of cases two days later. The number of recoveries in the country exceeded the number of active cases on 12 July.

**Bhutan**

Bhutan confirmed its first COVID-19 case on 6th March, a 76-year-old US male who travelled to the country via India. Around 90 people who came directly in contact with him, along with his 59-year-old partner, driver, and guide were promptly traced and quarantined. Bhutan immediately restricted entry of foreign tourists for two weeks. Schools in three areas including capital Thimphu were closed. The Government made it mandatory for everyone returning from abroad to be quarantined in designated quarantine facilities from 16 March 2020. The other three cases were Bhutanese students who returned from affected countries. They were detected from designated quarantine facilities. As of 12 April 2020, 4 confirmed cases tested negative and are fully recovered.

Under the leadership of His Majesty the King of Bhutan, the whole of society and government approach was followed to respond to this situation. The Health Emergency Operation Center (HEOC) was activated at the Ministry of Health.
No individuals were put under financial hardship due to current COVID-19 pandemic in Bhutan. On top of free testing and medical services, all meals and accommodation are provided freely by the State at the designated quarantine and isolation facilities. The government has reprioritized and consolidated savings from non-essential activities including ex country travels and meetings from all sectors and are investing these in COVID- 19 response and actions.

**Pakistan**

There is an ongoing pandemic of Novel Coronavirus (COVID-19) in Pakistan which was first notified on 26 February 2020. As of 14 April 2020, over 5,719 cases with 96 deaths (CFR 1.68%) had been reported. The pandemic has spread to all provinces in Pakistan with over 115 districts affected, largely in Punjab and Sindh.

The Government of Pakistan with support from partners have responded to the pandemic by

strengthening coordination, case management, disease surveillance, laboratory, community mobilization and sensitization.The COVID-19 Pakistan Preparedness and Response Plan (PPRP) outlines the international assistance required by the Government of Pakistan (GoP) to stop the transmission of the pandemic and respond to the emerging public health needs in Pakistan. It is created in line with the Pakistan National Action Plan. It aims to steer a coordinated international effort in consultation with Ministry of Foreign Affairs (MoFA) to support the Ministry of Health Services, Regulations and Coordination (M/O NHSRC), National Disaster Management Authority (NDMA) and Provincial Departments of Health (PDMAs), under the overall efforts of the Government of Pakistan (GoP).

It is prepared with the support of the UN and is guided by the WHO Strategic Preparedness and Response Plan (SPRP).This plan will strengthen and reduce gaps in coordination at all levels, support disease surveillance and laboratory diagnosis, enhance case management, ensure implementation of infection prevention and control and lastly mobilize community for control of the outbreak.The approach is dynamic, enabling resources to be adapted to support the most effective public health interventions as more is learnt about the virus and the key risk groups, with emphasis remaining on supporting the most vulnerable people. The primary focus of the plan continues to be prevention, preparedness and treatment of the COVID-19 outbreak.

**Afghanistan**

As of 17 June, 26,874 people have tested positive for COVID-19; 504 have died and 6,158 have recovered. Since the start of March, partners medically screened 422,232 people at points-of-entry, delivered WASH assistance to more than 1.3 million people and sensitized more than 1.1 million people on COVID-19 preventive measures across the country.

The Government of Afghanistan announced on 6 June that it was extending the nationwide lockdown for three more months, issuing new health guidelines for citizens to follow. According to the latest measures, people must: wear a face mask in public places at all times; maintain a 2-meter social distance; avoid gatherings of more than 10 people; disinfect all workplaces; and ensure older people stay at home. The Government has extended the closure of schools for three more months. Additionally, all hotels, parks, sports complexes and other public places will remain closed for three months, while public transport facilities, such as buses carrying more than four passengers, will not be allowed to travel.

All government offices have reopened with government employees attending in two shifts and on alternate days. Measures to contain the spread of the virus continue to differ across provinces, with provincial authorities maintaining the authority to decide on and implement their lockdown measures. In light of the newly announced nationwide preventative measures, provincial authorities are currently reviewing their lockdown measures. While provincial lockdown measures continue to impede humanitarian movement, in the last few

weeks, the situation significantly improved, with less obstructions reported.

**Nepal**

On 24 March 2020, the Government imposed a complete 'lock-down' of the country including business closures and restrictions on movement within the country and flight access in an out. Discussion is ongoing to enable the movement of those supporting the preparedness and response to the current situation, should the situation deteriorate. There are exceptions in place for businesses and people in relation to supply and access to medical supplies and food.

The Government of Nepal has formed a committee to coordinate the preparedness and response efforts, including the Ministry of Health Ministry of Home Affairs, Ministry of Foreign Affairs, Ministry of Finance, Ministry of Culture, Tourism and Civil Aviation, Ministry of Urban Development, Nepal Army, Nepal Police and Armed Police Force. The Humanitarian Country Team (HCT) includes the Red Cross Movement, civil society organizations (national and international NGOs). Under the joint leadership of the Resident Coordinator's Office and the WHO, the HCT has initiated the contingency planning and preparedness interventions, including dissemination of communications materials to raise community-level awareness across the country. The Clusters – led by the Government of Nepal and co-led by the IASC cluster leads and partners, are working on finalizing contingency plans which will be consolidated into an overall joint approach with the Government and its international partners.

**China**

In order to prevent and control novel coronavirus pneumonia (COVID-19), ensure "early detection, early reporting, early isolation and early treatment", prevent the spread of the outbreak, reduce infection rate, improve treatment rate and cure rate, reduce case fatality rate, protect people's safety and health and maintain social stability, the 5th Edition of the Novel Coronavirus Pneumonia Prevention and Control Protocol is now revised to this 6th Edition according to the policy that novel coronavirus pneumonia is classified as a category B infectious disease but regulated as a category-A infectious disease and based on the epidemic evolution across the country and research advances, in order to implement evidencebased, tailored and specific approaches for different regions and stages in the prevention and control of the diseases.

With the outbreak of COVID-19, the Chinese government has treated the outbreak of the disease as a victim crisis. Since the cause for the outbreak remains unknown, the government has not taken ownership for the cause of the disease. Its actions fit the deny crisis response strategy. The government initially attacked all charges levelled against its response. In the beginning of January, forty people were supposedly arrested for misinformation. Similar

to the SARS crisis in 2003, the government downplayed the existence of the crisis for a month until January 23, when Wuhan was placed under lockdown and annual Spring Festival travel plans were forcibly halted. This delay in confirming the outbreak is one of the reasons that the virus spread so widely. After the backlash on social media for the death of a whistleblower, Dr. Li Wenliang, the government suspended social media accounts of sympathizers and censored mention of the freedom of speech on Weibo and WeChat. It also blamed Hong Kong secessionists and foreign entities for taking advantage of people's anger. On the international stage, Beijing directed anger at other governments for not aiding China in its hour of need.

Scapegoating is also evident in the government's response. The rumors that the coronavirus was actually caused by a US bioweapon program were rampant on WeChat and bolstered by officials. The local government in Hubei also faced much of the public anger and took the blame for the lapse in governance. At this point, it is important to treat the Chinese government not as a monolith but as various stakeholders dealing with bureaucratic politics in crisis situations. This difference between local city governments, provincial governments and the central government in Beijing is evident through this crisis.

**Confirmed Cases Attributed to COVID-19 Across Countries**

Countries have, in fact, approached COVID-19 testing in different ways. For example, China and India have been much more aggressive in testing and confirming infections than other countries. With this in mind, we focus on daily confirmed cases related to COVID-19. The raw data on the daily confirmed for all countries of our sample come from the WHO dashboard. Figure 1 reports the data.

From Figure 1, daily cases in China reached a peak in mid-February before dropping again (isolated orange surface) and India reached to its peak in the beginning of July (Maroon surface). Daily cases in Pakistan reached a peak in late June 2020. Daily cases in Nepal, Bangladesh and Afghanistan reached a peak in early July 2020.

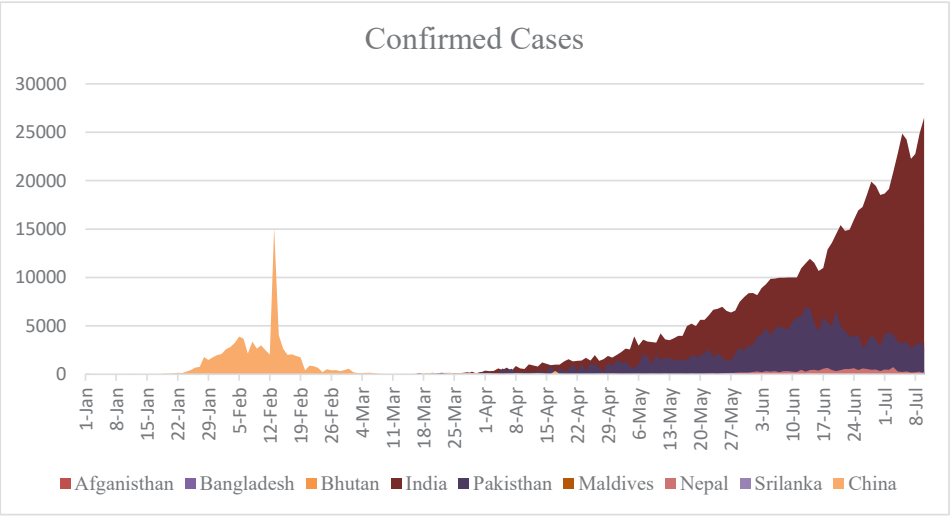



**FIGURE 1.** Confirmed deaths attributed to COVID-19 across countries

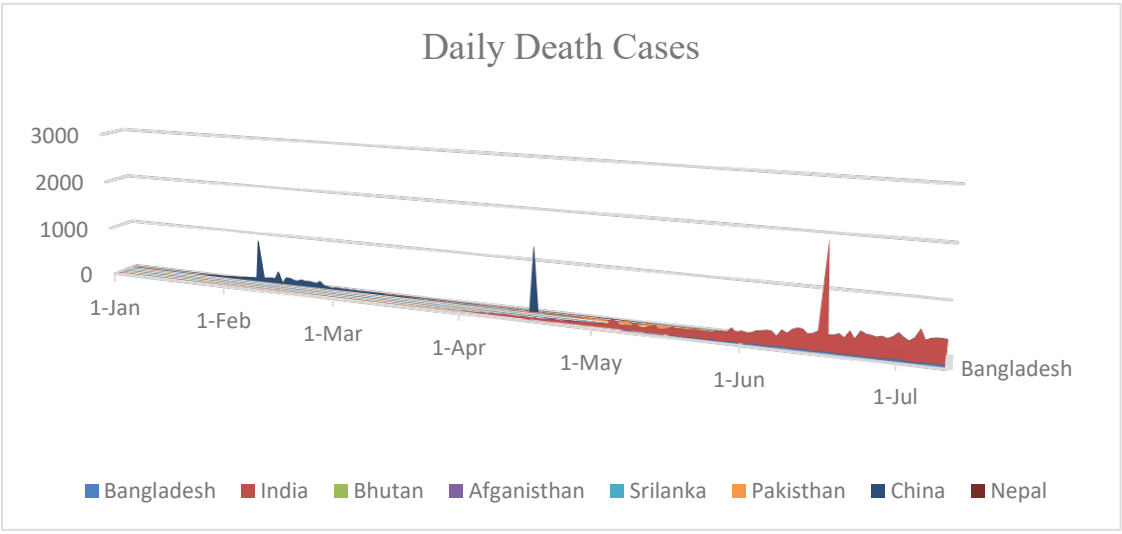


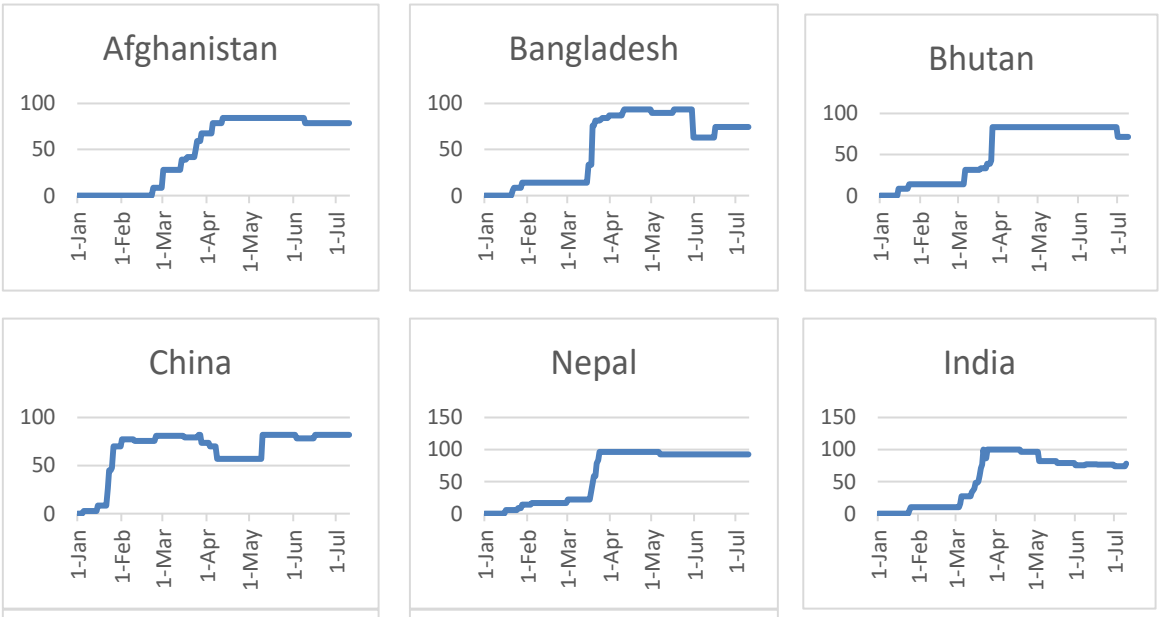

**FIGURE 2.** Confirmed deaths attributed to COVID-19 across countries

Figure 2 shows the raw data on the daily deaths for all countries,Figure 2 reports that daily deaths in China reached a peak in mid-February and in mid-April. Daily deaths in India reached a peak in mid-June 2020. Daily deaths in other countries are low compared to China and India.

**Stringent Measures**

Deaths due to COVID-19 forced governments to implement a range of policies to control the spread of the virus. The Blavatnik School of Government of the University of Oxford compiles the Oxford COVID-19 Government Response Tracker (OxCGRT) index (Hale et al., 2020) which quantifies the stringency of the conducted policies across countries. The value of the index on any given day in any given and country comes from the average of nine sub-indices8 pertaining to individual policy indicators, each taking a value between 0 and 100 (Hale et al., 2020).

Figure 3 demonstrates different governments' stringencies to ensure social distancing across countries over time (January 2020, to July 10, 2020). Pakistan, Afghanistan, Bangladesh, Bhutan had been experiencing a softer level of stringencies than the other studies countries mentioned in the Figure. On the other, the countries with Stringency Index over 90 and above are India, Nepal and Sri Lanka. Among the coronavirus hardest-hit countries, Afghanistan, China and Pakistan had the least level of stringencies from their governments. As of July 10, 2020, India shares around 15 percent of total death tolls in the world, while among the South Asian Countries, India has highest deaths per million populations of the country. Asian countries are among the top, where governments have stricter advice for their citizens. However, some Asian nations, for example Pakistan, Bhutan, and Bangladesh had softer advice for their citizens amid the Covid-19 pandemic



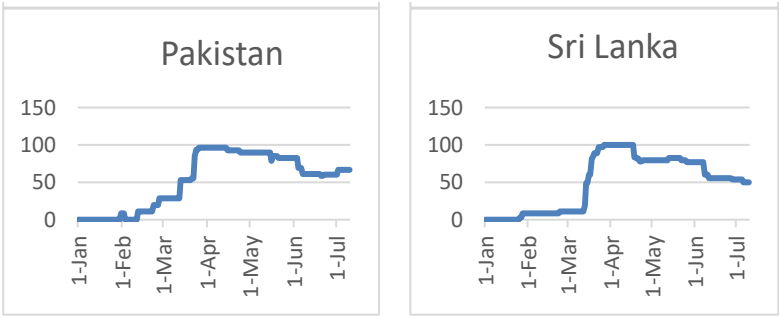



**FIGURE 3.** Stringencies across countries

In Figure 4, the chart shows regression lines on top of a scatter plot of stringency levels across countries. Using the data in views, we made another group of data-frame that has observations from South Asian Countries and China. For them, a 1 unit increase in stringencies of government measures results in a 14.32 unit increase in cases. This result is statistically significant, with a p-value of 0.000 and R-squared of0.03.

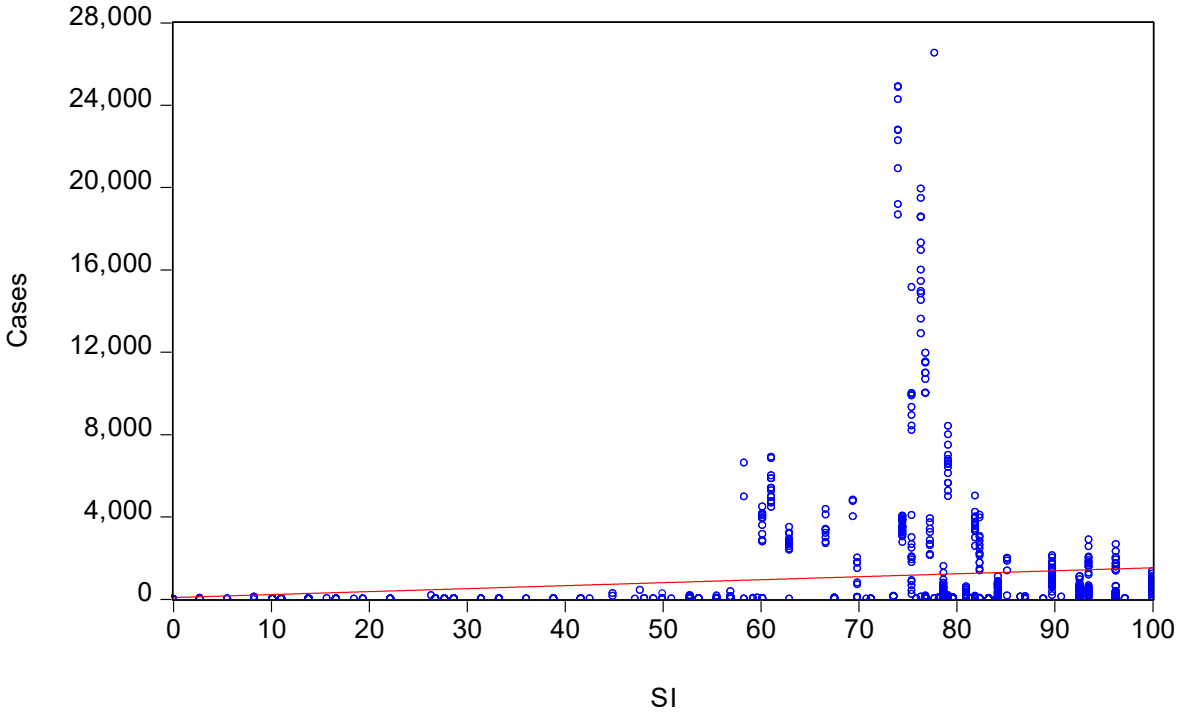



**FIGURE 4.** Governments' stringencies and daily growth in cases

## Government Response

Figure 4 brings together the state of government response index and resultant growth in confirmed cases in selected countries in south Asia and China. In figure shows, the linear

increase of government response levels in the countries.

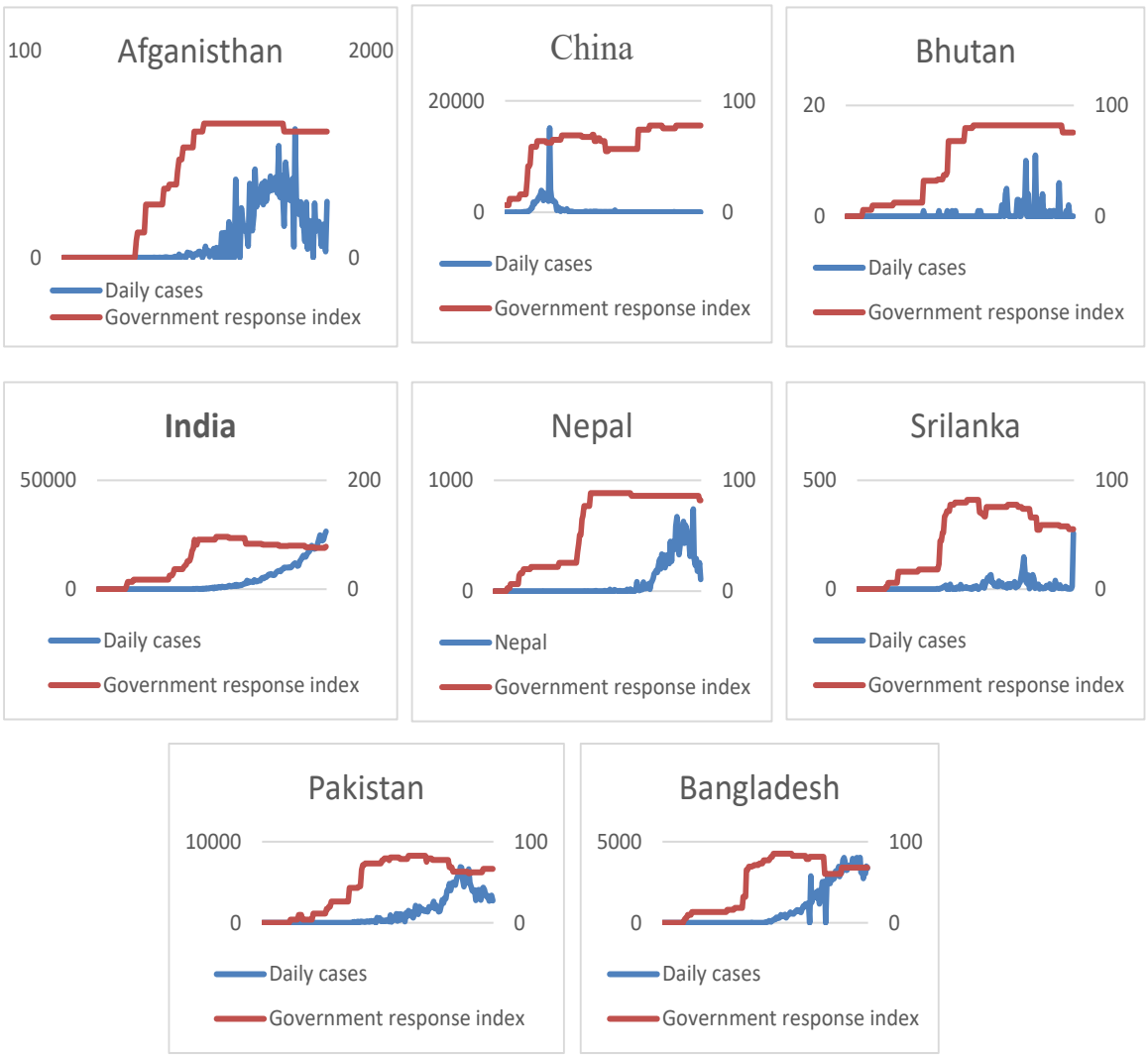



**FIGURE 5**. Government response and daily growth in cases

The figure also shows a sharp increase in government response to amid COVID-19 cases. Conversely, the government response seems effective only in case of China Nepal a Sri Lanka. Cases had increased compared to their baseline time. The chart indicates that from mid-February until mid-March 2020, the growth rate of confirmed coronavirus cases has risen that follow a slow decline after mid-March. As time advanced, the consequences of relative rise in the stringency levels of governments' policies and pieces of advice fell into the reductions in citizen's community mobility towards workplaces and public parks that indicate the sharp rise distancing performances. As the chart shows, after mid-March until the end of the month, indicator of government response has fallen than the baseline

period. From all the chart, the paper infers that the stricter the government rules, the less the confirmed cases can achieve by a country.

**Containment Health Response**

South Asia has been hit hard by the novel coronavirus, with a surge of new cases over the past week in Indonesia, the Philippines, Malaysia, Myanmar, and Singapore. Only Sri Lanka and Bhutan saw the number of daily cases drop. Indicating they may be making progress in flattening the curve. Even with this recent surge, the number of cases in many countries is still at the early stages of what is likely to be a steeply rising curve. The region's vulnerability to the spreading pandemic is unsurprising given the geographic proximity and close trade and tourism linkages to China. Like other regions that have been heavily impacted, including Europe, Northeast Asia, and the United States, we are witnessing a range of country experiences in Southeast Asia based on the onset of the crisis, initial government responses, the capacity of public health systems, and broader societal and political factors.

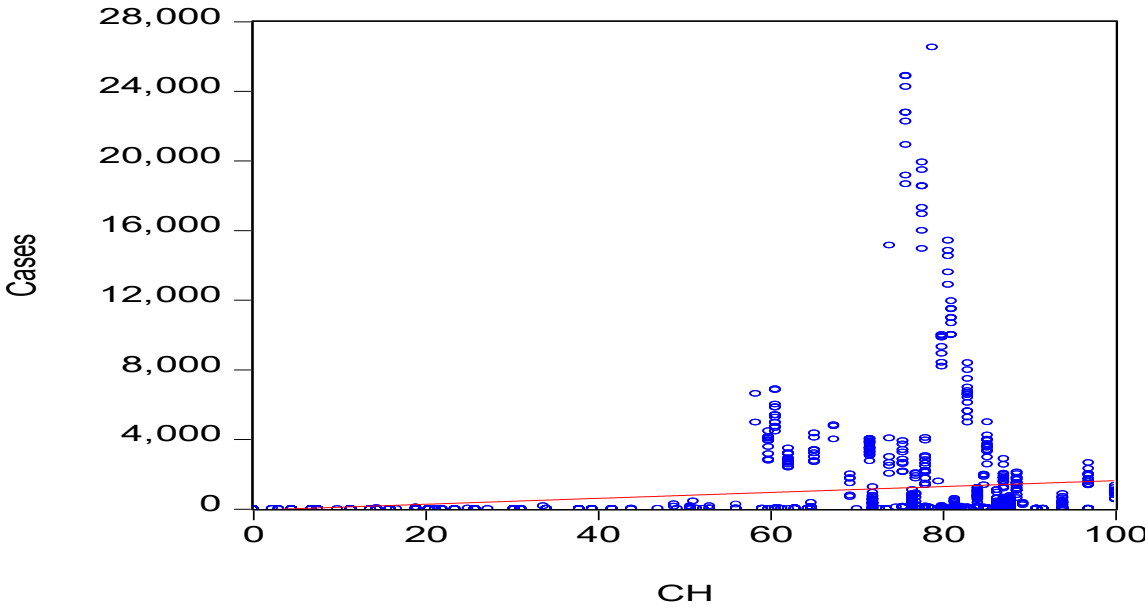



**FIGURE 6.** Governments' containment health response and daily growth in cases

Figure 6 demonstrates the level of Governments containment Health response and consequent growth in COVID-19 cases across the countries. In the chart, the "red" linear regression line indicates a sharp increase in government response. The findings infer that this increase is a result of stricter public health advice from the government. However, when it comes to comparing the top six affected countries, it is seen that the hardest-hit countries have even sharper decline than the overall fall in workplace presence For 8 countries, with 1 unit increase of stringencies in government containment health response -33.94 (p-value

= 0.000; R-squared = 0.33) unit of growth in COVID-19 cases.

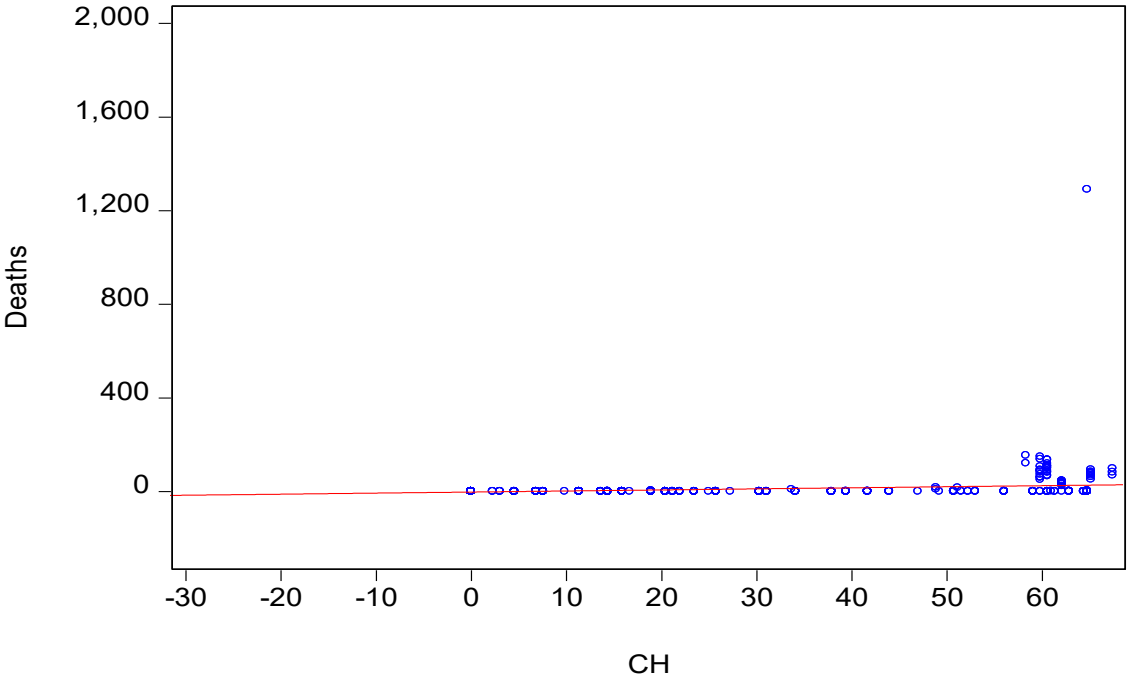



**FIGURE 7.** Governments' containment health response and daily increase in death

Figure 7 explains the level of Governments containment Health response and consequent growth in COVID-19 death across the countries. In the chart, the "red" linear regression line indicates a mild increase in government response. The findings infer that this increase is a result of soft public health advice from the government. However, when it comes to the countries, it is seen that the countries have increase in the death cases along with the governments increase in containment health response , with 1 unit increase of in government containment health response 0.45 increase in death cases (p-value = 0.000; R-squared = 0.027) unit of growth in COVID-19 death cases .

**School Closing**

Schools promote child education, growth, development, and overall well-being .Knowing whether school closure is effective in reducing infections is critical to reduce the negative effects of continued school closure on child health if school closure is ineffective. This study assessed the association between school closure and its timing with subsequent COVID-19 incidence, with the hypothesis that any association between school closure and incidence and mortality would be strongest in countries that closed schools early when the cumulative incidence of disease was low cause the relationships between baseline cumulative incidence and outcomes were not assumed to be linear

Using the aggregate stringency index of government interventions, we repeat our analysis

by focusing on the 'school closures' component of the OxCGRT index. Consequently, we look at the strength of the school closure policy defined as the average value of the 'school. School closures have been the focus of media attention. For instance, there is very little evidence that school closures are effective in combating COVID-19. Viner et al. (2020) provide a comprehensive review of the impact of school closures during coronavirus outbreaks around the world.

Figure 8 Suggests that the level of Governments School Closure response and consequent growth in COVID 19 cases across the countries. , with 1 unit increase of in school closure index 0.16 (p-value = 0.000; R-squared = 0.049) unit of growth in COVID 19 cases.

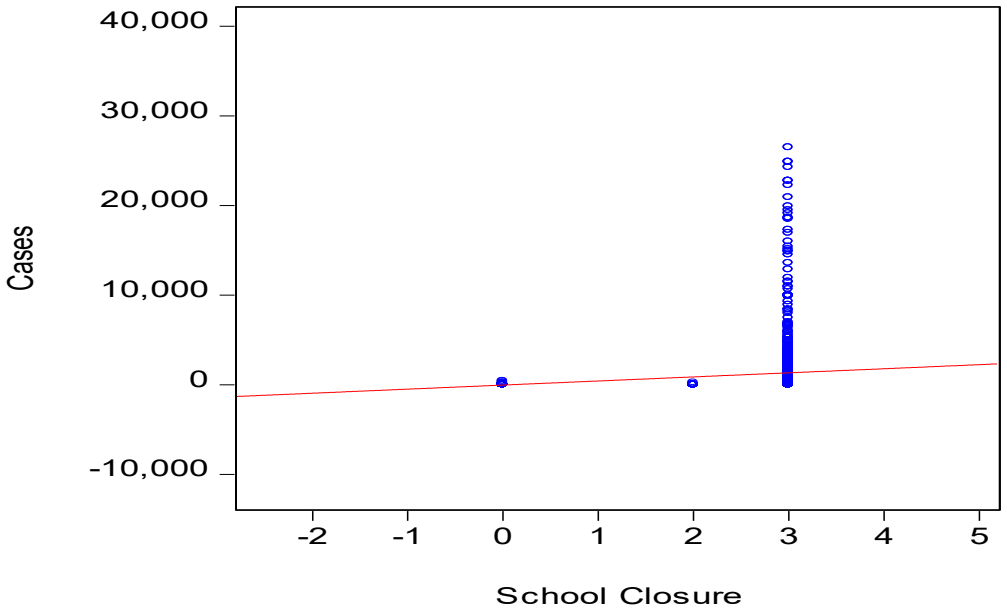



**FIGURE 8.** School closure and increase in cases

## CONCLUSION

COVID-19 developments dominate the news not only because of the challenging social costs and growing numbers of lives lost, but also the economic costs resulting from closures and social distancing measures. This paper assesses the quantitative impact of government interventions on COVID-19 cases deaths. Using daily data for 8 countries and relying on the stringency of the conducted policies, we find that the government interventions, is ineffective in slowing down or reversing the growth rate of deaths in the selected countries. School closures, on their own, is also nor powerful in driving cases and deaths down than are combinations of government interventions. Overall, government decisiveness in

taking early action is paramount to control the virus. The response is ineffective because in dealing with the pandemic, many countries followed the pattern observed in Wuhan, China, involving strict lockdowns, controls on mobility, economic and social activity and requirements of "social distancing" (hereafter referred to more correctly as physical distancing). In South Asia, a very stringent version of this strategy was adopted relatively early in the onset of the infection, and also very abruptly, with only four hours' notice given to the population. Unfortunately, this failed to take into account the specific socio-economic contexts and characteristics of life and work for most people in SA, which made the consequences of this strategy both more damaging and less effective. Further, around one-third of the urban population and at least quarter of villagers live in extremely crowded and congested conditions, in very small dwellings with five or more people confined to one room. "Stay-at-home" policies in such contexts are unreasonable, oppressive and even counterproductive. Physical distancing norms cannot be effectively followed, especially for prolonged periods. Requirements like frequent and prolonged washing of hands with soap cannot be met where access to clean water is limited and it must be collected and stored, often through lengthy and arduous journeys made by women and girls. All these aspects became more difficult as the lockdown continued, as declining incomes forced many people to cut back on spending for even essential items. But there were no official guidelines for people in these conditions to protect themselves from the virus.

Apart from this the countries in the region are so connected that the response made by one country directly or indirectly affects the other. Irregular cross border migration through a national security lens distorts policy responses to conditions on the ground. In the current situation there is high and irregular, cross border movement of migrant workers (between Bangladesh, India, Pakistan and Nepal) as well as refugees among the countries (Afghanistan and Pakistan) which has helped to make the government response more ineffective in the region.

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# MODELLING WITH SOLUTION TECHNIQUES TO HUB LOCATION PROBLEMS IN PUBLIC TRANSPORTATION

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## ABSTRACT

*Hubs are the facilities that collect flow from a set of sources and distribute it to the required destination. Hub location problem (HLP), aiming to minimize the total cost, are dealt to determine and allocate major facility nodes as hub nodes. In the paper, the new model of HLP in public transportation network is formulated. To derive such model some of the general assumptions of HLP are relaxed, that are usually satisfied in hub location problems but are not useful for public transportation networks. The new model is formulated by a flow conservation law based on network design formulations, in which the constraint that all flow has to be routed through some hub nodes. Different solution approaches for the new model are also presented.*

**Keywords:** Hub, spoke, location, public transportation, network design

## INTRODUCTION

In context of passenger service in Nepal, two types of vehicles are assumed to be used at an public transportation network. The first type of vehicles (small buses, taxi, tempo, rickshaw etc.) carry passengers from substation called spoke nodes to major station called hub node and vice versa while second type of vehicle (large buses) carry passengers from one major station to another major station. The carrying of passengers from origin to destination are assumed to be defined and given in pair of network nodes. The major task of the paper is to construct a public transportation network so that overall transportation costs are minimized. The location of major station (hub nodes or hubs) and the allocation of the other sub stations (spoke nodes) to these hub nodes are of quite interesting and also motivation to the work.

The idea of hub-and-spoke networks was first initiated by Goldman in 1969 [Goldman, 1969], which was followed and incepted the primitive study of hub-and-spoke networks on a plane by O'Kelly during 1986 and onwards [O'Kelley, 1986a & O'Kelley, 1986b]. O'Kelly was also the one who proposed the first mathematical formulation of hub-and-spoke networks as a quadratic integer programming model [O'Kelley, 1987]. Since that time, many researchers have been working on different classes of problems in hub location probles (HLPs); both in theoretical aspects and different applications. Main applications of

HLPs studied are in the field of air passenger and cargo transportation, telecommunication etc. The main types of problems which are dealt with are p–hub location, where the number of hubs to be located is fixed to p [Skorin-Kapov et al., 1996], and fixed cost hub location problems, where this number is unlimited, but a certain fixed cost has to be paid for establishing a hub facility [Ebery et al., 2000 & Campbell, 1994]. Furthermore it can be distinguished between single allocation [Ernst and Krishnamoorthy, 1996 & O'Kelly, 1987] and multiple allocation [Ernst

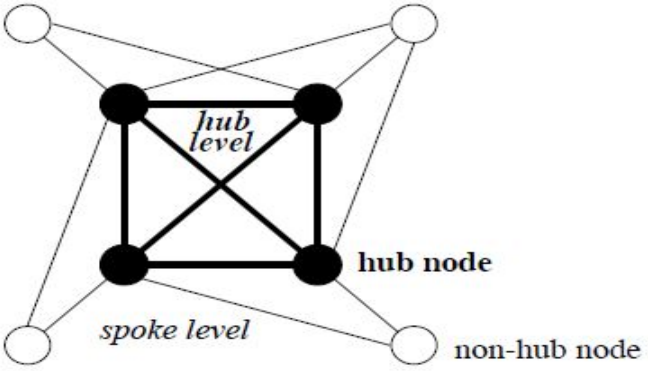


**FIGURE 1:** Hub-Spoke Network

and Krishnamoorthy, 1998a] problems. In the single allocation case every non–hub node must be allocated to exactly one hub, while in the multiple allocation case a non–hub node can be allocated to several hubs.

In this paper an application of hub location problems to public transportation is considered, which has not been studied so far. The problem which might be the most useful for applications in public transportation is the fixed cost multiple allocation hub location problem. In subsection 2.1, a modified uncapacitated version of this problem is derived, which will be the basis for this paper. In order to obtain new model that is more useful for public transportation networks in subsection 2.2 we relax some of the general assumptions that are usual satisfied in hub location problems. These new models correspond to network design problems. An overview of different possible solution ideas are discussed in section 3. Finally some conclusions are given in section 4.

## MODELLING

A hub network can be seen as a two level network: The hub level network connects the hubs among each other, and the spoke level network connects the non–hub to the hub nodes. But in case of multiple allocation, each non–hub node may be allocated to several hubs. In public transportation network the hub edges may represent highways connecting major stations while the spoke edge can be considered as subways connecting substation to major station. Passengers can change their buses at the hub nodes. The Network Hub Location Problem consists of two parts, which are dependent on each other. In the location part the nodes which should serve as hubs are selected, while in the allocation part the non–hub

nodes have to be allocated to the hub nodes.

In common hub location models the following general assumptions are used:

a. The hub level network is a complete graph.

b. Using inter-hub connections has a lower price per unit than using spoke connections. So we have a discount factor $\alpha \in [0, 1]$ for using inter-hub connections.

c. Direct connections between non–hub nodes are not allowed.

d. Costs are proportional to (e.g. Euclidean) distances and satisfy the triangle inequality

From (a) and (d) it follows that transportation in the hub level is always done directly

Together with (c) this means that every flow is routed via 1 or 2 hubs.

**Model for uncapacitated fixed cost multiple allocation hub location problem**

Let N be the set of all facilities and $W_{ij} \geq 0$ $(i, j \in N)$ be the given flow from facility $i$ to facility $j$. Also, $W_{ii} = 0$, $i \in N$. Let $F_k \geq 0 (k \in N)$ be the fixed cost for establishing a hub facility at node $k$, $I_{lk} \geq 0$, $(k, l \in N; k \leq l)$ be the fixed cost for establishing an undirected hub edge between nodes k and l and also $C_{ijkl} \geq 0 (\in i, j, k, l \in N)$ be the transportation cost per unit of flow that is routed from node $i$ to node $j$ via the potential hub nodes $k$ and $l$.

Let $d_{ij} \geq 0$ is usual cost for shipping one unit of flow directly from $i$ to $j$ & $\alpha \in (0, 1)$ is the discount factor for using the inter-hub connections.Then

$$C_{ijkl} = d_{ik} + \alpha d_{kl} + d_{lj}$$

Let

$$H_k = \begin{cases} 1, & \text{if facility k is a hub node} \\ 0, & \text{otherwise} \end{cases}$$

and

$$U_{kl} = \begin{cases} 1, & \text{if facility k and l are hubs} \\ 0, & \text{otherwise} \end{cases}$$

Let $x_{ijkl} \geq 0$ is the fraction of flow from $i$ to $j$ which is routed via nodes $k$ and $l$. We note that $U_{lk} = H_k.H_l$ for all $k, l \in N, k \leq l$. The problem is formulated [Nickel et al., 2001] as,

$$C_{ijkl} = d_{ik} + \alpha d_{kl} + d_{lj}$$

Let

$$H_k = \begin{cases} 1, & \text{if facility k is a hub node} \\ 0, & \text{otherwise} \end{cases}$$

and

$$U_{kl} = \begin{cases} 1, & \text{if facility k and l are hubs} \\ 0, & \text{otherwise} \end{cases}$$

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$$\text{Min} \sum_{i\in N}\sum_{k\in N}\sum_{l\in N}\sum_{j\in N} W_{ij}C_{ijkl}x_{ijkl} + \sum_{k\in N} F_k H_k + \sum_{k\in N}\sum_{l\in N:l\geq k} I_{kl}U_{kl} \tag{1}$$

subject to

$$\sum_{k\in N}\sum_{l\in N} x_{ijkl} = 1 \ \forall i, j \in N \tag{2}$$

$$\sum_{l\in N} x_{ijkl} \leq H_k \ \forall i, j, k \in N \tag{3}$$

$$\sum_{k\in N} x_{ijkl} \leq H_l \ \forall i, j, l \in N \tag{4}$$

$$U_{kl} \geq H_k + H_l - 1 \ \ \forall k, l \in N : \ k \leq l \tag{5}$$

$$U_{kl} \geq 0 \ \ \forall k, l \in N : \ k \leq l \tag{6}$$

$$H_k \in \{0, 1\} \ \ \forall k \in N \tag{7}$$

$$x_{ijkl} \geq 0 \ \ \forall i, j, k, l \in N \tag{8}$$

Here, in the model, objective function (1) minimizes the total costs. All flow between two nodes *i* and *j* has to be routed via one or two nodes *k* and *l* (2), but only if *k* and *l* are hub nodes((3) and (4)). In (5) and (6), it is ensured that in an optimal solution $U_{kl} = 1$ if and only if $H_k = H_l = 1$.

**Model for application in public transportation (PT Model)**

The current hub location models are not useful for applications in public transportation, because in this case the general assumptions (a), (c), and (d) are often not satisfied. So the requirement that routing in the hub level network must be done directly. The assumptions (a) and (d) are relaxed, because it may often be the case that the distance graph is not complete, the triangle inequality is not valid in public transportation networks, or the fixed

cost for establishing a direct hub edge is higher than the cost for non-direct transportation.

In the hub location models used so far this non–direct transportation cannot be modeled because the Xijkl variables are not sufficient to describe the whole flow paths. In the new model spoke connections are allowed only for the first and last edge of every flow path, and they must begin or end at a hub node. It can also be required that direct connections must be routed via at least one hub (corresponding to general assumption (c)).

Let ε be the set of edges which can be established in the whole hub–and–spoke network, *e.g.* $\varepsilon = \{\{i, j\} \in N^2 : i \leq j\}$. The variables $X_{ijkl}$ defines the fraction of flow of commodity (*i, j*) routed through the hub edge {*k, l*}. Also, define new variables $S_{ijkl} \geq 0, (\forall\ i, j, k, l \in N)$, which determine the fraction of flow of commodity (*i, j*) routed through the spoke edge {*k, l*}. Similarly, define new binary variables $Y_{kl}$ for $k \leq l$ by

$$Y_{kl} = \begin{cases} 1, & \text{if the edge } \{k,l\} \text{ is established as a hub edge} \\ 0, & Otherwise \end{cases}$$

Then constraint (2), which requires that all flow has to be routed, must be reformulated as a flow conservation law for the flow of commodity (*i, j*). Constraints (3) and (4) are rewritten by means of the new *Ykl* variables.

The mixed integer formulation for the Public Transportation Hub Location Problem (PT) based on network design formulations [Magnanti and Wong, 1984 & Balakrishnan et al., 1989] goes like this:

$$\min \sum_{i\in N}\sum_{j\in N} W_{ij}\left(\sum_{\{k,l\}\in\varepsilon} \alpha d_{kl}(X_{ijkl}+X_{ijlk}) + \sum_{k\in N} d_{ik}S_{ijik} + \sum_{l\in N:l\neq i} d_{lj}S_{ijlj}\right)$$

$$+ \sum_{\{k,l\}\in\varepsilon} I_{kl}Y_{kl} + \sum_{k\in N} F_k H_k \tag{9}$$

subject to

$$\sum_{l\in N}(X_{ijkl}+S_{ijkl}-X_{ijlk}-S_{ijlk}) = \begin{cases} +1, & \forall\, i,j,k \in N,\ k=i, i\neq j \\ -1, & \forall\, i,j,k \in N,\ k=j, i\neq j \\ 0, & \forall\, i,j,k \in N,\ k\neq i, k\neq j \end{cases} \tag{10}$$

$$\sum_{l\in N}(X_{iiil}+S_{iiil}) = 1,\ \ \forall\, i \in N \tag{11}$$

$$\sum_{l\in N}(X_{iili}+S_{iili}) = 1,\ \ \forall\, i \in N \tag{12}$$

$$X_{ijkl} \leq Y_{kl},\ \ \forall\, i,j \in N, \{k,l\} \in \varepsilon \tag{13}$$

$$X_{ijlk} \leq Y_{kl}, \ \forall i,j \in N, \{k,l\} \in \varepsilon \tag{14}$$

$$S_{ijik} \leq H_k, \ \forall i,j,k \in N : k \neq j \tag{15}$$

$$S_{ijkj} \leq H_k, \ \forall i,j,k \in N : k \neq i \tag{16}$$

$$S_{ijij} \leq H_i + H_j, \ \forall i,j \in N \tag{17}$$

$$S_{ijkl} = 0, \ \forall i,j,k \in N : k \neq i, \ l \neq j \tag{18}$$

$$Y_{kl} \leq H_k, \ \forall \{k,l\} \in \varepsilon \tag{19}$$

$$Y_{kl} \leq H_l, \ \forall \{k,l\} \in \varepsilon \tag{20}$$

$$S_{ijkl}, X_{ijkl} \geq 0, \ \forall i,j,k,l \in N \tag{21}$$

$$Y_{kl}, H_k \in \{0,1\}, \ \forall k,l \in N. \tag{22}$$

The first constraints are the flow conservation law for the flows of commodity *(i, j), $i \neq j$* (10) and (i, i) ((11) and (12)). The latter is only needed if $W_{ii} \neq 0$ for some $i \in N$. In (13) and (14) itis required that inter-hub connections must be routed via hub edges. Constraints (15) and (16) describes the requirement that spoke connections must begin or end at a hub. Direct connections must also be routed via at least one hub (17), which is exactly general assumption (c). These constraints may be dropped in some applications for public transportation. Constraint (18) allows the only spoke connections for the first and last edge of every flow path. Hub edges must begin and end at a hub node ((19) and (20)).

As the edge $\{k, l\}$ will be used only in one direction on a path from *i* to *j*, constraints (13) and (14) can be written as

$$X_{ijkl} + X_{ijlk} \leq Y_{kl} \ \forall \{k,l\} \in \varepsilon \tag{23}$$

An aggregation over the constraint (23), by summing up over all commodities (*i, j*) will reduce thenumber of constraints, but unfortunately it also makes the LP relaxation weaker

[Balakrishnan etal., 1989]. There exists an optimal solution of PT in which all $X_{ijkl}$ and $S_{ijkl}$ variables are binary,as it is usual in uncapacitated multiple allocation hub location problems. This means that all flow between each pair of nodes is routed only via one path. Also $Y_{kl} = 1$ for some $\{k, l\} \in \varepsilon$ implies $S_{ijkl} = 0$ for all $i, j \in N$ in an optimal solution of PT.

## SOLUTION TECHNIQUES

The new model PT has $O(|N|^4)$ variables and $O(|N|^4)$ linear constraints required. However, for network design problems several exact and good heuristic solution algorithms are known, e.g. dual ascent methods [Balakrishnan et al., 1989] and branch–and–bound algorithms using Bender's Decomposition [Magnanti and Wong, 1984] so that those methods can be applied also for solving the new hub location problem PT.

If the set of hubs H is already fixed, i.e. the location part is solved, the allocation part of an uncapacitated multiple allocation hub location problem can be solved by an all–pairs shortest–path algorithm, e.g. the Floyd–Warshall algorithm [Ahuja et al., 1993],

in time complexity $O(|H|.|N|^2)$ [Ernst and Krishnamoorthy, 1998a], where every shortest path must be routed only via hub nodes. For the location part one can apply an exact enumeration algorithm, branch–and–bound techniques using clustering theory [Ernst and Krishnamoorthy, 1998b] and several heuristics, e.g. Greedy or interchange [Ernst and Krishnamoorthy, 1998a].

Now, in the PT model, the hub location problem consists of three parts: There are two location parts, one for the location of the hub nodes and one for the location of the hub edges, and the allocation part. The allocation part can be solved again by an all–pairs shortest path algorithm. Hub edges must be used on every shortest path except for the first and last edge.

If the set of hub nodes H is already fixed, then there are $2C(|H|,2)$ possibilities to locate hub edges. An exact algorithm may only be useful for very small |H|, so again a heuristic algorithm has to be developed. The idea of such a heuristic algorithm is to let the hub level be connected, because for transportation in the hub level it can be taken advantage of the discount factor α for many flow paths. A least expensive connected starting configuration would be a (fixed–cost) minimal spanning tree (MST), which can be computed efficiently in $O(|H|2)$ time by means of e.g. the shortest–path algorithm of Dijkstra [Ahuja et al., 1993]. We can apply a Greedy and/or interchange heuristic to this MST to improve the objective value of the hub location problem.

## CONCLUSION

Starting with the Uncapacitated Fixed Cost Multiple Allocation Hub Location Problem (with additional fixed costs for hub edges), a new mixed integer formulation for hub location problems is presented, which is applicable for public transportation network not only to serve passengers but also to carry goods from origin to destination with minimum transportation cost. The requirements are relaxed so that the hub level has to be a complete graph. The formulations are based on network design problems, in which every flow path can use more than one hub edge. The model still requires that spoke edges are only allowed to be used as the first and last edge of every flow path. The solution approaches described in this paper are to be implemented and tested on numerical examples in future. Bounds gained from heuristics can be used to construct branch–and–bound–algorithms.

The feasibility polytopes of the LP relaxations may be examined to determine facets. From the modelling view even better applicable models can be found. As the model described here mainly consider the objective of cost minimizing, some other objectives may be defined and included. Capacitated versions of the new models are still to be studied, i.e. some or all hub nodes and/or hub edges can only deal with a limited amount of passenger flow.

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