TQH

Incidental Accessibility

How Mainstream Technology Is Expanding Accessibility in India

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Government of India
Ministry of Social Justice & Empowerment
Department of Empowerment of Persons with Disabilities (Divyangjan)

MESSAGE

It gives me immense pleasure to be associated with the launch of the white paper on ***Incidental Accessibility: How Mainstream Technology is Expanding Accessibility in India***.

The paper highlights how mainstream technology is increasingly creating new opportunities for persons with disabilities, often in ways that were not originally intended as accessibility solutions. Everyday technologies such as smartphone's, voice assistants, captions and digital platforms can significantly enhance independence, participation and inclusion.

I hope this white paper will contribute to a deeper understanding of the potential of mainstream technology in advancing accessibility and encourage policymakers, technology developers and other stakeholders to foster more inclusive and accessible solutions.

I congratulate the authors and all those associated with this important initiative and wish the launch every success.

Best Wishes,

MNanda

(Manmeet Kaur Nanda)
15/09/2026

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Accessible India Campaign

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Glossary

ADHD - Attention Deficit Hyperactivity Disorder

ADIP - Assistance to Disabled Persons for Purchase/Fitting of Aids and Appliances Scheme

AI - Artificial Intelligence

ALS - Amyotrophic Lateral Sclerosis

ANC - Active Noise Cancellation

APD - Auditory Processing Disorder

API - Application Programming Interface

ASR - Automatic Speech Recognition

AV - Audio/Video

BIS - Bureau of Indian Standards

CCTV - Closed-Circuit Television

CDSCO - Central Drugs Standard Control Organisation

CRS - Compulsory Registration Scheme

CSR - Corporate Social Responsibility

dB - Decibel

DEPwD - Department of Empowerment of Persons with Disabilities

DIY - Do-It-Yourself

DoT - Department of Telecommunications

DPDP Act - Digital Personal Data Protection Act, 2023

ERM - Eccentric Rotating Mass (actuator)

ETA - Equipment Type Approval

FDA - Food and Drug Administration (United States)

GST - Goods and Services Tax

ICT - Information and Communication Technology

IDC - International Data Corporation

IEC - International Electrotechnical Commission

IIT - Indian Institute of Technology

IoT - Internet of Things

IoTSCS - IoT System Certification Scheme

IS - Indian Standard

LLM - Large Language Model

LRA - Linear Resonant Actuator

MeitY - Ministry of Electronics and Information Technology

MTCTE - Mandatory Testing and Certification of Telecommunication Equipment

NHS - National Health Service (United Kingdom)

OS - Operating System

PwD / PwDs - Person with Disability / Persons with Disabilities

RPwD Act - Rights of Persons with Disabilities Act, 2016

STQC - Standardisation Testing and Quality Certification Directorate

TEC - Telecommunication Engineering Centre

TRAI - Telecom Regulatory Authority of India

UPI - Unified Payments Interface

WCAG - Web Content Accessibility Guidelines

WER - Word Error Rate

WPC - Wireless Planning and Coordination Wing

XR - Extended Reality

Preface

Most conversations about assistive technology start with devices built specifically for persons with disabilities. *Assistive Technologies* refer to products and services, such as wheelchairs, hearing aids, and digital products and services designed primarily to improve the lives of people with temporary or permanent functional difficulties.[1] These tools, therefore, matter enormously, and for many people they are life-changing. However, because the market for specialised assistive technology is often perceived as relatively small, products designed exclusively for persons with disabilities can be expensive, difficult to scale and harder to access, particularly in a country like India. This creates an opening for mainstream technologies, which can sometimes offer accessibility benefits at a scale and cost that specialised products cannot.

Take the smartwatch, for example. Fall detection was added as a safety feature for hikers and people prone to everyday accidents. It is now used by older adults with balance disorders, people with mobility impairments, and individuals who live alone and want the assurance that help can be summoned automatically. Voice assistants, similarly, began as instruments of convenience, built around small efficiencies: turning off lights, setting reminders, skipping a track without leaving one's seat. But their significance shifts entirely when seen through a different lens. For someone with a locomotor impairment, these same tools are not about marginal gains in efficiency; they reshape the terms of daily living. Tasks that once required assistance can now be performed independently, quietly restoring a measure of dignity and control. What was designed as a layer of ease has, in practice, become a means of autonomy. Noise-cancelling headphones were initially made for frequent flyers and open-plan offices. Many autistic users and people with sensory sensitivities now use them to manage environments that would otherwise be overwhelming.

A similar arc is visible in dictation software. Originally built to speed up typing and streamline workflows, it has become indispensable for people with visual impairments, learning disabilities, or limited hand mobility. For someone with a locomotor disability, voice dictation is often the most practical way to write independently. Parts of this preface itself were in fact drafted using speech-to-text software rather than a keyboard.

However, policy often fails to acknowledge the empowering role such technologies play in the lives of persons with disabilities (PwDs). Most of these technologies continue to be treated as mainstream consumer products across regulatory and policy frameworks, including tax and certification regimes, even though, for many users, they function as assistive technology in every meaningful sense.

This report examines five categories of widely available technologies that are already playing that role: smart home devices, dictation software, AI-based smart glasses, haptic feedback and headphones. These were chosen for their strong accessibility use-case, covering diverse kinds of needs across disabilities. It maps the evolving policy landscape in which these technologies

[1] "Global Report on Assistive Technology." World Health Organization and United Nations Children's Fund (UNICEF), 2022, https://iris.who.int/server/api/core/bitstreams/17a1cbf6-be26-466c-9fca-ab80eeb2d192/content

are developed, deployed and scaled, and further explores the tensions and debates shaping this ecosystem of mainstream technology with incidental accessibility benefits.

The report starts from the premise that access to technology for persons with disabilities is closely tied to independence, participation and dignity. It makes a simple argument: mainstream technology is already expanding accessibility, whether through accessibility features built into products or through uses that users have discovered themselves. The question, then, is how will India's policy landscape evolve alongside these technologies to shape the markets that determine which innovations emerge, scale and become meaningfully empowering for persons with disabilities.

Executive Summary

This report examines mainstream, consumer-market technologies that serve an accessibility function for persons with disabilities, whether through accessibility features built into the product or through uses that users have discovered and adapted themselves. It terms this broader phenomenon *Incidental Accessibility*: accessibility benefits that emerge from mainstream products, rather than products built specifically for users with disabilities. This phenomenon is further examined through five widely available technologies covered across five chapters, referred to as *Incidental Assistive Technologies* in this report.

The five examples, however, are not intended to suggest that these are isolated use cases. A larger question is how widespread this form of incidental accessibility is, and how many persons with disabilities already rely on mainstream technologies in this way. That question is difficult to answer with precision.

Manufacturers building for the mainstream market rarely track accessibility use cases, while disability surveys tend to focus on recognised assistive technologies rather than mainstream consumer products that have acquired an accessibility function. India's official data on disability is itself outdated. The 2011 Census, conducted more than a decade ago, measured disability across seven categories, while the Rights of Persons with Disabilities (RPwD) Act, 2016 subsequently expanded the legal definition to twenty-one categories. Besides, disability questions in the census were not framed from a social lens as defined under the Washington Group of Questions embraced by developed countries.[2] As a result, the 2011 census count of 26.8 million persons with disabilities - 2.21% of the population - significantly underrepresents the number of people[3] who could benefit from incidental assistive technologies.[4]

Taken together, these gaps make it difficult to precisely measure the extent of incidental accessibility in India. This report therefore traces the phenomenon through individual experiences of how mainstream technologies are already being used as access technologies. It draws on structured interviews with five persons with disabilities, each centred on one incidental assistive technology that has become part of how they navigate daily life. These accounts are supplemented by research into the technologies themselves, including interviews with representatives from some of the companies building these, as well as a review of the wider literature and policy landscape.

Note on Format: Unlike a conventional policy paper, this report uses a first-person narrative and interview-based format to foreground the lived experiences of persons with disabilities.

[2] Washington Group on Disability Statistics. (2022, October). Washington Group Short Set on Functioning (WG-SS). https://www.washingtongroup-disability.com/fileadmin/uploads/wg/Washington_Group_Questionnaire__1_-_WG_Short_Set_on_Functioning__October_2022_.pdf

[3] "Disabled Population by Type of Disability, India: Census 2011." Census of India 2011, Office of the Registrar General & Census Commissioner, Government of India, 2011, https://www.censusindia.gov.in/nada/index.php/catalog/2255

[4] "India's Commitment to Disability Rights." *Press Information Bureau*, Government of India, Dec. 2025, www.pib.gov.in/PressReleasePage.aspx?PRID=2197426&reg=3&lang=2.

The aim is to ensure that the legal and policy questions explored in this report do not become so abstract that they obscure the people and experiences at the heart of them. The individual accounts are, however, supplemented with wider research to situate these experiences within the broader community of persons with disabilities.

The five people featured in this report illustrate the range of ways in which mainstream technology can acquire an accessibility function. Rahul is blind and uses AI-enabled smart glasses to navigate conferences and interpret his surroundings. Shishir, a wheelchair user, uses smart home devices to manage tasks around his home. A locomotor disability limits Amrit's use of his fingers, so he relies on dictation rather than typing to write. Kushagra, who is hearing impaired, uses haptic feedback from his smartwatch to know when his phone is alerting him. Sakshi, who has ADHD (Attention-Deficit Hyperactivity Disorder), uses noise-cancelling headphones to manage sensory overload and focus at work. For each of them, a mainstream technology they encountered for reasons other than disability has become an important part of living with greater independence.

Across these experiences, a consistent pattern emerges: mainstream consumer technologies can acquire significant assistive uses for persons with disabilities. Some of the technologies examined were primarily developed for mainstream purposes such as photography, fitness, productivity or convenience. Yet users with disabilities identified accessibility applications that manufacturers may not have anticipated. In other cases, such as voice assistants, smart glasses and text-to-speech technologies, accessibility considerations either featured at the initial design stage itself, or user-driven adoption later prompted more deliberate accessibility-focused development. A common thread across all five technologies is that they are not primarily marketed as assistive technology, even though they can serve meaningful assistive functions.

Several chose these products over dedicated assistive technologies for reasons that went beyond functionality. Consumer products can be less socially conspicuous than specialised devices, allowing users to avoid having their disability signalled visibly. Cost was another recurring consideration. Dedicated assistive devices can cost substantially more than their mainstream equivalents, although even some mainstream products can remain expensive for users in India.

The benefits, however, are not without limitations. Most such technologies depend on batteries, network connectivity or cloud processing to function, so a dead battery or a dropped connection can cut off the accessibility benefit entirely. They are also not usually built with the full range of needs of persons with disabilities in mind. This could lead to a speech pattern not being recognised by a dictation tool or a level of accuracy an AI description may not reliably convey. And while these technologies are markedly cheaper than dedicated assistive devices, cost and quality remain tiered even within the mainstream market, such that the most reliable versions are often the least affordable.

Where they do help, they usually complement the assistive tools a person already relies on - rather than replacing them fully - extending the range of ways a person with a disability can interact with their surroundings. In doing so, they can fill gaps that India's formal assistive technology ecosystem continues to struggle with, particularly given affordability and access. Yet most assistive technology in use is still purchased privately and out of pocket rather than provided through government schemes.[5]

Despite these emerging accessibility use cases for mainstream technologies, the policy landscape has not evolved alongside them. Conversations with manufacturers, policymakers and disability-rights advocates, together with a review of the existing literature, point to three broad areas where this gap is most visible: **how assistive use is recognised and supported through fiscal and procurement frameworks; how existing accessibility standards are translated into the design and market pathways of mainstream technology; and how the data and AI systems on which many of these technologies depend are governed.**

India's existing assistive technology support, including through schemes such as the Assistance to Disabled Persons for Purchase/Fitting of Aids and Appliances Scheme (ADIP) and GST concessions for specified assistive devices, is built around recognised categories of assistive technology. Incidental assistive technologies generally fall outside these frameworks, even when they perform an assistive function in practice. Some companies have stepped in through corporate social responsibility programmes, but these depend on what an individual company chooses to fund, and cannot substitute for a systemic policy response.

A similar gap is evident in how these devices reach the market. India's disability law, the Rights of Persons with Disabilities (RPwD) Act, 2016, already establishes an expectation that consumer-facing technology should be accessible, not only products designed specifically for persons with disabilities. India's ICT accessibility standard, IS 17802, translates this into technical requirements. Yet it is not always clear how these accessibility requirements connect with the product-specific regulatory process through which mainstream products reach the market. As a result, a product can meet the requirements governing its safety, spectrum use and security while accessibility remains unevenly integrated into how it is designed and brought to users.

This report also notes that most incidental assistive technologies rely on personal data such as voice, location, health signals, images and video. The collection and processing of this data is often integral to the functionality that makes these technologies accessible. The Digital Personal Data Protection (DPDP) Act, 2023 provides a general framework for governing personal data, but its application becomes more complicated when data is captured incidentally. A smart speaker registered to one person may capture the voices of everyone in the room, while AI-enabled smart glasses can capture people around the wearer without any direct interaction between those individuals and the company processing their data. A similar tension arises in AI development: people who could benefit most from better-trained models, including those with atypical speech patterns, are often underrepresented in training datasets, while the current legal

[5] "Assistive Technology Usage, Unmet Needs and Barriers to Access: A Sub-Population-Based Study in India," National Library of Medicine (PMC), Aug. 2023, pmc.ncbi.nlm.nih.gov/articles/PMC10442958/.

framework provides limited clarity on how such data can be responsibly anonymised and used for AI model training.

The treatment of guardianship under the DPDP framework provides a useful illustration of why disability needs to be considered actively in technology policy. The original formulation of the Act risked treating a person with a disability who had a guardian as requiring guardian consent, without adequately distinguishing between disability and decision-making capacity. The final Rules narrowed this approach following public consultation and aligned the requirement more closely with the functional approach under the RPwD framework. The episode demonstrates the value of applying a disability lens during policy design rather than assuming that general rules will automatically work for persons with disabilities.

The illustration above spotlights a recurring pattern we observe across India's policy landscape. Accessibility is often considered after a framework has been designed, emerging through litigation or advocacy, rather than being treated as a standing consideration in the policy process.

The answer, however, is not to simply reclassify mainstream consumer products as assistive devices. Doing so could delay market entry and increase costs, reproducing some of the barriers that have made dedicated assistive technology expensive and difficult to access in the first place. **Instead, this report makes a targeted case: fiscal, procurement and accommodation frameworks should be able to recognise assistive use without requiring formal assistive classification, and accessibility should become a standing consideration in technology policy, weighed alongside safety, security and innovation, rather than addressed separately after the fact.**

01

Smart Home Devices

This chapter draws on an interview with **Shishir Bhatnagar**, conducted in May, 2026. Shishir has a locomotor disability and has used smart home devices since 2014.

Shishir did not go looking for assistive technology when he set up his first smart home device. He was recovering from an injury and beginning to use a wheelchair when a pilot programme brought an Alexa speaker, a few smart plugs, and some smart bulbs into his home. With this he began controlling the home setup entirely by voice. He could adjust fan speed and air conditioner temperature without locating a switch or picking up a remote.

Each of these actions is small on its own. Taken together over the course of a day, however, they remove a substantial amount of physical effort, and a substantial number of requests he would otherwise make of a caregiver. The cumulative effect of these small changes has allowed him to move more independently in his day-to-day life.

Manufacturers built these devices for the mainstream consumer market. Amazon, Google and Apple sold smart speakers as convenience products, marketed on music, timers and shopping.[6] They were designed to solve small everyday frictions for mainstream users. For a person with a locomotor disability, however, those same small conveniences became a meaningful gain in independence.

A 2020 study of voice assistant accessibility found that research on these systems had largely focused on able-bodied users, with relatively few studies examining how well they work for people with disabilities, despite this being an important consumer group.[7] The authors highlight how voice control can remove some of the physical and visual demands that make conventional interfaces difficult to use. For people with motor or cognitive disabilities who may currently rely on caregivers for everyday tasks, voice assistants can therefore offer a way to perform some of these tasks more independently. Interviews and ethnographic studies have also recorded how persons with disabilities use this tech but there is a lack of evidence on just how many use them, in which context and to what extent.

Smart home technology often takes two forms: the **consumer or do-it-yourself (DIY) stack**, assembled by the user from off-the-shelf devices, and the **professionally integrated stack**, wired into the home by an installer.

The two approaches differ significantly in both cost and installation requirements. A DIY setup typically costs between Rs. 5,000 and Rs. 30,000 (about US$30 to US$300), while a professionally integrated system can cost upwards of Rs. 1.5 lakh (about US$1,575) for a two-bedroom home. These differences in cost and infrastructure have important implications for who can access each type of system and how useful it can be for people with different levels of mobility.

[6] Gibbs, Samuel. "How Smart Speakers Stole the Show from Smartphones." *The Guardian*, Guardian News and Media, Jan. 2018, www.theguardian.com/technology/2018/jan/06/how-smart-speakers-stole-the-show-from-smartphones.

[7] Masina, Fabio, et al. "Investigating the Accessibility of Voice Assistants with Impaired Users: Mixed Methods Study." *Journal of Medical Internet Research*, U.S. National Library of Medicine, Sept. 2020, pmc.ncbi.nlm.nih.gov/articles/PMC7547392/.

This chapter examines how each works, traces how users with disabilities like Shishir deploy them day to day, while highlighting some of their limitations.

1.1. The Market for Smart Home Devices

While voice assistants have a longer history, Amazon's Echo, launched in 2014, marked the emergence of the smart speaker as a mainstream consumer product. Dedicated environmental control systems, by contrast, have existed in some form since the 1960s, but have traditionally been far more specialised and expensive.

Table 1.1. Overview of both smart home systems

Component	Function	Leading suppliers	Indicative Indian price
Voice-controlled speaker	Acts as the hub; receives commands and controls connected devices	Amazon Echo, Google Nest, Apple HomePod	Rs. 3,400 upward (about US$35)
Smart plug	Connects the wall socket with the appliance and makes any devices voice and app controllable	Wipro, Oakter, TP-Link, Amazon, Zebronics	From Rs. 650 (about US$7)
Smart bulb	Replaces an ordinary bulb; responds to voice for switching, brightness, colour and timers	Philips (Signify), Wipro, Syska	Rs. 500 upward (about US$5)
Smart lock	Allows door operation without physical reach	Godrej, Yale, Qubo	Rs. 8,000 upward (about US$84)
Professional integrated system	Control layer wired into the home; supports assistive input devices	Schneider Electric, Honeywell, ABB	From Rs. 1.5 lakh (about US$1,575)

Smart home devices have been adopted at scale, though no dataset separately identifies buyers with disabilities from the rest. In India, Amazon reported that smart home devices connected to Alexa in Indian homes grew by more than 200 per cent over three years.[8] According to TechInsights, global smart speaker and display market shipments reached 156

[8] "200% Increase in Smart Home Devices Connected to Alexa in Last 3 Years: Amazon." *Economic Times Telecom*, Feb. 2024, telecom.economictimes.indiatimes.com/news/devices/200-increase-in-smart-home-devices-connected-to-alexa-in-last-3-years-amazon/107545695.

million shipments in 2025; Amazon, Google and Apple together account for the large majority of this market.[9]

The cost of smart plugs, such as the Wipro 10 Amp Smart Plug, has fallen from about Rs. 2,200 (US$24) in 2022 to Rs. 750 (about US$8) in 2026, with other brands showing similar price reductions. As component costs have fallen, a basic voice-controlled setup can now cost less than a single dedicated assistive device, bringing this technology within reach of users who might otherwise never have considered, or had access to, a dedicated environmental control unit.

1.2. Architecture of Home-Automation and Smart Home Appliances

1.2.A. Consumer/ Do-it-yourself (DIY) Stack

The consumer or DIY stack is what people picture when they think of a smart home. It is relatively affordable, works in a rented apartment and is buildable by adding one device to the network at a time. This is a convenient measure for everyday tasks such as switching lights on or off with voice, controlling appliances with smart plugs and getting questions answered through voice commands.

Box 1.1. What makes up a DIY home automation stack

All devices within this stack are connected to a voice-controlled speaker. Smart bulbs are then connected to this speaker to turn them on/off or change hue and brightness with voice. A smart plug is needed for other home electrical appliances to be connected to the speaker. When the appliance is plugged into the wall with a smart plug, a person can turn fans, kettles, water heaters on and off through voice commands or from a phone app.

These components can generally be purchased separately and, in many cases, can come from different brands. The key requirement is that the smart plugs are compatible with the same voice assistant or home automation platform, rather than necessarily being from the same brand.

1.2.B. Professional Stack

The professional stack builds control into the home directly. An installer replaces switchboards, adds motion sensors and voice points, and programmes the system to act without commands. A light comes on when someone enters a room and stays on until told otherwise.

Box 1.2. How a professional stack works

Key components include touch panels, scheduled electronic controls, and motion and voice triggers. Some more assistive controls can also be integrated here such as eye-gaze

[9] "Smart Speaker Market Size, Trends, Share & Research Report 2031." *Mordor Intelligence*, 2026, www.mordorintelligence.com/industry-reports/smart-speaker-market

systems, head trackers and scanning interfaces all of which help people with severe locomotor disabilities navigate and operate appliances in their surroundings.[10] Because it replaces the physical switches themselves, the user never needs to reach a switchboard, a socket or a control panel. While the consumer stack removes the need to reach *some* controls; the professional stack removes the need to reach any. The system usually runs on local hardware and therefore it can keep working through internet outages.

This setup can be found in high end newly constructed homes and offices where wiring and infrastructure can be integrated during the early stages of construction.[11]

The consumer stack costs a fraction of the professional stack and can be installed in almost any home. The professional stack, however, is the one that can integrate specialised assistive input devices and continue to function without an internet connection. This creates a significant accessibility gap: the system best suited to people with severe motor impairments is often the one that is least affordable or practical, particularly for someone living in a rented home.

1.3. Incidental Benefits for Persons with Disabilities

Home automation through smart home devices have an incremental but significant impact on enhanced accessibility and independent living for persons with disabilities. However, the functional support that automation provides varies as per the type of stack used.

For people with mobility impairments, the consumer stack addresses a meaningful subset of daily tasks through voice and app control. The professional stack goes further, replacing physical switches altogether, so that even reaching for a control is no longer necessary.

For people with progressive neurological conditions such as Amyotrophic Lateral Sclerosis (ALS) or Parkinson's disease, the consumer stack may be useful in early stages when voice and smartphone use is still viable.[12] Unfortunately, up to 75% of patients with Parkinson's disease experience voice and speech impairments that worsen over time.[13] When that happens, voice-assisted technology can struggle to recognise dysarthric or disordered speech, making the consumer stack increasingly unreliable as neurological conditions progress.[14] The professional stack, by contrast, supports a wider range of input modalities, including eye-gaze,

[10] **Eye-gaze systems** track where a user is looking and let them select on-screen options by holding their gaze. **Head trackers** translate small head movements into cursor movement. **Sip-and-puff** devices let a user issue commands by breathing in or out through a tube. **Switch scanning** presents options in sequence and lets a user select with a single button press, which may be operated by hand, head or foot.

[11] "Home Automation Cost in India: What Homeowners Should Expect." *OOB Smart Home Design*, 2026, www.oobsmarthome.com/blog/home-automation-cost-in-india-what-homeowners-should-expect.

[12] Mills, Jodie, et al. "Voice-Assisted Technology for People with Parkinson's Disease Experiencing Speech and Voice Difficulties: Co-Designing Solutions Using Design Thinking." *JMIR Rehabilitation and Assistive Technologies*, U.S. National Library of Medicine, Feb. 2026, pmc.ncbi.nlm.nih.gov/articles/PMC12917486/.

[13] Lee, Sol-Hee et al. "Smartphone Application-Based Voice and Speech Training Program for Parkinson Disease: Feasibility and Satisfaction Study With a Preliminary Rater-Blinded Single-Arm Pretest and Posttest Design." *Journal of medical Internet research* vol. 27 e63166. 13 Feb. 2025, https://pmc.ncbi.nlm.nih.gov/articles/PMC11888063/

[14] **Dysarthria** is a motor speech disorder in which weakness or poor control of the muscles used for speech makes words slurred, slow or hard to understand. It commonly accompanies conditions such as Parkinson's disease, ALS and cerebral palsy. Voice recognition systems trained on typical speech patterns often fail to interpret it.

head tracking, sip-and-puff and switch scanning, allowing it to remain useful even as a person's motor abilities change.[15]

For blind and low-vision users, both stacks work. Voice control needs no screen, and companion apps are usually screen-reader compatible. The professional stack adds automated routines, so home devices adjust themselves and the user does not have to track and command every device.[16] Deaf and hard-of-hearing users can enable these professional systems to replace audio alerts with visual signals and screen notifications. The consumer stack can offer some of the same functionality, but integration is often inconsistent across devices and varies by brand.

For people with cognitive impairments, automated routines can be more useful than voice commands that have to be learned and recalled. The professional stack can be designed around these routines from the outset, while the consumer stack can be configured to provide some of the same functionality.

Research on home automation use by people with physical disabilities further supports this picture. Users with cerebral palsy report using both voice and touch control, and switching between them as fatigue makes speech harder. Alternative input methods are therefore a practical necessity, not merely a convenience.

1.4. Limitations

The functional utility of these set ups is accompanied by high costs, which emerges as the most immediate constraint. A person with a disability may need several devices simultaneously to reach a functional baseline: a voice speaker, smart plugs, compatible bulbs, and potentially a smart lock. This means the upfront cost is fundamentally different from that for an able-bodied consumer, who may add devices incrementally over time as a matter of convenience. Shishir noted that government-distributed assistive technology in India tends toward substandard devices, and that quality smart home products remain a private-market proposition with no systematic support.

The consumer stack also places the burden of setup and configuration on the user or their family. Installing and pairing devices, setting up routines, troubleshooting connectivity, and managing app permissions requires a degree of technical familiarity that cannot be assumed. For a person with a disability who may have limited motor control or vision, and whose family members may not be technically confident, this barrier rarely features in product marketing but frequently determines whether a device gets used at all.

[15] Mills, Jodie, et al. "Voice-Assisted Technology for People with Parkinson's Disease Experiencing Speech and Voice Difficulties: Co-Designing Solutions Using Design Thinking." *JMIR Rehabilitation and Assistive Technologies*, U.S. National Library of Medicine, Feb. 2026, pmc.ncbi.nlm.nih.gov/articles/PMC12917486/.

[16] An **automated routine** is an action the system performs on its own when a condition is met, rather than when the user asks. For example, a motion sensor detects a wheelchair user entering a room and switches on the light, so they do not have to reach a switch or issue a command. A light switched on by voice is a command; a light that switches itself on is a routine.

A stable internet connection is a precondition for both stacks in most configurations. The Telecom Regulatory Authority of India (TRAI) reported roughly 1,087 million broadband subscribers in June 2026.[17] Only 47.7 million of those were fixed wired connections, and wireline density stood at about 3.4 per cent.[18] Indian households connect overwhelmingly through mobile networks rather than home broadband.[19] The consumer stack relies heavily on cloud connectivity. A dropped internet connection can therefore disable voice commands, automation routines and app-based control simultaneously.

In Indian urban homes where connectivity can be inconsistent, this is not a hypothetical problem. For an able-bodied user a brief outage is an inconvenience. However, for someone who depends on the system to operate lights, fans, or door locks, it is a more serious interruption to basic functioning. The professional stack can be configured to run locally and is therefore more resilient, but this adds to installation complexity and cost.

1.5. Conclusion

A device designed for hands-free convenience, to play music, set timers or check the weather, can become a meaningful source of independence for Shishir. He no longer needs to rely on someone else to adjust the fan or turn on a light.

Yet this incidental use also highlights a policy gap. India's certification and regulatory frameworks are built around a product's intended function, and do not readily account for the assistive role a mainstream device can acquire through use. Chapter 6 examines these policy tensions in greater detail.

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[17] "TRAI (Press Release No. 104/2026)." *Telecom Regulatory Authority of India*, June 2026, www.trai.gov.in/sites/default/files/2026-07/PR_No104of2026_0.pdf.

[18] "'Indian Telecom Services Performance Indicator Report' for the Quarter January - March, 2026." *PIB*, June 2026, www.pib.gov.in/PressReleasePage.aspx?PRID=2276780&reg=3&lang=1

[19] Chowdhuri, Madhura. "The True Measure of Digital Inclusion Is How Effectively People Use Opportunities Offered." *Down To Earth*, June 2026, www.downtoearth.org.in/governance/the-true-measure-of-digital-inclusion-is-how-effectively-people-use-opportunities-offered.

02

Speech Technologies

This chapter covers two forms of speech technology in turn before considering the limitations they share. It also draws on an interview with **Amrit Hallan**, conducted in June, 2026. Amrit has a locomotor disability and first began using dictation on his computer in 2008. He types with one finger and uses a power wheelchair, and he needed a tool that would let him build a writing career. He discovered speech-to-text software in 2008 and used the same product for the next decade, because nothing else on the market worked for him. Making it usable, however, took sustained effort. He spent a considerable amount of time training it with his own vocabulary so that it could learn how he spoke and accurately transcribe his dictation.

Speech-to-text software began as a productivity feature for people who wanted to write faster while keeping their hands free. This technology, commonly known as dictation software, can significantly speed up the writing process. A 2016 Stanford study found that speaking is roughly three times faster than typing on a smartphone, and more accurate too.[20] For most people, these tools make everyday workflows more efficient. For Amrit, however, they enabled something more fundamental: the ability to build a writing career.

Notably, users with speech loss and similar challenges, too, have turned to speech technologies for assistance and accessibility support. Text-to-speech services, which turn written text into spoken audio, help those with ALS in communication and work tasks, thereby enhancing their sense of independence and participation in the society.

Both of these technologies started as productivity tools, but have evolved into important access technologies for persons with disabilities, serving different groups and addressing different barriers to communication.

2.1. The Market for Speech Technologies

When Amrit began his career, Dragon Dictate was the only dictation tool available to him. This was released in 1990 as the first consumer speech-to-text product. Nuance (later acquired by Microsoft) rebranded it in 1997 and sells it today as Dragon Professional. It cost Amrit Rs. 24,000 in 2008, roughly Rs. 50,000 (US$555) in 2026 terms. He bought it because nothing else worked; not because it worked well. He spent another Rs. 40,000 on upgrades over the years. Since then, the market has expanded, with more options available at significantly lower prices.

Table 2.1. Overview of leading speech technology products, 2026

Product	Developer	Type	Price
Dragon Professional v16	Nuance (Microsoft)	Speech-to-text, on-device	US$699.99 one-time

[20] Ruan, Sherry, et al. "Comparing Speech and Keyboard Text Entry for Short Messages in Two Languages on Touchscreen Phones." *arXiv.Org*, Jan. 2018, arxiv.org/abs/1608.07323.

Wispr Flow	Wispr	Speech-to-text, cloud	Free tier; Pro US$15/month or US$144/year 2,000 words per week on free tier
Aqua Voice	Aqua Voice	Speech-to-text, cloud	US$8/month or US$96/year
Whisper	OpenAI	Speech recognition model	Free, open source
Built-in dictation	Apple, Google, Microsoft, OpenAI	Speech-to-text	Free with device or service
ElevenLabs	ElevenLabs	Text-to-speech, voice cloning	Free tier (10,000 credits/month); paid plans from US$6/month for individuals; free licenses under their impact program
IndicWhisper	AI4Bharat, IIT Madras	Speech-to-text, Indian languages	Free, open source, supported by MeitY

The potential for users to access these technologies is also being shaped by a rapidly expanding commercial market. Venture funding for voice AI rose from about US$315 million in 2022 to US$3.75 billion in 2026.[21] ElevenLabs raised US$500 million in February 2026 at an US$11 billion valuation.[22] Wispr Flow raised US$81 million in 2025.[23] The five largest vendors hold roughly 45 per cent of the voice recognition market.[24]

Bhashini, under the Ministry of Electronics and Information Technology (MeitY), is developing speech services across Indian languages and offering them through open APIs.[25] AI4Bharat at IIT Madras has also released IndicWhisper, an open-source model that fine-tunes OpenAI's Whisper on extensive Indian-language datasets, including Vistaar and Kathbath, to improve recognition accuracy. Together, these developments point to a speech technology ecosystem that is increasingly well-funded, competitive and capable of supporting a wider range of users and use cases.

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[21] "Voice AI - 2026 Market & Investments Trends - Tracxn." *Voice AI*, Aug. 2026, tracxn.com/d/sectors/voice-ai/__ooDO2Zv7I7Lr6Wb6_VbfEVpA8rhLHYzpKzl-EEZFlGw.

[22] Staniszewski, Mati, and Piotr Dabkowski. "ElevenLabs Raises $500M Series D at $11B Valuation." *ElevenLabs*, Feb. 2026, elevenlabs.io/blog/series-d.

[23] Kothari, Tanay. "WISPR Raises New Funding, to Build the Voice OS: WISPR Flow." *Wispr Raises New Funding, to Build the Voice OS | Wispr Flow*, Nov. 2025, wisprflow.ai/new-funding.

[24] "Voice Recognition Market Size, Share & Growth, 2031." *Mordor Intelligence*, 2026, www.mordorintelligence.com/industry-reports/voice-recognition-market

[25] "Bhashini." *Government of India*, 2026, bhashini.gov.in/

2.2. Architecture of Speech Technologies

2.2.A. Speech-to-Text Softwares

Speech-to-text software has followed the same process for decades: it captures speech through a microphone, processes the audio through a series of computational models, and converts it into text. What has changed significantly is how those stages are implemented. The box below explains the basic sequence.

Box 2.1. How speech becomes text

- ➔ The software records the audio snippet of the person speaking.
- ➔ The recording is converted into a *mel-spectrogram*, a visual representation of how the frequencies in the sound change over time
- ➔ The built-in acoustic model in the software then reads the chart and identifies speech sounds in the recording.
- ➔ A language model weighs those sounds against possible corresponding words that would most likely make sense in a sentence.
- ➔ The software assembles these results into the finished text with punctuation and capitalisation added where needed.

Older systems used the acoustic and language components as separate modules bolted together, which made the chain brittle. Most current systems use a single transformer-based encoder-decoder model. An encoder extracts features from the raw audio, while a decoder generates the corresponding text, using language modelling to determine the most likely sequence of words.

In this regard, OpenAI's Whisper is the best-known example, Whisper is a speech recognition model trained on roughly 680,000 hours of multilingual audio. Its design is credited with better understanding of accents and background noise than previous softwares.[26] This broadly captures the shift from older tools such as Dragon to newer, more advanced speech-to-text systems.

Box 2.2. Why accuracy matters

Speech recognition is measured using word error rate (WER), the share of words that a system transcribes incorrectly. Whisper records a WER of 2.7 per cent on clean benchmarked audio and between 8 and 12 per cent in everyday conditions with background noise.[27] Nuance markets Dragon Professional at 99 per cent accuracy, but Amrit's particular experience suggests otherwise. For someone who types, a 10 per cent error rate may mean a quick

[26] "Whisper | Openai." *OpenAI*, 2026, openai.com/index/whisper/.

[27] "What is OpenAI Whisper?" *Gladia*, 2026, https://www.gladia.io/blog/what-is-openai-whisper

round of edits.[28] For someone with a locomotor disability, correcting those errors can take considerably longer, particularly when typing itself is difficult or impossible. The same error rate therefore has very different consequences depending on who is using the technology.

Incorporating language models into speech-to-text software also enables more contextual transcription. The software uses surrounding words/context to determine which word the speaker is likely to have meant. Amrit values this because it gets enough right on the first pass that he can correct the odd mistake out loud while keeping his train of thought, rather than stopping to fix the errors on the screen. This is why he prefers Aqua Voice. Aqua Voice transcribes continuously, so he sees and corrects as he speaks. Other tools like Wispr Flow process a whole passage and return it complete which may be preferred by someone with a different writing style.

Technology has also reduced some of the practical effort involved in using dictation. Dragon required a headset positioned close to the mouth, because its acoustic matching depended on a clean, consistent signal. Setting that up correctly each day was itself a task for someone with limited hand mobility. Contemporary tools, on the other hand, work well with whatever microphone is in the room, including a laptop mic or a phone that is kept on the table, thus removing an added layer of logistical effort required of the user.

2.2.B. Text-to-Speech Softwares

Unlike speech-to-text software, text-to-speech tools reverse the process: they take written text as input and convert it into spoken audio.

Box 2.3. How text becomes speech

- ➔ The software reads the text input and maps which letters correspond to which sounds along with mapping the stresses and pauses in sentences. This is called *prosody*. *Prosody* is what stops the output from sounding mechanical by supplying it the rhythm and intonation like a human speaker would.
- ➔ An acoustic model then converts this information into a mel-spectrogram. This is essentially a visual map of the sounds that the system intends to produce.
- ➔ A component called the vocoder then converts the spectrogram into an **audio waveform,** which becomes the voice the user hears.

[28] “Dragon Professional.” Nuance, 2026, https://dragon.nuance.com/en-us/dragon-professional

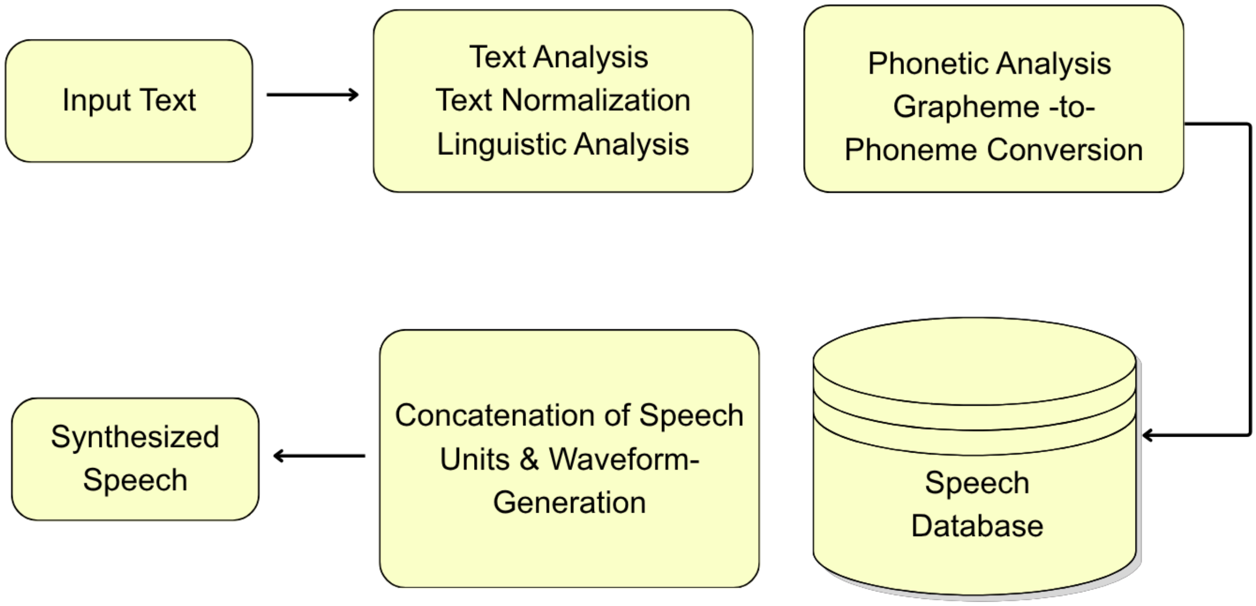

Figure 2.1. Overview of a typical text-to-speech system[29]

Modern text-to-speech systems can produce increasingly natural-sounding speech, with rhythm, stress and intonation that more closely resemble human speech.[30] But unlike speech-to-text, text-to-speech has its roots in assistive technology. It was initially developed to help people with visual impairments and reading disabilities such as dyslexia access written content, before expanding into mainstream applications such as navigation, audiobooks and customer service.

The most familiar example is the synthesised voice used by physicist Stephen Hawking, who had motor neurone disease, to speak through a computer for more than three decades.[31] His experience also illustrates an important development in text-to-speech: voice banking, which allows a person to create a synthetic version of their own voice for use when they can no longer speak.[32]

Box 2.4. Voice Banking

Voice banking involves recording a person's voice while they can still speak and using those recordings to create a synthetic version of it. Later, when the person can no longer speak, they can type or use another input method and have the synthetic voice speak for them, preserving something of their own voice rather than relying on a generic one. Traditional voice

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[29] "Development of Text-to-Speech Synthesizer for Pali Language," Suhas Rajaram Mache and Mahender, IOSR Journal of Computer Engineering, May 2016, researchgate.net/publication/304601298_Development_of_Text-to-Speech_Synthesizer_for_Pali_Language..

[30] "Complete Guide to Text-to-Speech (TTS) Technology ." *Picovoice Wordmark*, 2025, picovoice.ai/blog/complete-guide-to-text-to-speech/.

[31] Bell, Sarah A. "Stephen Hawking's Eternal Voice." *The MIT Press Reader*, Feb. 2026, thereader.mitpress.mit.edu/stephen-hawkings-eternal-voice/.

[32] "Voices Enabled by the Elevenlabs Impact Program." *ElevenLabs*, 2026, elevenlabs.io/11-voices.

banking required hundreds or even thousands of scripted phrases to be recorded. Newer AI-based voice cloning can create a convincing likeness from far less audio.[33]

The voice as identity: A generic synthetic voice can restore the ability to communicate, but it cannot fully preserve the identity carried by a person's voice. Voice conveys personality, accent, regional identity and familiarity. For someone with ALS, losing speech means losing the sound by which family and friends recognise them. Voice banking lets them retain that connection and continue to sound like themselves.

2.3. Incidental Benefits for Persons with Disabilities

Speech technologies have varying degrees of relevance for functional and accessibility needs across different types of disabilities. For people with limited hand mobility, dictation becomes the primary input method rather than a faster alternative to typing. For people with visual impairments, both text-to-speech and speech-to-text systems work well. The screen reader reads the text out loud using text-to-speech and the user can reply by using a speech-to-text software.

For people with dyslexia and similar learning disabilities, dictation removes a specific obstacle. Spelling and sequencing letters can require significant effort that is unrelated to the quality of the underlying idea. Dictation handles these mechanical demands, allowing the user to focus on what they want to say.[34]

For people losing their speech, voice cloning has changed the cost and effort involved in preserving their voice. Newer models need far less recorded audio to produce a convincing likeness, which removes the need for hours of scripted recordings that the older methods demanded. ElevenLabs illustrates where this is heading. Gabi Leibowitz, who leads the company's impact work, told us that accessibility "found the company" rather than the other way around. People with ALS seeking voice preservation approached ElevenLabs directly, and that demand eventually became a formal programme. The company now gives people with permanent voice loss free access to its voice cloning and text-to-speech tools. It frames this as part of a roughly one-billion-dollar in-kind philanthropic commitment to reach a million people with accessibility needs.[35] The programme has since widened beyond ALS to support people experiencing other forms of permanent voice loss, and beyond the United States to countries including India.

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[33] Brandt, Cassandra. "Voice Banking: Preserving Your Voice through Assistive Technology." *Ability Central*, May 2026, abilitycentral.org/article/voice-banking-preserving-your-voice-through-assistive-technology.

[34] F. Masina et al., "Investigating the Accessibility of Voice Assistants With Impaired Users: Mixed Methods Study," JMIR, 2020. https://pmc.ncbi.nlm.nih.gov/articles/PMC7547392/

[35] "ElevenLabs Impact Program." *ElevenLabs*, 2026, https://elevenlabs.io/impact-program ; "ElevenLabs Presents 11 Voices." *ElevenLabs*, 2025, https://elevenlabs.io/blog/elevenlabs-presents-11-voices ; "ElevenLabs Impact Program Innovates in Assistive Technology." *ElevenLabs*, 2025, https://elevenlabs.io/blog/elevenlabs-impact-innovates-in-assistive-technology

For users like Amrit, these advances are not abstract. He uses dictation across all of his workstreams and in his social life. Because he writes professionally, he has also built some tools of his own for keyword and content analysis, including one that leverages the dictation capabilities of LLMs such as ChatGPT.

2.4. Limitations

The tools identified above work well for people whose speech patterns are relatively easy to recognise. Amrit raised a more fundamental limitation almost in passing: **the people who may need dictation most can be those whose speech the systems are least able to understand.** This includes people with severe stutters, dysarthria and other atypical speech patterns. As with the voice assistants discussed in the previous chapter, these systems are largely developed and trained on clear, intelligible speech. Yet speech impairments often accompany motor disorders, meaning that people who are most likely to benefit from dictation can also be among those least well served by it. A better interface alone cannot solve this problem. **It requires models trained on different data, and that work has progressed quite slowly.**

Crucially, there is also the additional language gap that matters for a multilingual country like India. English speech recognition now reports error rates in the single digits on clean audio. Indian languages fare far worse.[36] IndicWhisper, fine-tuned specifically on Indian language data, records an average Hindi word error rate of 13.8 per cent.[37]

Usage in field conditions unfortunately makes matters worse. A 2026 benchmark tested leading systems on Indian-language speech recorded in real agricultural settings. For Odia, a low-resource language, Google's system recorded a word error rate of 70.7 per cent and OpenAI's Whisper recorded 125.6 per cent.[38] A word error rate above 100 per cent means the system produced more incorrect words than the number of words in the reference transcript.

Indian-accented English presents a different problem. AI4Bharat built the Svarah benchmark specifically to test English ASR (Automatic Speech Recognition) on Indian accents, using 117 speakers across 65 districts and 19 states, and found that systems perform significantly worse on non-native speakers than standard benchmarks suggest.[39] Custom dictionaries let users add their own words, including non-English ones, which can improve recognition at the margins. But there is an important distinction: a workaround that users must build and maintain is not the same as a tool that works well out of the box.

[36] Foster, Kelsey. "How Accurate Is Speech-to-Text in 2026?" *AssemblyAI*, July 2026, www.assemblyai.com/blog/how-accurate-speech-to-text.

[37] Jain, Navvya. "Whisper vs Indicwhisper vs Shunya." *Shunya Labs*, June 2026, www.shunyalabs.ai/blog/whisper-vs-indicwhisper-vs-shunya-best-speech-to-text-for-indian-languages.

[38] M S, Chandrashekar M, et al. "Benchmarking Automatic Speech Recognition for Indian Languages in Agricultural Contexts." *arXiv*, Jan. 2026, arxiv.org/html/2602.03868v1.

[39] Javed, Tahir, et al. "Svarah: Evaluating English ASR Systems on Indian Accents." *Ar5iv*, 2023, ar5iv.labs.arxiv.org/html/2305.15760

A further reliability issue follows from the architecture of these systems. Older tools like Dragon ran on the device, so they kept working without a network. Most current tools send audio to the cloud for processing. While it improves accuracy considerably, it also means that an outage or a weak connection can disable the tool entirely. For a casual user that is a mere annoyance. For someone who depends on dictation to communicate and work, it is a significant functional disruption.

2.5. Conclusion

A tool that was designed for hands-free productivity, to write faster and dictate notes, has become a tool of independence for Amrit, enabling him to build a career as a writer. Newer speech technologies are also opening up possibilities for people who are losing their ability to speak, by allowing them to communicate through synthetic versions of their own voices.

But Amrit's experience is not representative of everyone who could benefit from these technologies. Speech recognition remains less reliable for people whose speech differs significantly from the data on which these systems have been trained. Improving performance for these users requires more representative data, creating a tension between the need to improve accessibility and the privacy concerns that come with collecting and processing highly personal voice data. Dictation and voice banking can both involve the recording, storage and cloud processing of a person's voice, while synthetic voices can become closely tied to a person's identity. These questions, alongside the wider challenges of data use, anonymisation and AI development, are examined further in Chapter 6.

03

AI-Based Smart Glasses

AI-integrated smart glasses are designed, marketed and sold as consumer electronics. At the same time, their capabilities offer a range of use cases for blind and low-vision users. This chapter draws on a semi-structured interview with **Rahul Gambhir**, a visually impaired working professional, about his use of AI-based smart glasses. It uses his experience as a starting point to explore the broader ways in which blind and low-vision people are using these devices.

Rahul bought a pair of Ray-Ban Meta Glasses in November 2024. Interestingly, it wasn't the device's unique features that first attracted him to these glasses. He was tired of using conventional medical devices that made his disability visible to anyone who saw him, even before he had spoken a word. In fact, research on assistive technology abandonment has shown that social visibility, cost and poor fit are some of the most frequent reasons why users reject devices that otherwise work perfectly well.[40] For a working professional moving between client meetings and conferences, the need to 'fit in' becomes even more important. As Rahul began using the glasses, he came to appreciate the efficiency enabled by the glasses' app integration and hands-free functionality.

Most smart glasses on the market today are designed around mainstream features such as hands-free photography, music and voice assistance.[41] The addition of AI, which can interpret what the camera sees and respond through open-ear speakers, has created immense possibilities for users with disabilities.

3.1. The Market for AI-Based Smart Glasses

Multiple studies point to a rapidly growing market for AI-integrated eyewear, although available market data does not distinguish between regular buyers and buyers who are persons with disabilities. The International Data Corporation (IDC), for example, recorded 2.25 million smart glasses shipped worldwide in the first quarter of 2026, a 167 per cent increase year on year, and forecasts about 13.6 million units for the full year.[42] Counterpoint Research reported growth of 110 per cent in the first half of 2025 and 139 per cent in the second.[43]

Meta is the leading player in the category, with IDC putting it at 69.2 per cent market share in the first quarter of 2026, while Counterpoint's estimates indicate an even higher market share at 84 per cent. EssilorLuxottica, Meta's manufacturing partner, reported that its smart glasses sales more than tripled between 2023 and 2025.[44] While these figures are not specific to India, they establish that the category is growing rapidly. They do not, however, tell us how people in

[40] Saul, Helen. "Why Do People Abandon Assistive Technologies?" *National Institute for Health and Care Research Evidence*, 30 June 2024, evidence.nihr.ac.uk/alert/why-people-abandon-assistive-technologies-research-suggests-users-become-partners-in-design-users/

[41] "Who Invented Smart Glasses? The Complete History & Why They Failed." *Even Realities*, Apr. 2026, www.evenrealities.com/blogs/buyers-guide/who-invented-smart-glasses?srsltid=AfmBOopDRTtaUi4djPsmdd5C6sT0s-vnF8vkKW4Tnfkp9XTz0K2QaYOD

[42] "Augmented and Virtual Reality Headsets Market Insights." *IDC*, 1 July 2026, www.idc.com/promo/arvr/

[43] "Global Smart Glasses Shipments Grew 139% Yoy in H2 2025; Meta Expanded Market Share to 82%." *Counterpoint Research*, 27 Feb. 2026, counterpointresearch.com/en/insights/Global-Smart-Glasses-Shipments-Grew-139-Percent-YoY-in-H2-2025.

[44] Subin, Samantha. "Ray-Ban Maker Essilorluxottica Says It More than Tripled Meta AI Glasses Sales in 2025." *CNBC*, CNBC, 11 Feb. 2026, www.cnbc.com/2026/02/11/ray-ban-maker-essilorluxottica-triples-sales-of-meta-ai-glasses.html

India are using these devices for accessibility, which this report seeks to explore through conversations with users.

3.2. Architecture of AI-Integrated Wearable Glasses

AI-integrated wearable glasses generally rely on three types of inputs: a camera that captures images, a microphone that picks up voice commands, and motion sensors that track the position and movement of the wearer's head. These inputs feed into a cycle of capture, processing and output, which repeats each time the user makes a request.

Voice plays an integral role in these glasses. The user speaks a *"wake command"* and asks a question out loud. Alternatively, a physical button on the frame can also trigger the wake command. The glasses capture an image through a built-in camera and answer back with spoken audio through small speakers placed near the ears, eliminating the use of handheld devices.[45]

It is important to note that, at this stage, the glasses are not standalone computing devices. They are paired with a smartphone, with most of the computationally intensive processing taking place either on the phone or on the AI provider's servers rather than within the glasses themselves. Offloading these computations allows the glasses to remain lightweight, with relatively limited onboard hardware.

Box 3.1. What happens when you ask AI glasses to describe what is in front of you

- ➔ The built-in camera on the glasses captures an image in response to the user's request.
- ➔ The glasses transmit the image to a paired smartphone or other connected device.
- ➔ The connected device sends the image to the AI provider's servers over the internet.
- ➔ The servers analyse the image and generate a response or description.
- ➔ The response is transmitted back to the connected device and converted into audio.
- ➔ The wearer hears the response through the glasses' speakers.

For AI-enabled features such as image description, this process can take a few seconds and typically depends on an internet connection. Simpler device functions, such as checking the time or controlling music, can be handled through the glasses without going through the same AI-processing workflow.[46]

A stable internet connection is generally needed for these AI-enabled commands, while Bluetooth maintains a constant, low-power connection between the glasses and the paired phone. The phone's Wi-Fi or mobile data handles the heavier processing and data transfer. The overall system can therefore be understood as operating across four layers.

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[45] "How Do AI Glasses Work?" *Even Realities*, Aug. 2025, www.evenrealities.com/blogs/buyers-guide/how-ai-glasses-work

[46] "Edge AI Architecture for Wearable Smart Glasses with Real-Time Multimodal Processing." *ZenML*, 2025, www.zenml.io/llmops-database/edge-ai-architecture-for-wearable-smart-glasses-with-real-time-multimodal-processing

Box 3.2. The four layers of Smart Glasses

- ➔ **Hardware:** The camera captures images when triggered by a voice command or button press, while an LED indicator signals when recording is taking place.
- ➔ **Transmission:** Bluetooth and other wireless connections carry data between the glasses, the paired phone and, where required, cloud servers.
- ➔ **Processing:** The phone and cloud servers analyse the image or request and generate a response.
- ➔ **Interaction:** The user issues a voice command and receives the response as audio through the glasses' speakers.

Beyond the core AI features

Because the glasses connect to a smartphone, they can also provide hands-free access to functions such as music, calls and navigation. Users can dictate and send messages using speech-to-text, and have incoming messages read aloud. They can also provide audio access to text displayed on the phone. These features can be particularly useful for people using a walking cane or those with limited hand mobility.

3.3. Incidental Benefits for Persons with Disabilities

The design of the device is itself an accessibility benefit. The glasses look like ordinary eyewear, which Rahul highlighted as particularly important for people like him navigating the corporate world. Being able to use assistive technology without visibly signalling his disability helps him feel less excluded.

Fig 3.1. Oakley Meta smart glasses and Ray-Ban Meta (Gen 2)

One of the most direct use cases of the glasses for the blind is to read text aloud - whether it's a menu at a restaurant, a product label at a grocery store, identifying a medicine at a pharmacy or navigating a printed document. In professional settings, blind employees can read documents, identify colleagues and follow meetings using AI smart glasses.

Our interviewee, Rahul uses his glasses frequently at conferences and in client-facing work, where he can read presentation slides in real time rather than waiting for a colleague to describe them. The glasses are also actively used in navigation, with users asking the glasses to identify street signs, locate crossings and describe their surroundings on the move. Notably, research has found that nearly 42% of blind and partially sighted people need some support even on familiar journeys.[47] Used alongside a cane or guide, the glasses can help bridge part of that accessibility gap.

Meta's Live AI extends this capability by providing continuous, real-time assistance about the user's surroundings, allowing a user to have a running conversation with the AI without restarting each interaction. This can make multi-step tasks more natural, such as identifying several objects in a kitchen or getting successive descriptions while moving through an environment. The glasses can also connect users to a sighted volunteer through the **"Be My Eyes"** feature, activated by voice. This provides a human fallback in situations where AI may be unreliable or where a user needs more detailed visual assistance, such as while travelling.

Navigating a busy street can, however, remain challenging. The open-ear speakers designed to keep users aware of their surroundings can sometimes be difficult to hear in noisy environments, limiting the usefulness of some navigation features precisely where they may be needed most.[48] Audio performance has already improved across successive generations of smart glasses,[49] but noisy environments remain a limitation. This is a constraint that may ease as the underlying hardware and software mature, much as audio performance has improved with the evolution of ANC (active noise cancellation) headphones discussed in Chapter 5.

The same capabilities extend beyond navigation to more personal, everyday tasks. People with visual disabilities can face challenges when grooming or choosing what to wear for the outside world. The glasses can describe the colour and pattern of a garment, allowing users to match an outfit without asking someone else.[50] They can also describe the user's own appearance in a mirror before they leave home. Blind users often have to rely on sighted people for such tasks. The glasses can reduce that dependence and, importantly, give users greater privacy and control over how they present themselves.

The accessibility applications of smart glasses also extend to communication. Smart glasses with displays can provide real-time translations or transcriptions that hard-of-hearing users can read as a conversation takes place. Some AI-enabled glasses also use their microphones to

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[47] "World Report on Vision." *World Health Organization*, 2019, www.who.int/docs/default-source/documents/publications/world-vision-report-accessible.pdf

[48] "Inclusive Journeys: Improving the Accessibility of Public Transport for People with Sight Loss." *Royal National Institute of Blind People & Motability Foundation*, Apr. 2023, www.motabilityfoundation.org.uk/media/dcvcrvpp/inclusive-journeys-motability-research-final.pdf

[49] O'Brien, Ciara. "Ray-Ban Meta Gen 2 review: More than a fun toy." The Irish Times, Apr. 2026, https://www.irishtimes.com/technology/consumer-tech/review/2026/04/30/tech-review-meta-ai-gen-2/

[50] Hogan, Susan, and Ambar Rodriguez. "'Hey, Meta. What's in Front of Me?' How AI Glasses Are Changing a Blind DC Woman's Life." *NBC4 Washington*, Oct. 2025, www.nbcwashington.com/news/local/hey-meta-whats-in-front-of-me-how-ai-glasses-are-changing-a-blind-dc-womans-life/4005349/

focus on or enhance the voice of the person the wearer is facing.[51] While such features are not a substitute for a certified hearing aid, they can make conversations easier for people with mild to moderate hearing loss, particularly in noisy settings.

Research on the accessibility benefits of smart glasses for other disabilities remains limited, but several potential uses are already apparent. For people with locomotor disabilities, hands-free calling and camera capture can reduce the need to lift or hold a phone. For people with cognitive or learning disabilities, step-by-step prompts and reading assistance could provide useful support through a device that does not draw attention to itself. As these devices become more mainstream, further accessibility use cases are likely to emerge.

3.4. Limitations

The main limitation of these glasses is not whether they can provide useful information, but how reliably they can do so across different tasks and environments. AI-generated descriptions have improved rapidly, but the systems can still misidentify objects, colours, spatial relationships or other details, and sometimes confidently report information that is not there.[52]

For blind and low-vision users, the consequences of such errors can be greater because they may have no visual way to verify the answer. Rahul, for example, noted that for work requiring precision or sustained reading, such as technical documents or contracts, he still relies on a screen reader, a software that converts on-screen text to speech. He finds the glasses unreliable for high-stakes material and therefore does not depend on them when accuracy is critical. Newer AI models perform better on many standard benchmarks, but these gains are uneven across tasks.[53] A 2026 study tracking six generations of leading AI models found similar variation even within visual reasoning.[54]

The glasses are therefore a welcome supplement to existing aids, but not a complete replacement, at least for now. Reviewers writing for blind and low-vision audiences caution against relying on the AI for tasks such as street crossings and recommend that the device sit alongside a cane or guide rather than stand in for either.[55]

The glasses can nevertheless enable forms of everyday independence that were previously difficult or required assistance. For example, AI-based visual recognition can help a blind user identify people, objects and other features in their surroundings. Being able to recognise a colleague or acquaintance independently can offer a meaningful form of everyday parity.

[51] Strom, Karl. "'Conversation Focus': AI Speech Enhancement in Meta Ray-Ban Gen 2 Offers New Hearing Help." *Hearing Tracker*, June 2026, www.hearingtracker.com/news/meta-ray-ban-gen-2-conversation-focus-ai-speech-enhancement-for-hearing-loss.

[52] Tang, Yilin, et al. "'This Is My Fault', Really? Understanding Blind and Low-Vision People's Perception of Hallucination in Large Vision Language Models." *Association for Computing Machinery*, Sept. 2025, dl.acm.org/doi/full/10.1145/3746059.3747597

[53] Hendrycks, Dan, et al. "Measuring Massive Multitask Language Understanding." *arXiv.Org*, Jan. 2021, arxiv.org/abs/2009.03300.

[54] Galatzer-Levy, Isaac, et al. "Uneven Evolution of Cognition across Generations of Generative AI Models." *arXiv.Org*, May 2026, arxiv.org/abs/2605.06815.

[55] Kelley, Steven. "A Review of the Ray-Ban Meta AI Glasses for People With Low Vision." *The American Foundation for the Blind*, 2025, afb.org/aw/fall2025/meta-glasses-review.

However, these capabilities also raise privacy questions, particularly around facial recognition and the incidental capture of people nearby, which are explored in Chapter 6.

The glasses also depend on a chain of infrastructure that conventional aids do not. They require a paired smartphone, network connectivity and sufficient battery power, while more complex AI requests are processed in the cloud. A loss of connectivity can therefore disable some of the features that make the glasses useful as an accessibility tool.[56] Battery life presents another constraint, although this has already improved significantly across generations.

When it comes to pricing, it is worth noting that assistive glasses are priced at approximately Rs. 4 lakhs (about US$4,700) or higher.[57] By comparison, consumer AI glasses discussed in this chapter range from ₹ 22,000 to ₹ 45,000 (US$250 to US$470). Yet even at the lower end, these glasses remain unaffordable for most of India's blind population.[58]

3.5. Conclusion

Smart glasses demonstrate how accessibility can emerge both through users adapting mainstream technology and through accessibility features built into the product. By combining cameras, microphones, speakers and AI, these devices can give blind and low-vision users hands-free access to visual information. Accessibility-focused features such as Be My Eyes and live captioning further expand their potential to support individuals like Rahul.

Yet the same capability that creates independence for a person with disability can also create privacy concerns for the people around them. The camera that reads a menu or describes a presentation can also capture bystanders who may be unaware that they are being recorded. Manufacturers have begun addressing some of these concerns through safeguards built into the devices themselves. At the same time, India's data protection framework provides protections for personal data, but its conventional mechanisms of notice and consent are difficult to apply when data is captured incidentally by a wearable device, without any direct interaction between the person being recorded and the entity processing the data. These policy tensions are explored in greater detail in Chapter 6.

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[56] "Meta Glasses Review." *American Foundation for the Blind*, 2025, www.afb.org/aw/fall2025/meta-glasses-review

[57] "Orcam Myeye Smart | Wearable Reading Device." *Sight and Sound Technologies*, 2026, www.sightandsound.co.uk/product/orcam-myeye-smart-access-to-work-wearable-reading-device-sight-and-sound-technology/

[58] Udayakumar, Devi et al. "Artificial intelligence-powered smart vision glasses for the visually impaired." *Indian journal of ophthalmology* vol. 73,Suppl 3 (2025): S492-S497. https://pubmed.ncbi.nlm.nih.gov/40444311/

04

Haptic Feedback

Kushagra Sahu, a fitness enthusiast, was a regular user of the FitBit - a fitness tracker - to measure his vitals. In 2022, he moved to the Apple Watch. Born with a hearing and speech impairment and a user of hearing aids, he soon realised that its uses extended beyond tracking his fitness goals. The watch's vibrating features particularly stood out to him. A vibration on his wrist could now substitute for the alerts a hearing person receives through sound, turning a lifestyle device into an assistive one.

This technology is called "haptic feedback". Manufacturers added haptics to consumer devices as a refinement to enhance the user's experience, a way to make a notification feel less intrusive and to signal an action even when a phone, watch or similar devices are kept on silent. For users like Kushagra, haptic feedback becomes the primary channel for notifications.

This chapter examines how haptic technology works, its applications across different disabilities, and the limitations that remain.

4.1. Architecture of Haptic Feedback

Haptic feedback is delivered through touch rather than sight or sound. Some examples of this are a phone vibrating in a pocket, a gaming controller shuddering when a car revs up in a videogame, and a small tap felt under the thumb when a letter is pressed on the touch screen of a smartphone. It is now widely available as a third sensory channel alongside a device's screen and speaker, yet for a long time it remained the least developed of the three interfaces.[59]

What's fascinating is that using touch to convey information predates the modern smartphone by decades. During the Second World War, aircrafts used systems that vibrated the control stick to warn pilots of an approaching stall, allowing them to feel the warning without looking away from the controls.[60] In the 1960s, neuroscientist Paul Bach-y-Rita developed a vision-substitution device that converted camera images into a grid of tactile points pressed against the skin, demonstrating that touch could convey information typically processed through vision.[61]

The Motorola StarTac phone was the first consumer device to adopt haptics in 1996 with the introduction of a vibration function.[62] This was followed by vibration features in Nintendo's N64 controller. For almost two decades after the launch of the StarTac, the vibration in phones continued to be a single inexpensive mechanical component (detailed in the next section) before we started seeing significant innovation in haptics.

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[59] Morin, Marc-andré. "Types of Haptic Feedback and How They're Used." *Boréas Technologies*, Boréas Technologies, 4 July 2023, pages.boreas.ca/blog/piezo-haptics/different-types-of-haptic-feedback-and-their-applications.

[60] "Understanding Haptics: A Journey through the History and Evolution of Haptic Technology." *TITAN Haptics*, July 2024, titanhaptics.com/understanding-haptics-a-journey-through-the-history-and-evolution-of-haptic-technology/.

[61] Bach-Y-Rita, Paul, et al. "Vision Substitution by Tactile Image Projection." *Nature News*, Nature Publishing Group, 1969, www.nature.com/articles/221963a0.

[62] Dolcourt, Jessica. "Legendary Motorola Startac: Revisiting the World's First Flip Phone." *CNET*, July 2020, www.cnet.com/pictures/legendary-motorola-startac-revisiting-the-worlds-first-flip-phone/.

4.2 Mechanical Components & Applications of Haptics

The component that produces these vibrations is called an actuator, and the type of actuator determines how sophisticated the haptic feedback can be. Actuators broadly fall into three categories, and their evolution has taken haptics from blunt buzzes to increasingly precise and nuanced sensations.

Box 4.1. The three types of actuators

1. **Eccentric rotation mass (ERM)** is the oldest and cheapest category. It works by spinning a small motor with an off-centre weight, and this wobbling spin is responsible for the vibration. ERM is reliable and cheap but can be slow to start and stop, and its strength and speed are locked together, limiting the precision of the feedback they can produce. This actuator was used in older feature phones.[63]
2. **Linear resonant actuator (LRA)** moves a mass back and forth on a spring using electromagnetic force. It behaves more like a miniature loudspeaker than a conventional motor. Because the movement is controlled and centred around a resonant frequency, it can produce sharper, more distinct haptic effects. Apple's **Taptic Engine**, first introduced in the Apple Watch[64] in 2014 and subsequently used across the iPhone and other Apple devices, is a well-known example of an LRA-based haptic system.
3. **Piezoelectric actuator** uses ceramic material that bends when a voltage is applied across it. No weight has to spin and no spring has to settle, so the actuator can start and stop almost instantly and produce anything from a faint tick to a firm click. Piezoelectric actuators are used in some compact haptic interfaces and touchscreens, where their thin profile and fast response are particularly useful.

The **move from the ERM to the LRA and the piezo** has opened up the possibility of using distinct vibrations to communicate different kinds of notifications. Unlike the ERM, newer actuators produce vibrations that differ in length, sharpness and rhythm, which means a device can assign different patterns to different events. A user learns that one pattern means a call and another means a message, in the same way they would learn two different ringtones.

Android's design guidance differentiates clearly between 'buzzy' haptics, which are the long ringing vibrations of older devices and the 'clear' and 'rich' haptics that inhabit newer devices, directing developers to avoid the buzzy kind.[65]

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[63] Schweber, Bill. "Haptics Components, Part 1: LRA, ERM, and Piezo Actuators." *Power Electronic Tips*, 2021, www.powerelectronictips.com/haptics-components-pt-1-lra-erm-and-piezo-actuators/.

[64] "Apple Unveils Apple Watch, Apple's Most Personal Device Ever." *Apple*, Sept. 2014, www.apple.com/newsroom/2014/09/09Apple-Unveils-Apple-Watch-Apples-Most-Personal-Device-Ever/

[65] "Haptics Design Principles ." *Android Developers*, 2026 developer.android.com/develop/ui/views/haptics/haptics-principles

Box 4.2. Haptics as a design signal

Android's guidance treats touch as a design signal rather than a by-product. It sets out three principles:

- The strength of the vibration must match the importance of the event.
- The same sensation must always signal the same action and this should work in tandem with what the user sees and hears.
- Touch should carry consistent and readable meaning which helps users with hearing and visual impairment understand the action.

4.3. Incidental Benefits for Persons with Disabilities

Haptic feedback helps alert deaf and hard-of-hearing users regarding incoming calls, messages, alarms or other alerts through different types of vibration. The most frequent use of haptics has been through the smartphones. However, when worn continuously against the skin, smartwatches offer a distinct accessibility advantage. A notification is less likely to be missed than when a phone is in a pocket or a bag, and the user does not need to retrieve the device to feel it.

The Apple Watch, for instance, gives a tap on the wrist for every notification through its Taptic Engine. It also offers a "Prominent" haptic setting that adds a stronger tap to pre-announce certain alerts, along with a haptic wake-up alarm that taps the wrist rather than making a sound.[66]

Notably, deaf and hard-of-hearing users have reported preferring smartwatches over smartphones for sound and notification awareness generally, often pairing it with a phone or headset for the accompanying visual information.[67]

Haptics, therefore, emerges as a gamechanger for users like Kushagra. When a call comes in, the watch taps his wrist, with the vibration serving as a tactile ringtone. He accepts the call straight from his watch, listening in with his hearing aid that's directly connected to his apple ecosystem. Ever since he started using the Apple Watch, Kushagra depends on it to wake him up every morning too. A vibrating alarm on his wrist has removed his dependence on a hearing person for waking him up every morning.

A research team at University of Washington pushed the use case for haptics further by building *SoundWatch* which is a smartwatch app that listens for sounds such as sirens, microwave

[66] "Adjust Volume and Haptics on Apple Watch." Apple Support, https://support.apple.com/en-in/guide/watch/apd62807a9f3/watchos

[67] "Deaf and Hard-of-hearing Individuals' Preferences for Wearable and Mobile Sound Awareness Technologies," Leah Findlater, Bonnie Chinh, Dhruv Jain, Jon Froehlich, Raja Kushalnagar and Angela Carey Lin, Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, 2019, https://dl.acm.org/doi/10.1145/3290605.3300276

beeps and smoke alarms.[68] Once the sound is identified, it sends a buzz to the wrist notifying the deaf or hard-of-hearing user. A standalone market for bedside devices and smartwatches for the deaf community has existed for some time, but the above discussed built-in features integrated in a consumer facing smartwatch has made these technologies more accessible.[69] Even though Kushagra started using the Apple Watch for fitness, he began to find it useful to also locate his phone and gadgets whenever he couldn't find them. He triggers the locator from the watch, Apple's "Precision Finding"[70] feature gets him the general area and then the strong vibration lets him feel his way to finding his phone. For a hearing user this is an added benefit, whereas for him this is the only way to find a misplaced phone.

For blind and low-vision users, turn-by-turn navigation apps on smart watches with haptic feedback can deliver directional cues as distinct vibration patterns. The ability to feel instructions rather than having to listen to them is particularly useful on a noisy street or when audio output would be intrusive. Haptics can also help notify a blind user when they tap a key or complete a transaction. A vibration tells them the device received the input, which a sighted user would confirm by looking at the screen. For example, while using a UPI app, a blind person might be notified regarding a successful payment through a fluttering pattern of short buzzes and a failed one through a single continuous buzz.

For persons with locomotor disabilities, the smartwatch haptics alert them of incoming phone calls and notification without having to make the effort to lift the phone, especially if the phone is kept a distance away. For **Shishir Bhatnagar**, who we introduced in Chapter 1, the smartwatch is a safeguard, ensuring he is not cut off from his caregivers or emergency help when his phone is physically out of reach.

4.4. Limitations

Despite developments over the last decade, haptics remain more limited in the amount of information they can convey than visual or audio interfaces. Users can learn and distinguish a small number of vibration patterns, but as these patterns become more numerous or similar, they can be harder to distinguish and remember. Haptics therefore work well for alerts and simple cues, but are less suited to conveying detailed information. The Haptics Industry Forum, an industry body working on haptic standards, uses the term "haptic vocabulary" to describe this constraint and identifies it as a core design limitation for wearables.[71]

This places an inherent limitation on how far the haptic channel can substitute for other sensory alerts. A deaf user may know that a call is incoming but they will not be able to tell who is calling without access to the screen. For a blind user, a directional buzz can indicate a turn but the

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[68] McQuate, Sarah. "SoundWatch: New Smartwatch App Alerts d/Deaf and Hard-of-Hearing Users to Birdsong, Sirens and Other Desired Sounds." *UW News*, Oct. 2020, www.washington.edu/news/2020/10/28/soundwatch-alerts-ddeaf-and-hard-of-hearing-users-to-desired-sounds/

[69] Abraham, Eyra. "Vibrating Smart Watches for Deaf: ." *Lisnen*, Apr. 2025, lisnen.com/deaf-friendly-vibrating-smart-watches-for-people-with-hearing-loss/.

[70] "iCloud - Find My - Features." *Apple (India)*, www.apple.com/in/icloud/find-my/

[71] "Resources." *Haptics Industry Forum*, hapticsif.org/resources/

richer information a sighted person reads from a map or a street sign has no equivalent in vibration. Haptic feedback is, therefore, useful as an assistive tool when functioning in conjunction with others in a supplementary or complementary capacity.

Unsurprisingly, the most capable and consistent haptic hardware tends to sit in premium devices. The seamless integration that makes a system dependable, where a watch, phone and hearing aid work together without friction, also often requires users to buy into a single, expensive ecosystem. Kushagra values this integration within the Apple ecosystem, but it also highlights a broader concern: the most reliable version of this accessibility can remain out of reach for many people with disabilities. More affordable devices tend to offer weaker and less consistent haptic experiences, making them harder to rely on.

4.5. Conclusion

A technology designed to make notifications feel less abrupt has become a tool of independence for Kushagra, allowing him to wake up each morning without relying on another person in the house.

Yet the same sensors that enable accessibility features also generate detailed information about a person’s health, activity and daily routines. Chapter 6 explores the policy questions this creates for technologies that can simultaneously enable independence and generate highly personal data.

05

Noise-Cancelling Headphones and Earphones

Sakshi (name changed), a public policy researcher started using noise-cancelling headphones at the age of 28 to help her focus at work, two years before she understood why they helped her focus after she was diagnosed with Attention Deficit Hyperactivity Disorder (ADHD).

For millions like Sakshi, the core difficulty that ADHD presents is sensory gating. Sensory gating is the brain's ability to filter incoming information automatically, deciding what deserves attention and what can be tuned out. A person with ADHD struggles to sort incoming information: the hum of a ceiling fan or a conversation two desks away competes for attention as readily as the work one is focusing on. Moreover, with the sensory channel running at full volume all day, the share of working memory left for executive function shrinks.

Strategies to manage noise sensitivity for neurodivergent individuals predate the invention of noise cancelling headphones. Innovations to cope with the same have ranged from foam earplugs to ear defenders. Foam earplugs produce the occlusion effect, an echoing sensation that makes the wearer's own voice sound muffled and unnatural. Ear defenders are visible, bulky and unmistakably clinical. Research on ear-level assistive listening devices for autistic children identifies stigma as a reason for poor uptake, precisely because the devices are designed to look like hearing aids.[72] Newer filtering earplugs such as *Loop* reduce these problems, but they still set a fixed level of attenuation.[73] The wearer cannot adjust it as they move between a quiet room and a crowded one.

Interestingly, noise-cancelling headphones were developed to improve the listening experience in noisy environments, particularly during air travel. However, for neurodivergent people, particularly those with ADHD they present a chance to reduce stimulation while engaging with the world around them. This chapter looks at what makes noise-cancelling headphones an effective assistive technology and examines incidental use-cases mapping their cost, design and questions around long term use.

5.1. The Market for Active Noise Cancellation (ANC) Headphones and Earphones

ANC is now available across a range of consumer audio devices, but two form factors dominate the market: over-ear headphones and in-ear wireless earbuds. Over-ear headphones generally have larger batteries and more room for microphones and processing hardware, while their ear cups also provide substantial passive noise isolation. Wireless earbuds are much smaller and more portable, but the seal created by the ear tip can complement ANC by reducing external sound. As a result, effective ANC is no longer limited to large headphones and is increasingly available in compact earbuds.

The broader personal-audio market illustrates the scale at which this technology can reach consumers. Omdia recorded 108 million smart personal audio devices shipped worldwide in the

[72] Zanin, Julien, et al. "Effectiveness of Noise Cancelling Earbuds in Reducing Hearing and Auditory Attention Deficits in Children with Autism." *Journal of Clinical Medicine*, U.S. National Library of Medicine, 2024, pubmed.ncbi.nlm.nih.gov/39200929/

[73] Kollböck, E. (2026, April 19). Concert earplugs tested: Which protect hearing without killing sound. InspiredByBeatz. https://www.inspiredbybeatz.com/en/concert-earplugs-tested-which-protect-hearing-without/

second quarter of 2026.[74] Of these, over 75% were true wireless stereo (TWS) devices, the term used for wireless earbuds and similar products in which the two earpieces operate without a connecting wire.[75]

The technology is also moving down the price curve. Omdia reported in late 2025 that ANC was increasingly appearing in products priced below US$25,[76] signalling the growing availability of what was once primarily a premium feature. This does not mean that all low-cost earbuds offer ANC, but it does indicate that the technology is no longer restricted to expensive headphones.

India reflects this broader shift towards affordable personal audio. The Indian market is dominated by lower-priced wireless earbuds, with domestic brands accounting for a substantial share of shipments. This growing availability matters for accessibility because ANC is increasingly a feature that users can access through mainstream consumer products rather than specialised devices. Counterpoint Research estimates that India's wireless earbuds market grew 14% in 2024, with boAt retaining the leading position at a 32.9% share of shipments, followed by Boult Audio at 12.9% and Noise at 9.7%.[77] Together, the three brands accounted for 55.5% of shipments. The market remained broadly flat in 2025.[78]

5.2. Architecture of Noise-Cancelling Headphones

There are two primary forms of noise cancellation technology, with most headphones using a combination of both. The first is Passive Noise Cancellation (PNC) that uses a physical seal such as foam or silicone placed either at the tip of an earbud or the cushion of an over-ear cup. This blocks sounds in the same way an earplug does. The second is Active Noise Cancellation (ANC) which works by canceling sound with an opposing sound wave. The physical seals help with high-frequency sounds while the electronics handle low and steady drones.

Box 5.1. Mechanics of Active Noise Cancellation

1. A small microphone on the headphone picks up the noise around the wearer.
2. The headphone's processor generates a second sound wave that is the inverse of the original noise, the same wave turned upside down.
3. The two waves meet and cancel out before reaching the eardrum. This is called destructive interference.

[74] Wang, Rory. "Smart Personal Audio Market Snapshot for 2Q26." *Omdia*, Sept. 2026, https://omdia.tech.informa.com/om147049/smart-personal-audio-market-snapshot-for-2q26

[75] "OWS Shipments Grow 12% as TWS Market Remains Broadly Flat in 2Q26." *Omdia*, Sept. 2026, https://omdia.tech.informa.com/pr/2026/sep/ows-shipments-grow-12percent-as-tws-market-remains-broadly-flat-in-2q26

[76] "OWS Crosses 10-Million-Unit Milestone as TWS Market Pivots to Value Creation." *Omdia*, Dec. 2025, https://omdia.tech.informa.com/pr/2025/dec/ows-crosses-10-million-unit-milestone-as-tws-market-pivots-to-value-creation

[77] "India's TWS Shipments Grow 14% in 2024, Surpassing $1.3 Billion in Value: Counterpoint." *ETTelecom*, Feb. 2025, https://telecom.economictimes.indiatimes.com/news/devices/indias-tws-shipments-grow-14-in-2024-surpassing-1-3-billion-in-value-counterpoint/118147541

[78] "India's TWS Market Remains Flat in 2025, But Q4 Delivers Strong 12% YoY Growth." *Counterpoint Research*, Mar. 2026, https://counterpointresearch.com/en/insights/India-TWS-Market-Remains-Flat-in-2025

It works best against steady, low-frequency sound: the drone of an aircraft engine, an air conditioner, or traffic. That noise is predictable enough for the processor to mirror accurately. Sudden or high-frequency sounds are harder to cancel this way and remain more audible to the wearer.[79]

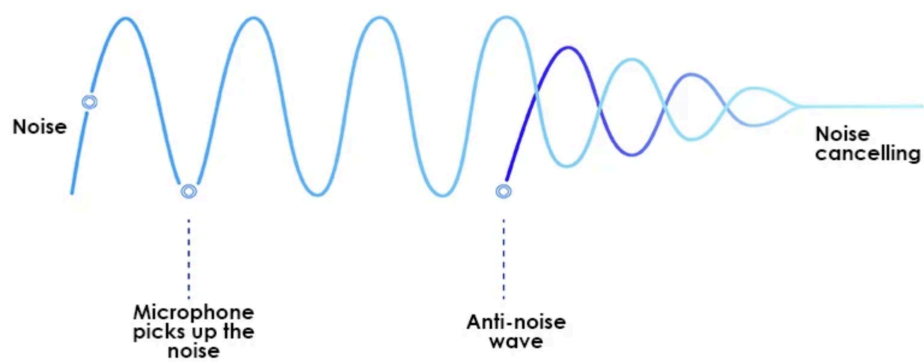

Figure 5.1. How Active Noise Cancellation Works[80]

All forms of ANC depend on a digital signal processor that continuously calculates and generates the noise-cancelling signal in real time. As this technology has become cheaper, it has moved beyond premium headphones into increasingly affordable earbuds.

Most consumer headphones also offer transparency or ambient mode. This uses the same external microphone to let outside sound through deliberately, or even help further amplify it. The wearer can hear a conversation or announcements without having to remove their earphones.[81]

This ambient mode has incidentally become an accessibility use-case in its own right, letting a user move between blocking ambient noise out and letting it back in. This allows users to adjust the sensory load a moment or task calls for. Sakshi described switching between the two through her day, blocking out all sound to focus at her desk in the office, then turning to ambient mode while reading during her commute, so she could still hear announcements and stay aware of her surroundings while travelling.

[79] Thomas, Christian. “Active Noise Canceling (ANC) Technology Types Explained.” *SoundGuys*, Oct. 2025, www.soundguys.com/noise-canceling-anc-explained-28344/.

[80] “Active vs Passive Noise Cancelling – Understand the Difference.” *NG EarSafe*, 2025, ngearsafe.com/blogs/open-ear-headphones/active-vs-passive-noise-cancelling?srsltid=AfmBOorPI74otNbM4mXv-DAMV33C7TWJQzJEMDxfMWX1HdmR_-qk3Ckj.

[81] Watanabe, Hiroki & Terada, Tsutomu Transparency Mode of Hearable Reduces Your Spatial Hearing: Evaluation and Cancelling Method to Restore Spatial Hearing. *IEEE Access*, 2023 11. 97952-97960. https://www.researchgate.net/publication/373749403_Transparency_Mode_of_Hearable_Reduces_Your_Spatial_Hearing_Evaluation_and_Cancelling_Method_to_Restore_Spatial_Hearing

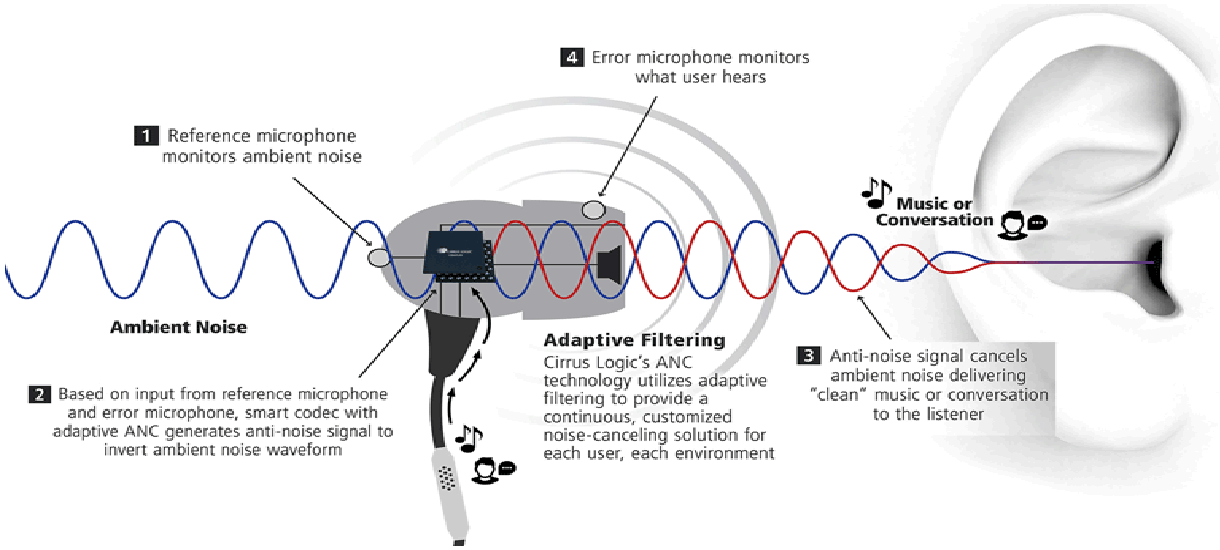

Figure 5.2. Process of Adaptive Noise Cancellation[82]

Box 5.2. Hearing Augmentation Software Solutions

In 2024, the United States Food and Drug Administration (FDA) authorised a software feature that turns Apple's Airpods Pro 2 into a hearing aid for adults with mild to moderate hearing loss. **It was the first time the agency cleared hearing-aid software for an ordinary consumer audio product**.[83]

The feature works through *self-fitting*, meaning the user calibrates the device themselves rather than visiting an audiologist. Users take a hearing test on their phone, and the resulting profile customises the earbuds to amplify the frequencies they struggle with, raising the level of speech while reducing background noise. The authorisation rested on a clinical study of 118 adults, which found that self-fitting produced comparable perceived benefit to professional fitting of the same device.

5.3. Incidental Benefits for Persons with Disabilities

As seen above, noise-cancellation headphones help with filtering out background noises, an essential accessibility support for those with ADHD. Such sensory processing difficulties are common in autism too where sound is the most frequently reported challenge.[84]

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[82] ibid.

[83] "FDA Authorizes First Over-the-Counter Hearing Aid Software." *U.S. Food and Drug Administration*, FDA, Sept. 2024, www.fda.gov/news-events/press-announcements/fda-authorizes-first-over-counter-hearing-aid-software.

[84] Pfeiffer, Beth et al. "Effectiveness of Noise-Attenuating Headphones on Physiological Responses for Children With Autism Spectrum Disorders." Frontiers in integrative neuroscience vol. 13 65. 2019, https://www.frontiersin.org/journals/integrative-neuroscience/articles/10.3389/fnint.2019.00065/full

A study published in *Frontiers in Integrative Neuroscience* found that noise-attenuating headphones reduced physiological stress responses in autistic children aged approximately 8 to 16, as measured by skin conductance, a standard indicator of physiological arousal.[85] Because ANC headphones allow the wearer to choose how much of the surrounding environment to hear, they offer a degree of moment-to-moment regulation that a fixed earplug does not.[86] The same adjustability helps people with autism, ADHD, anxiety disorders, and other conditions, when they need to cancel out distractions, reduce sensory overwhelm, or create a calmer sound environment to focus.

Sakshi's account adds an interesting dimension to the incidental benefits mapped above. She uses over-ear headphones rather than earbuds. For her, small earbuds lead to an extra level of mental stress - the need to charge them frequently and the fear of misplacing them. For someone whose condition already taxes working memory and planning, that overhead is not trivial. She has, therefore, settled for over-ear headphones as they are harder to lose and hold longer charges.

Using ANC has significantly improved Sakshi's quality of life. With a lowering of her sensory load, she has also seen her stress levels go down. This has visibly reduced her susceptibility to ADHD's co-occurring illnesses like migraines, thereby creating more space for her to thrive in all spheres of life.

5.4. Limitations

ANC headphones carry an important safety trade-off: they can reduce ambient sounds such as an approaching vehicle, an alarm or someone calling out the user's name. This can be a significant concern near traffic or in other environments where awareness of surroundings is important. Transparency modes can mitigate this risk, but only when the user switches them on.

In 2025, NHS audiologists in the UK began to voice their concerns that for young people whose auditory processing is still developing, heavy-use of ANC headphones, might contribute to a rise in auditory processing disorder (APD).[87] This condition causes one to struggle processing speech from noise. The hypothesis for this argument is that if a brain is given too little background noise to practise on, it becomes worse at filtering it; this is, however, not an established finding.[88] Various medical studies have also recommended that irrespective of age, one must not run cancellation constantly, especially at a high volume.

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[85] Pfeiffer, Beth, et al. "Effectiveness of Noise-Attenuating Headphones on Physiological Responses for Children with Autism Spectrum Disorders." *Frontiers*, Frontiers, Aug. 2026, doi.org/10.3389/fnint.2019.00065.

[86] Ikuta, Nobuhiko et al. "Effectiveness of Earmuffs and Noise-cancelling Headphones for Coping with Hyper-reactivity to Auditory Stimuli in Children with Autism Spectrum Disorder: A Preliminary Study." Hong Kong journal of occupational therapy : HKJOT vol. 28,1, 2016 : 24-32. https://pmc.ncbi.nlm.nih.gov/articles/PMC6091992/

[87] Hewitt, Dale R. "Does the Overuse of Noise-Cancelling Headphones Cause APD?" *ENT & Audiology*, May 2025, www.entandaudiologynews.com/features/audiology-features/post/does-the-overuse-of-noise-cancelling-headphones-cause-apd.

[88] "Do Headphones Cause Auditory Processing Disorder?" *Tobias & Battite*, Mar. 2025, www.tobias-battite.com/blog/do-headphones-cause-auditory-processing-disorder/.

The second challenge is affordability, which in the Indian market is tiered by quality. A budget ANC earbud may reduce noise, but not as effectively as a premium high quality headphone.[89]

Awareness of noise cancellation as a tool for managing sensory processing difficulties also remains limited in India. Sakshi used these headphones for two years before understanding why they worked so well for her. Manufacturers have yet to fully recognise or communicate these use cases in how they market ANC devices, while clinicians do not routinely recommend them for this purpose.

5.5. Conclusion

A device designed to make travel and music better has become an aid for Sakshi, allowing her to get through the workday without being overwhelmed by sounds she finds difficult to filter out.

Yet, her experience also highlights a policy gap: workplace accommodation and assistive technology support frameworks are largely built around recognised or purpose-built assistive devices, making it harder to support mainstream products when they acquire an assistive function through use. Chapter 6 examines these gaps in greater detail.

[89] "Apple Airpods vs Boat Airdopes 171: What Is the Difference?" *Versus*, 2026, versus.com/en/apple-airpods-vs-boat-airdopes-171.

06

The Policy Landscape

Across the five technologies studied in this report, a consistent pattern emerges where users with disabilities discovered incidental accessibility benefits when they came across mainstream consumer technologies. From noise-cancelling headphones which assist neurodivergent persons in managing sensory overload to smart home set ups which enable wheelchair users to navigate their way around their household tasks without needing a caregiver, these accessibility use cases sprung up along the wider adoption of mainstream technologies.

At the same time, these technologies rarely replace existing assistive tools or support systems completely. Instead, they tend to complement and extend them. Blind users, for instance, may use AI-enabled smart glasses for situational awareness while continuing to rely on screen readers for tasks requiring greater accuracy. Deaf users may combine haptic feedback from smartwatches with other devices and visual alerts. The value of incidental accessibility, therefore, often lies not in replacing assistive technology, but in expanding the range of ways in which people with disabilities can interact with their surroundings.

The current policy landscape for consumer technology does not fully account for this dual reality. Regulatory and support frameworks in India are largely organised around a product's intended function, market and technical classification, and are not designed to capture the assistive role a mainstream device may acquire through use. As a result, a product can meet the requirements applicable to a consumer device without its accessibility implications, or the needs of people who rely on it for everyday tasks, being adequately reflected in the wider policy framework. For example, smart home technologies used as assistive tools by wheelchair users may offer significant gains in independence, but the accessibility of their interfaces, installation requirements, connectivity needs and affordability are not necessarily considered in the ways that purpose-built assistive technologies are.

This points to a broader gap: accessibility is rarely treated as a consideration that cuts across technology policy. As mainstream technologies increasingly perform functions once associated primarily with assistive technologies, policy trade-offs between innovation, cost and safety continue to be made without consistently accounting for accessibility. The growing use of mainstream technology as incidental assistive technology, therefore, calls for accessibility to become a more deliberate lens through which technology is designed, regulated and evaluated.

Box 6.1. What this chapter covers

1. Accessibility mandates through the RPwD Act and India's Information and Communication Technology (ICT) standards
2. Device certification ecosystem that determines tax and procurement treatment in India
3. Architecture of India's data protection framework covering consent, guardianship, and the storage of data collected by these devices

4. Copyright and AI-enabled accessibility, including the legal questions that arise when AI systems interpret copyrighted text, images or other works to make them accessible

5. Access and affordability of accessibility-enhancing tools and devices

6.1. Accessibility under the Indian Legal Framework

The technologies covered in this report were designed for a general consumer market, but the growing use by persons with disabilities places them within a broader conversation around accessibility in mainstream technology.

The Rights of Persons with Disabilities Act, 2016 (RPwD) is the key legislative framework through which accessibility obligations under Indian law are most directly established. Section 40 of the RPwD Act directs the government to set accessibility standards for information and communication technologies. Section 42(iii) turns this into a specific requirement: everyday electronic goods, not only products built for disability, must follow universal design, meaning they must be usable by everyone rather than requiring a separate accessible version. IS 17802, released by the Bureau of Indian Standards in 2021 and modelled on the international WCAG standards, translates this requirement into testable technical criteria.[90] Furthermore, a 2023 amendment added it to Rule 15 of the RPwD Rules, the rule meant to carry Section 40's mandate into practice.[91]

Whether Rule 15 actually functions as mandatory was tested before the Supreme Court in Rajive Raturi v. Union of India.[92] In November 2024, the Court found that Rule 15 fell short of what the RPwD Act required: the Act's own language was mandatory, while Rule 15 offered only persuasive guidelines on accessibility. Based on this gap the Court made Rule 15 ultra vires the Act's scheme and intent. It, therefore, directed the government to frame mandatory accessibility rules within three months.

The government's response is still taking shape: in July 2026, the Department of Empowerment of Persons with Disabilities published draft rules on mandatory accessibility standards for the ICT sector for public consultation.[93] These draft rules were still under consultation at the time this report was being drafted.

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[90] "IS 17802 (Part 1):2021 — Accessibility for the ICT Products and Services, Part 1: Requirements," Bureau of Indian Standards, services.bis.gov.in/.../isdetails_mnd/26752.

[91] "RPwD (Amendment) Rules 2023 dated 10th May 2023 on ICT Products and Services," Department of Empowerment of Persons with Disabilities, May 2023, depwd.gov.in/en/rpwd-amendment-rules-2023-dated-10th-may-2023-on-ict-products-and-services.

[92] "Rajive Raturi v. Union of India," 2024 INSC 858, Supreme Court of India, 8 Nov. 2024, Indian Kanoon, indiankanoon.org/doc/98908321.

[93] “Draft rules on non-negotiable accessibility standards for Information and Communication Technology Sector”. Department of Empowerment of Persons with Disabilities (DEPwD), July 2026. https://depwd.gov.in/en/draft-rules-on-non-negotiable-accessibility-standards-for-information-and-communication-technology-sector/

This raises an interesting question. As mainstream products acquire important accessibility use cases, how can accessibility considerations be encouraged early in design and development without treating every consumer technology as a specialised assistive device? Interviews conducted in this study indicate that accessibility is beginning to enter design thinking for some of the larger manufacturers, but remains uneven across the wider technology ecosystem.

The experiences documented in this report suggest that there is not just a regulatory case for encouraging accessibility in mainstream technology, but also a business opportunity. Designing with persons with disabilities in mind can expand the usefulness of mainstream products, reach new users and, more broadly, integrate people with disabilities into the technology ecosystem as both consumers and participants in its development.

6.2. Device Certification Ecosystem

India does not have a single, uniform certification regime for consumer technology. Instead, different regulatory requirements apply depending on a product's characteristics, such as electrical and electronic safety, use of radio frequencies, telecom functionality and, in some cases, cybersecurity. These requirements are administered through different bodies and regulatory schemes.

The principal bodies relevant to the devices covered in this report are:

- **Bureau of Indian Standards (BIS):** India's national standards body which sets product safety standards and administers the Compulsory Registration Scheme (CRS) under the Ministry of Electronics and Information Technology (MeitY).[94]

- **Standardisation Testing and Quality Certification Directorate (STQC)**: A MeitY body that, among other functions, operates the IoT System Certification Scheme (IoTSCS) for testing and certifying IoT[95] product security.[96]

- **Telecommunication Engineering Centre (TEC):** Housed within the Department of Telecommunications (DoT), TEC is the technical body that sets telecom standards and administers mandatory certification for telecom equipment through the Mandatory Testing and Certification of Telecommunication Equipment (MTCTE) regime.[97]

[94] "About CRS," Bureau of Indian Standards (CRS Portal), crsbis.in/BIS/about-crs.do.

[95] The Internet of Things (IoT) refers to a network of physical devices, vehicles, appliances, and other physical objects that are embedded with sensors, software, and network connectivity, allowing them to collect and share data. https://www.ibm.com/think/topics/internet-of-things

[96] "IoT System Certification Scheme (IoTSCS)," STQC Directorate, stqc.gov.in/en/iot-system-certification-scheme-iotscs.

[97] "Mandatory Testing and Certification of Telecom Equipment (MTCTE)," TEC, Department of Telecommunications, tec.gov.in/mandatory-testing-and-certification-of-telecom-equipments-mtcte.

- **Wireless Planning and Coordination Wing (WPC)**: The DoT wing responsible for spectrum-related approvals for devices using radio frequencies.[98]

A connected consumer product may, therefore, encounter more than one regulatory requirement, depending on the technologies and functions it incorporates. A device using radio communication, for example, may require WPC approval, while a product falling within a notified BIS category may also require CRS registration. Certain telecom equipment may additionally fall within MTCTE.

The product categories themselves are also evolving. A MeitY notification in October 2025 brought Extended Reality Products as a distinct registration category under the Electronics and Information Technology Goods (Requirement of Compulsory Registration) Order, 2021 covering augmented, virtual and mixed reality devices.[99] At the time of drafting, however, questions remained around the precise scope of the category.

The applicable requirements are, therefore, determined largely by the technical characteristics and regulatory category of the product. Compliance practitioners report that clearing BIS CRS and WPC in parallel takes roughly eight to twelve weeks, against fourteen to twenty if done sequentially.[100]

This fragmentation matters for incidental assistive technology not simply because manufacturers face multiple compliance processes, but because **accessibility is not generally assessed as a distinct consideration within these product-specific regimes**. A device can, therefore, meet the requirements governing safety, radio-frequency use, telecom functionality or security, while accessibility remains unevenly reflected in how it is designed and brought to market.

The policy landscape is, however, beginning to evolve, with the government working on draft RPwD Rules focusing on accessibility for the ICT sector, as discussed in the section above. The question going forward is how these accessibility requirements can be meaningfully connected to the standards, design processes and market pathways through which mainstream products reach consumers.

6.3. Architecture of India's Data Protection Framework

Most of the incidental assistive technologies examined in this report rely on personal data: voice recordings, location information, health and activity signals, and images and video captured by cameras. How India's data protection framework treats consent, guardianship, data retention and processing will, therefore, shape the protections available to people who depend on these technologies. The Digital Personal Data Protection (DPDP) Act, 2023 establishes this

[98] "Equipment Type Approval (ETA)," Department of Telecommunications eServices Portal, eservices.dot.gov.in/equipment-type-approval-eta.

[99] Ministry of Electronics and Information Technology. (2025, October 29). *S.O. 4997(E): Migration to IS/IEC 62368 : Part 1 : 2023 from IS 13252 : Part 1 : 2010 and IS 616:2017*. The Gazette of India. https://worldtradescanner.com/267449-S.O.%204997(E)-29.10.2025.pdf

[100] "BIS Parallel Testing for Electronics and IT Goods in India 2026 — Complete Guide," Rego Services, regoservices.com/bis-parallel-testing-electronics-it-goods-india-2026.html

framework, although its substantive provisions are being brought into force in phases, with most obligations relating to processing, consent, notice and *Data Principal*[101] rights scheduled to take effect in 2027.

6.3.A. Consent, Accessibility and Incidental Capture

The Digital Personal Data Protection Act (DPDP Act) treats consent as one of the principal grounds for processing personal data.[102] It requires consent to be free, specific, informed and unambiguous, while also requiring processing to be for a lawful purpose.

6.3.A.1. Consent as an Accessibility Question

For consent to be meaningful, however, the person giving it must also be able to understand what they are agreeing to. For a person with a disability, this raises an additional accessibility question: can the privacy notice be read, heard, navigated or otherwise understood in a format that works for them? The DPDP Rules require notices to be clear and understandable, but do not establish a general accessibility standard for privacy notices comparable to the accessibility obligations discussed earlier in this chapter.

There is a second, less obvious accessibility question: how much effort does it take to exercise consent? A privacy architecture built around repeated permissions, re-authentication or other small decisions may create a practical barrier for the very users the technology is intended to assist. For someone with limited hand mobility, every additional tap or confirmation can add physical effort; for someone with cognitive or attention-related disabilities, repeated decisions can add cognitive load. Consent that is formally available may, therefore, still be difficult to exercise in practice.

6.3.A.2. When the Person Captured is not the User

But even where consent can be meaningfully understood, incidental assistive technologies complicate the conventional data protection relationship in another way: the person using the technology may not be the only person whose data is being captured. A smart speaker in a home like Shishir's, for example, may be linked to one account, but its microphones can pick up the voices of everyone in the room. The person who set up the device may have agreed to the service's processing practices, while a family member, caregiver or support worker whose voice is also captured may never have encountered the company's notice or consent mechanism. The distinction between the person using the technology and the people whose data it incidentally captures, therefore, becomes difficult to manage through a model built around a direct relationship between the user and the service.

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[101] Section 2(j) of the Digital Personal Data Protection Act, 2023: "Data Principal" means the individual to whom the personal data relates and, where such individual is a child, includes the parents or lawful guardian of such child.

[102] "The Digital Personal Data Protection Act, 2023 (No. 22 of 2023)," Ministry of Electronics and Information Technology, Aug. 2023, meity.gov.in/static/uploads/2024/06/2bf1f0e9f04e6fb4f8fef35e82c42aa5.pdf.

AI-enabled smart glasses create a similar problem in a different setting. Rahul's glasses can capture images of people around him when he uses camera-based features in public and private spaces. Where those images can identify the people captured, those individuals would themselves be *Data Principals*, even though they have no account with the manufacturer or direct relationship with the company. The practical difficulty is, therefore, not that the DPDP framework necessarily excludes them, but that conventional mechanisms of notice, consent and the exercise of rights are difficult to apply when personal data is captured incidentally and without a direct interaction with the *Data Fiduciary.*[103]

The issue becomes particularly difficult when incidental capture is itself the accessibility function. Speech-to-text tools, live captioning and AI-enabled glasses may need to capture and process the words spoken by another person, while camera-equipped glasses may also capture images of people around the user. For a deaf or hard-of-hearing user, for example, the other person's speech is not incidental to the accessibility function; it is what makes captioning possible. An analogy helps illustrate the tension: in an ordinary conversation, a person does not seek separate permission from another person to hear and interpret their words, just as a sighted person can look at a face or object and recognise it without digitally recording it. The difference is that these technologies perform similar functions by capturing and processing information digitally, which **creates privacy questions that do not arise in the same way with ordinary human perception.**

The concern also extends beyond consent. Without appropriate safeguards, wearable cameras can create risks around identification or misuse, particularly when images are retained beyond the immediate function for which they were captured. The question for a person in the frame is not simply whether an image was taken, but what happens to it afterwards: whether it is stored, whether it is sent to a remote server, whether it is used for another purpose, and whether it can be linked to an identifiable individual.

Facial recognition takes this concern a step further. Unlike ordinary scene description, recognising a person generally requires a system to detect a face and compare its distinguishing features with stored reference information. The accessibility benefit is clear: a blind user could use glasses to recognise a colleague, friend or family member without asking someone else. Dedicated assistive products such as OrCam MyEye[104] and Envision Glasses[105] already offer this capability by allowing users to teach the device the faces of people they know.

But identifying a person is more privacy-sensitive than simply describing what is in front of the camera. It raises design questions that merit careful attention, particularly around what information is stored, where and for how long. Mainstream consumer glasses have so far approached this capability more cautiously because there is clearly a tension that is particularly

[103] Section 2(i) of the Digital Personal Data Protection Act, 2023: "Data Fiduciary" means any person who alone or in conjunction with other persons determines the purpose and means of processing of personal data.

[104] "Face Recognition on OrCam MyEye." *OrCam*, accessed Sept. 2026, https://orcam.helpjuice.com/myeye-faqs/2714232-how-do-i-use-face-recognition-on-my-orcam-myeye

[105] "Find People." *Envision*, accessed Sept. 2026, https://support.letsenvision.com/hc/en-us/articles/7603968016273-Find-People

hard to resolve: a capability that could provide a meaningful accessibility benefit for someone, can simultaneously create a significant privacy risk for another person.

6.3.A.3. Building Safeguards

Recognising these challenges, some manufacturers have begun building safeguards into devices rather than relying on user discretion alone. These include visible indicators that signal when media is being captured, with tamper detection if the indicator is obscured; user-initiated rather than continuous capture; on-device processing of simpler requests; and data-minimisation that removes identifying information before images are processed by AI systems. Meta, for example, says its glasses use a capture LED for photos and videos intended for the gallery or streaming, and that covering or disabling the LED disables those captures.[106] Snap's forthcoming SPECS similarly emphasise a visible recording indicator, on-device processing and user controls over what is stored, synced, shared or deleted.[107]

These safeguards are important, but they do not eliminate the underlying tension. The technology, the safeguards around it, and the ways in which the technology can be misused are all evolving together. The challenge is to develop safeguards that allow these technologies to perform functions analogous to human perception while minimising the additional privacy risks created by digital capture and processing. There is still no settled answer on how best to address this challenge and it remains an area where further technical development, user research and policy consideration are needed.

6.3.B. Consent, Capacity and Guardianship

Section 9 of the DPDP Act, 2023 requires a *Data Fiduciary* to obtain a lawful guardian's verifiable consent before processing the personal data of a person with disability who has a lawful guardian. As enacted, the provision did not distinguish between disabilities that affect a person's ability to make legally binding decisions and those that do not. The statutory trigger was therefore linked to disability status and the existence of a lawful guardian, rather than to the individual's actual capacity to make the decision.

Rule 11, finalised in November 2025, narrowed the applicability of the section after the mismatch with the RPwD Act's limited-guardianship model was flagged, under which a court specifies exactly which decisions a guardian can make.[108] Guardian consent under Rule 11 now applies only where a person, despite receiving adequate support, is unable to make legally

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[106] "Responsible Innovation in AI Glasses and Quest." *Meta*, accessed Sept. 2026, https://www.meta.com/en-gb/actions/responsible-innovation/; "Meta's AI Glasses: Your Questions Answered." *Meta*, July 2026, https://about.fb.com/news/2026/07/metas-ai-glasses-your-questions-answered/.

[107] "Snap Inc. Debuts SPECS Augmented Reality Glasses to Make Computing More Human." *Snap Inc.*, Sept. 2026, https://investor.snap.com/news/news-details/2026/Snap-Inc--Debuts-SPECS-Augmented-Reality-Glasses-to-Make-Computing-More-Human/default.aspx

[108] "The Digital Personal Data Protection Rules, 2025 — G.S.R. 846(E)," Gazette of India / Ministry of Electronics and Information Technology, Nov. 2025, dpdpa.com/DPDP_Rules_2025_English_only.pdf.

binding decisions, reflecting the functional approach already adopted under the RPwD Act. This is significant for the users featured in this report. A locomotor, visual or hearing disability does not, by itself, imply an inability to make decisions about how a smartwatch, smart speaker or pair of AI glasses processes personal data, yet a guardian appointed for an unrelated reason would still have triggered mandatory consent under the Act.

The evolution from the Act to the Rules also illustrates why accessibility needs to be considered throughout the policy process, rather than only after a framework has been enacted. Stakeholder engagement and public consultation provided an opportunity to identify where a seemingly neutral rule may have had unintended consequences for people with disabilities. The lesson extends beyond data protection: accessibility needs to remain a standing consideration as policies are designed, debated and refined, not something addressed only after problems emerge.

6.3.C. Beyond Consent: Training, Anonymisation and the Accessibility Trade-off[109]

The privacy questions do not end once data has been collected to provide an accessibility function. Many of the technologies examined in this report are powered by AI models that need large and diverse datasets to improve their performance. This creates a particular tension for incidental assistive technologies: the people who benefit most from better models may also be those whose voices, images, movements or other signals are poorly represented in existing training data.

This is especially relevant for speech technologies. As discussed earlier, people with dysarthria, stutters, Indian accents and other atypical speech patterns remain poorly served by many mainstream speech recognition systems. Improving these systems requires training data that captures those patterns. Yet the same recordings that can make a model more accessible can also contain highly personal information about the people whose data is used.

India's data protection framework does not yet provide a clear pathway for navigating this tension. The DPDP Act excludes anonymised data from the definition of personal data, but the law does not establish a detailed statutory benchmark for when data can be considered "effectively" anonymised. This creates uncertainty for organisations seeking to use data for AI development while ensuring that individuals cannot reasonably be re-identified.

Moreover, anonymisation is also not a binary process. Different degrees of anonymisation may be appropriate depending on the risk of re-identification, the context in which the data is used and the purpose for which it is needed. Stronger anonymisation can reduce privacy risks, but may also remove information that is valuable for AI systems, limiting the data's usefulness. This trade-off is particularly important for accessibility-related technologies. A speech dataset, for

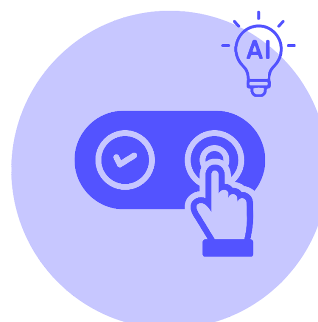
[109] "Open Loop India Report". The Quantum Hub. (2026), https://thequantumhub.com/wp-content/uploads/2026/03/Open-Loop-India_AI-Innovation-Effective-Anonymization-the-DPDP-Act_26-02-16_HR.pdf

example, may need to retain characteristics of atypical speech to help improve recognition for people with dysarthria or stutters. Removing too much of that information may make the dataset safer from a privacy perspective, but less useful for building a model that can actually recognise such speech.

Research applying anonymisation to pathological speech data has also found that diverse speaker and disorder profiles complicate the process, making a reasonable level of anonymity difficult to establish for precisely this kind of data.[110]

This underscores the need for clearer pathways for the responsible use of appropriately anonymised personal data in AI model training, so that privacy can be protected without limiting the development of technologies that work better for people with disabilities.

6.4. Copyright and AI-enabled accessibility



Several of the technologies examined in this report use AI to read, view or otherwise interpret copyrighted material and convert it into a form that a person with a disability can access. AI-enabled glasses, for example, can read text from a document or describe what is shown in a photograph or presentation. This creates a copyright question that is distinct from, but connected to, the data and privacy issues discussed above.

India already has an accessibility exception in Section 52(1)(zb) of the Copyright Act, 1957.[111] It permits the adaptation, reproduction, issue of copies or communication of any work in an accessible format to facilitate access by persons with disabilities, subject to specified conditions. India also ratified the Marrakesh Treaty in 2014, which established an international framework for creating and exchanging accessible-format copies for people who are blind, visually impaired or otherwise print disabled.[112]

AI has changed the practical context in which this exception operates. Converting an inaccessible document into an accessible format has traditionally required significant time and technical effort. AI can now perform parts of this process in real time, allowing a person to have text read aloud, documents structured or visual information described without first waiting for a separately prepared accessible copy. But this also raises questions that the existing exception was not designed specifically to answer. Does a real-time AI-generated rendering of a copyrighted work, created dynamically for an individual user, fall within the concept of an "accessible format" under Section 52(1)(zb)? And how should the exception apply where the

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[110] "Addressing challenges in speaker anonymization to maintain utility while ensuring privacy of pathological speech," Soroosh Tayebi Arasteh et al., *Communications Medicine*, vol. 4, article 182, Sept. 2024, https://www.nature.com/articles/s43856-024-00609-5

[111] The Copyright Act, 1957, s. 52(1)(zb)," Government of India, 1957, https://copyright.gov.in/documents/copyrightrules1957.pdf

[112] "Marrakesh Treaty to Facilitate Access to Published Works for Persons Who Are Blind, Visually Impaired or Otherwise Print Disabled, 2013," World Intellectual Property Organization, June 27, 2013, wipo.int/treaties/en/ip/marrakesh/; "India Is First to Ratify 'Marrakesh Treaty' Easing Access to Books for Persons Who Are Visually Impaired," World Intellectual Property Organization (WIPO), June 30, 2014, https://www.wipo.int/pressroom/en/articles/2014/article_0008.html

processing is performed by an AI system? These questions have not yet been squarely tested in India.

6.5. Access and Affordability of Accessibility Devices

For any accessibility tool, whether purpose-built assistive technology or the incidental cases we highlighted in this study, impact depends on two basic conditions: the product has to be physically available and financially affordable. The devices this report has examined, smart speakers, dictation software, AI glasses, haptic smartwatches and noise-cancelling headphones, were priced and taxed as mainstream consumer electronics, because that is what they were designed to be. As established above, for users like Shishir, Amrit, Rahul, Kushagra and Sakshi, these devices are playing the role of assistive technology. The question this raises is whether India’s fiscal and regulatory systems for recognising and supporting assistive technology can account for devices that become assistive through use, rather than through their intended design.

6.5.A. Recognising Assistive Technology

The recognition for assistive technology is decided through two separate government mechanisms. The first is the Assistance to Disabled Persons for Purchase/Fitting of Aids and Appliances (ADIP) Scheme, run by the Department of Empowerment of Persons with Disabilities which subsidises the purchase of assistive aids for users below a specified income threshold, with the extent of assistance scaled by both income and the category of device.[113] The second is the GST framework's own Annexure of assistive devices such as wheelchairs, braille equipment and similar items, taxed at a concessional 5% rather than the 18% levied on ordinary electronics.[114]

The two mechanisms work in different ways for getting an assistive device into a user's hands. ADIP functions as an access measure: it reimburses an income-qualified user's device cost directly, addressing a specific buyer's ability to pay. The GST concession functions as an affordability measure instead, lowering the retail price for any buyer through a lighter tax burden and widening the market a device can reach.

For a device to qualify as assistive technology, therefore, it must appear on one of these two lists, drawn up in advance, rather than qualify based on what it functionally enables for the person using it.

[113] "Unstarred Question No. 1526: Assistance Metrics under the ADIP," Lok Sabha, Ministry of Social Justice & Empowerment (Department of Empowerment of Persons with Disabilities), answered 28 Jul. 2026, sansad.in/getFile/lsapps/loksabhaquestions/annex/188/AU1526_bT6rUe.pdf.

[114] "Unstarred Question No. 2394," Lok Sabha, Ministry of Finance, Aug. 2026, https://sansad.in/getFile/lsapps/loksabhaquestions/annex/188/AU2394_o75TWg.pdf?source=lsapps.

The incidental assistive technology devices examined in this report carry no such designation. They are priced and taxed like comparable consumer electronics, regardless of the role they may play in enabling independence for the person using them. Classification is effectively fixed at the point of manufacture and sale, based on a device's intended market and users rather than the assistive function it may acquire once in use.

6.5.B. A Reverse Curb-Cut Effect

This creates what might be described as a reverse curb-cut effect. The curb-cut effect describes disability-specific innovation crossing into the mainstream: ramps built for wheelchairs, captioning built for deaf viewers and voice assistants built for blind users, each now used well beyond the population it was designed for.[115] Incidental assistive technology, however, moves in the opposition direction: a mainstream product ends up performing an assistive function for a user with a disability.

Presently, India's fiscal and regulatory framework recognises the first direction of travel, not the second. A device must start out being classified as assistive to receive concessional tax treatment or ADIP support, and the framework has no equivalent way of recognising one that acquires that function later. This considerably impacts affordability of such technology for users with disabilities.

Several of the interviewees, including Sakshi, Kushagra and Shishir, noted that cost was a real consideration, even when costly devices were in their reach. In a study of assistive technology access in India, the inability to afford a device was the most commonly cited barrier among those with an unmet need, reported in over a third of the cases.[116]

6.5.C. Existing State Support

This exclusion is not necessarily for want of state support for persons with disabilities. State support exists, and is expanding, but has not yet extended to incidental assistive technologies. The Union Budget for 2026-27[117] introduced the Divyang Sahara Yojana, a scheme that funds the expansion of assistive-device manufacturing, invests in AI-led research for better devices, and sets up retail centres where users can try devices before buying.[118] This works the same way as ADIP and the GST framework, funding devices which are already declared assistive, not a mainstream product a user has come to depend on for that purpose.

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[115] "The Curb-Cut Effect," Angela Glover Blackwell, Stanford Social Innovation Review, Winter 2017, ssir.org/articles/entry/the_curb_cut_effect.

[116] "Assistive Technology Usage, Unmet Needs and Barriers to Access: A Sub-Population-Based Study in India," National Library of Medicine (PMC), Aug. 2023, pmc.ncbi.nlm.nih.gov/articles/PMC10442958/.

[117] "Two New Schemes for Empowerment of Divyangjan in Union Budget 2026-27," Press Information Bureau, Feb. 2026, pib.gov.in/PressReleasePage.aspx?PRID=2221393.

[118] "Union Budget: ALIMCO to Scale Up Production of High-Quality Assistive Devices, Deepen Research & Development," News on Air, Feb. 2026, newsonair.gov.in/union-budget-alimco-to-scale-up-production-of-high-quality-assistive-devices-deepen-research-development.

In this context, corporate social responsibility (CSR) spending can expand reach.[119] Notably, some CSR programmes are already distributing smart glasses to blind users who could not otherwise afford them.[120] Even so, their reach remains dependent on individual corporate priorities and cannot substitute for a systemic mechanism to address access and affordability.

A recent DEPwD circular offers another, potentially more flexible model. It allows Central Government employees with disabilities to claim reimbursement of up to ₹10 lakh every three years, with the device chosen in consultation with the employee rather than picked off a fixed list.[121] Its illustrative examples include wheelchairs, hearing aids, screen-reading software and head mouse, all of which are purpose-built assistive technologies. Smart glasses, dictation software and noise-cancelling headphones do not currently appear among the examples, although the circular describes the list as indicative rather than exhaustive.

Several stakeholders we interviewed described precisely the kind of workplace use that such an open-ended mechanism could accommodate: smart glasses reading out slides, headphones creating a focus zone, or dictation software enabling someone to write without typing. Its reach, however, is limited to Central Government employees, and it remains unclear whether incidental assistive technologies can in practice be reimbursed through this mechanism.

6.5.D. The AirPods Pro Case

The same gap persists even when a manufacturer deliberately builds an assistive function into a mainstream product. Apple's AirPods Pro 2, covered in Chapter 5, offers a useful example: unlike some of the other incidental use cases examined elsewhere in this report, the hearing-assistance function was designed specifically for people with hearing loss.

The feature, which sits alongside the earphones' more conventional audio functions, can detect and amplify sounds for users with mild to moderate hearing loss, allowing the product to function like a hearing aid. American regulators cleared this feature in September 2024, letting Apple sell and market the earphones as an over-the-counter hearing aid at the ordinary consumer price.[122] The feature has since reached more than 150 countries.[123] In India, however, Apple's May 2026 rollout of health

[119] Cyrill, M. (2026, August 20). Corporate social responsibility in India: A guide. India Briefing. https://www.india-briefing.com/news/corporate-social-responsibility-india-5511.html/

[120] News On AIR. (2026, May 6). AIIMS distributes AI-powered smart vision glasses to help the visually impaired. Akashvani News. https://newsonair.gov.in/aiims-distributes-ai-powered-smart-vision-glasses-to-help-the-visually-impaired/

[121] "Circular on Reimbursement of High-Technology Assistive Devices for Central Government Employees with Disabilities," Department of Empowerment of Persons with Disabilities, Sept. 2025, cdnbbsr.s3waas.gov.in/.../20250929770894159.pdf.

[122] "FDA Authorizes First Over-the-Counter Hearing Aid Software," U.S. Food and Drug Administration, Sept. 2024, fda.gov/news-events/press-announcements/fda-authorizes-first-over-counter-hearing-aid-software.

[123] "AirPods Pro 2 Hearing Aid and Hearing Test Features Expand to New Countries," MacRumors, Jul. 2025, macrumors.com/2025/07/15/airpods-pro-2-hearing-aid-expansion.

features included only the hearing test; the hearing aid feature itself was not available at the time of writing.

Presently, India's medical device rules place hearing aids in Class B, the lower-risk tier that Central Drugs Standard Control Organisation (CDSCO) licenses through state authorities rather than its central process.[124] Further, approval covers only whole, standalone products, reviewed against the same framework built for a conventional hearing aid device, not for a feature embedded in a mainstream consumer device.

This mismatch has practical consequences. For a person with a hearing disability, it delays access to clinically validated hearing assistance through a device that is already available and widely used. For a manufacturer, it creates a choice between running a medical-device approval process built for standalone hearing aids, or withholding a feature that is already functioning in the product elsewhere. The technology already exists and is available, but the regulatory pathway for recognising such a function within a mainstream device is less clear in India.

The AirPods Pro 2 case, therefore, reinforces a broader finding from this section. India's policy architecture is largely organised around products that are identified as assistive at the outset; it is not designed for the ones Sakshi, Kushagra, Rahul, Shishir and Amrit have adapted.

6.6. A Landscape Still Catching Up

This report began with a simple premise: mainstream technology is already functioning as assistive technology for many people in India, often more meaningfully than tools built exclusively for that purpose. This chapter traced what that reality means for policy. The RPwD Act establishes the obligation to make technology accessible, the certification regime decides what actually reaches the market, the DPDP Act governs the data these devices depend on to work and policies of taxation and subsidies shape affordability.

For policymakers, industry and researchers, the value of looking at these frameworks together is to recognise that they are not separate policy questions. They collectively shape the technologies that are developed, the products that reach consumers, the data that can be used to improve them and the extent to which people with disabilities can access and rely on them. Incidental assistive technology is already part of India's technology landscape. The policy opportunity now is to ensure that accessibility is not merely an outcome that users discover along the way, but a consideration deliberately built into the systems that shape technological development and adoption.

[124] "List of Class B Medical Devices in India," Medical Device Registration, medicaldeviceregistration.com/blog/list-of-class-b-medical-devices.

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